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Literature Department SV3-3
3065 Bowers Avenue
Santa Clara, CA 95051
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Integrated Microcomputer Systems
SYSTEM 86/330
MICROCOMPUTER SYSTEM

- Compact desk-top or rack-mount integrated microsystem
- High performance 16-bit iAPX 86/20 processor set (iSBC™ 86/12A + iSBC™ 337 boards)
- Full function iRMX™ 86 real-time, multitasking operating system
- Intel® resident languages include PL/M-86 and ASSEMBLER-86. Intel® PASCAL-86, FORTRAN-86, plus independent software vendor languages (BASIC, COBOL, C), also available
- MULTIBUS® system bus (IEEE-796) multiprocessor architecture
- 35MB Winchester and 1MB DD/DS 8” floppy for program, data storage and back-up
- 320KB of high speed RAM memory to execute multiple jobs and tasks
- Extensive self-test routines for reliable operation and simple fault isolation
- Modular, standard products allow flexible decomposition of the system to board level products for custom configurations

The Intel SYSTEM 86/330 Microcomputer System is a comprehensive integrated, 16-bit hardware and software package designed to give the OEM the fastest path to high performance VLSI. The system, which is based on standard Intel MULTIBUS system bus board level products, also incorporates the VLSI operating system, iRMX 86, state-of-the-art high capacity mass storage and high density RAM memory boards. In addition to the 8086 general purpose microprocessor, the system provides 3 to 5 times the numeric performance of low-end minicomputers through the use of the 8087 numeric data processor. The system's capabilities can be greatly expanded through the use of additional general purpose processors and intelligent I/O boards.

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SYSTEM TECHNICAL DESCRIPTION

Hardware

PROCESSOR SECTION

The single board computer used in the SYSTEM 86/330 is the MULTIBUS-based iSBC 86/12A board. The central processor of the iSBC 86/12A board is the powerful 5 MHz 16-bit 8086. The architecture includes four 16-bit byte addressable registers, two 16-bit index registers, all accessed by a total of 24 operand addressing modes for complex data handling and flexible memory addressing.

The base SYSTEM 86/330 is supplied with 320KB of high speed RAM memory. There is 64KB of dual ported (iSBC 300 memory expansion board supplied) RAM accessible to both the local and MULTIBUS system bus on the iSBC 86/12A processor board. The system can address up to 1 megabyte of main memory. The processor board includes an RS232C serial channel for the connection of a user supplied terminal. Cabling to the rear panel of the system is provided. Asynchronous baud rates of 110 to 19.2K are supported by the system. A parallel I/O interface is also available on the processor board. The port has been configured to be interfaced to a Centronics compatible line printer.

NUMERIC PROCESSING EXTENSION

Also included with the base SYSTEM 86/330 is the iSBC 337 Numeric Data Processor. This MULTIMODULE board contains the Intel 8087 numeric co-processor. The co-processor interface between the 8087 and the 8086 host CPU provides a simple means of extending the instruction set of the system with over 60 additional numeric instructions supporting six additional data types. The data formats used in the SYSTEM 86/330 conform to the proposed IEEE floating point standard insuring highly accurate results. Dramatic numeric performance improvements are provided by the 8087 co-processor. For example a 50X improvement in the Whetstone benchmark over the standard 8086 processor is afforded by the 8086 numeric co-processor.

The 8087 arithmetic, logarithmic, transcendental and trigonometric instructions are fully supported by ASM-86, as well as other Intel higher level languages such as PL/M-86, PASCAL-86 and FORTRAN-86.

MEMORY EXPANSION

In addition to the 64KB of dual ported RAM on the iSBC 86/12A processor board, the SYSTEM 86/330 also includes a 256KB memory expansion board.
This brings the system RAM memory supplied with the base SYSTEM 86/330 to 320KB. The 256KB memory board uses the latest technology 64K bit dynamic RAMs. Through the use of optional memory expansion boards, the total memory capacity of the SYSTEM 86/330 may be expanded to 1 megabyte.

MASS STORAGE

Intelligent Controller — The SYSTEM 86/330 uses the intelligent, 8089-based iSBC 215B Winchester controller. This high performance interface contains firmware which is executed directly on the 8089 processor. This intelligent I/O processor coupled with an on-board RAM buffer off loads a significant portion of disk I/O overhead from the host 8086 processor. In addition to the Winchester control firmware, there is also 8089 firmware resident on the iSBC 215B board to control the iSBX 218 floppy disk controller. The floppy controller plugs directly onto the iSBC 215B board via one of the two available iSBX connectors.

Mass storage expansion beyond the single Winchester and floppy diskette drives configured with the system is easily accomplished by the OEM through the use of daisy chain connector on the back panel of the SYSTEM 86/330 chassis. In addition to the Winchester and Floppy interfaces provided with the system, Intel also can provide a board level interface and iRMX 86 software for SMD compatible disk drives.

Winchester Disk Drive — The SYSTEM 86/330 contains a high performance 35MB (32MB formatted) 8" Winchester technology hard disk drive for program and data storage. The drive has an average access time of 43 ms and a transfer rate of 6.44 Mbits/sec.

Floppy Diskette Drive — A double density/double sided, 8", 1MB, floppy disk drive is included in the base system. This high density floppy drive, which has an average access time and a transfer rate of 250Kbits/sec, can be used for both data storage and system backup.

SYSTEM CHASSIS

The chassis used in the SYSTEM 86/330 is the compact iSBC 680 Multistore User System Package. This 21.0" x 16.75" x 12.25" package houses up to six MULTIBUS cards (two available for expansion in the SYSTEM 86/330). The 8" Winchester disk drive and 8" floppy disk drive are housed in the iSBC 680 package with simple slide-in, slide-out service access. In addition to providing the necessary voltages for the MULTIBUS cards, the efficient switching power supply also provides the 24 volts needed for the DC powered Winchester drive. The SYSTEM 86/330 has been designed to meet UL, CSA, FCC and VDE safety and EMI/RFI requirements. Supplied with the SYSTEM 86/330 are connectors for the RS232 channel, parallel line printer, and additional floppy disk and Winchester disk drives. Cut-outs are also available for OEM supplied connectors.

System Decomposition for Low Cost

The entire SYSTEM 86/330, both hardware and software, is built using standard, modular off-the-shelf Intel products that are available separately. The system is designed so that the OEM can easily decompose the SYSTEM 86/330 into the individual Intel products needed to tailor a custom system. Through the use of industry standard modules and interfaces, the OEM can perform his own system integration without changing software code, thus lowering his end product cost.

System Software

The SYSTEM 86/330 can be used for iRMX 86 software development, as well as being the target system for the OEM application.

VLSI OPERATING SYSTEM (iRMX™ 86)

The powerful iRMX 86 Operating System is an easy-to-use, comprehensive multiprogramming software system designed not only for the SYSTEM 86/330, but for iAPX 86/88-based ISBC board and component level designs.

Services provided by the RAM-based iRMX 86 Operating System include facilities for executing programs concurrently, sharing resources and information, servicing asynchronous events, and interactively controlling system resources and utilities. In addition, the iRMX 86 Operating System provides all major real-time facilities, including priority-based system resource allocation, means for concurrently monitoring and controlling multiple external events, real-time clock control, interrupt management, and task dispatching. The iRMX 86 Operating System contains the following modules: an object-oriented Nucleus; Device Independent Basic and Extended I/O Systems; Terminal Handler; Bootstrap and Application Loaders; Human Interface with complete command line interpreter; and an interactive, object-oriented Debugger.
Because the modules and services provided by the operating system are user selectable, application specific operating systems can be created by iRMX 86 users. The iRMX 86 Operating System therefore eliminates the need for custom operating system design, thereby reducing development time, cost, effort, and risk.

**iRMX™ UTILITIES PACKAGE (iRMX™ 860)**

The iRMX Utilities Package consists of the following software:

**iRMX™ 86 EDIT** — The iRMX 86 EDIT program provides users with a powerful, sophisticated, line-oriented editing facility. EDIT delivers a range of capability suitable for novice users as well as advanced capabilities for sophisticated users. Its key features include a macro processor capable of creating and executing complex strings of commands, which ease the editing chore, as well as defining blocks of text which may be included anywhere in the text file. EDIT offers variable command sourcing, symbolic line numbering and reference by symbol. The facilities of EDIT allow users to create, maintain and manipulate extensive libraries of source code with minimal effort. For more information on iRMX 86 EDIT, see the EDIT Software Package data sheet (143883).

**iRMX™ 86 LINK/LOCATE** — The iRMX 86 LINK/LOCATE program connects object modules which
have been individually compiled into a single, relocatable object module. The input object code may have been produced by any Object Module Format-compatible compiler. Output object modules may be recombined into larger object modules, allowing work from a large programming staff to be easily integrated into an application system.

iRMX™ 86 LIB — the iRMX 86 LIB “Library Manager” allows creation and maintenance of object module libraries. These libraries allow easy collection of related object code to reduce the overhead of maintaining many separate modules. Users may create new libraries, add and delete object modules, as well as list the contents of the library and their public symbols.

PL/M-86 (iRMX™ 863)
The PL/M-86 compiler provides users with a powerful, microcomputer-oriented system programming language. The PL/M-80 Language was introduced in 1976 by Intel. It was the first microcomputer-oriented, block structured, high-level language available. Since 1976, thousands of users, shipping over millions of microcomputer-based systems have generated their system software with PL/M-80 and PL/M-86.

PL/M-86 is a compatible superset of PL/M-80 which offers easy portability of software across the full range of microcomputers supplied by Intel. For more information about PL/M-86, see the PL/M 86/88 Software Package data sheet (402175).

FULL REALMATH SUPPORT
The iRMX 86 Languages support the REALMATH floating point standard. This allows users of all iRMX 86 languages to access the iAPX 86/20 Numeric Data Processors using the ISBC 337 MULTIMODULE board. These numeric processors offer over 100 times greater performance than comparable software-implemented algorithms, and reduce the system memory requirements by at least 16KB. The REALMATH standard (proposed IEEE standard) provides universal consistency in results of numeric computations. The iRMX 86 Languages provide efficient object code generation and access to the highest performance floating point package available on microcomputers.

COMPREHENSIVE SELF-TEST AND SYSTEM DIAGNOSTICS
In order to insure correct system operation and rapid location of both hardware and software problems, the SYSTEM 86/330 is supplied with three levels of diagnostic routines:

SCT (System Confidence Test) — Automatically executed at power on and system reset, the SCT performs a GO-NO GO condition for the processors, memory and devices in the system.

SDT (System Diagnostic Test) — In the event that the SCT finds a system problem, the SDT may be executed by the user for a detailed analysis of the hardware status. This menu driven monitor program can perform tests on all hardware boards in the system and mass storage peripherals.

SAT (System Analysis Test) — This diagnostic tool tests the integration of the hardware and software at the system level. This helps to isolate intermittent failures by running a load stress test on both hardware and software.

SYSTEM DEBUGGING TOOLS
The iRMX 86 Operating System provides a comprehensive tool for interactive software debugging. The Debugger has two capabilities that greatly simplify the process of debugging a multitasking system. First, the Debugger allows users to debug several tasks while the balance of the application system continues to run in real-time. Second, the Debugger allows programmers to interactively view and modify system constructs as well as the system RAM and CPU registers. The debugger is structured to enable system designers to track system-wide problems easily. It can also remain in the final application as a continuous maintenance tool.

OEM SOFTWARE LICENSING
The Intel software products listed above require the signing of an Intel Master Software License Agreement. All products include 1 year of update service. Software is shipped on floppy media in two object forms: 1) a ready-to-run, fully configured system, and 2) a configurable version of all software products.

OPTIONAL INTEL® SOFTWARE SUPPORT
In addition to ASM-86 and PL/M-86 included in the base SYSTEM 86/330, the following Intel languages are available for use on the system:

PASCAL-86 (iRMX™ 861) — The PASCAL-86 compiler provides a strict implementation of the proposed ISO language standard. All source programs are validated by the compiler to ensure its conformance to the standard. Many extensions to
the language are available which allow PASCAL programs to be written specifically for microcomputers. Separate module compilation and iAPX 86/20, 88/20 Numeric Data Processor support are a few of its many features. The ISO standard "source evaluator" can be switched off to accept these extensions. For more information on iRMX 86 PASCAL features, see the PASCAL 86/88 Software Package data sheet (121680).

FORTRAN-86 (iRMX™ 862) — The iRMX 86 FORTRAN compiler provides users total compatibility with existing FORTRAN 86 language-generated code, plus many new language features provided by the FORTRAN 77 language standard. These new features offer FORTRAN programmers many new capabilities, including "IF-THEN-ELSE", random access I/O and character variables. For a more detailed explanation of iRMX 86 FORTRAN, see the FORTRAN 86/88 Software Package data sheet (400630).

iMMX 800 MULTIBUS® Message Exchange — The advanced design of the MULTIBUS system bus coupled with the iMMX 800 software package allows the SYSTEM 86/330 to easily support additional 8 and/or 16-bit Intel single board computers. This powerful option enables OEMs to increase the SYSTEM 86/330's general purpose processing power with boards such as the ISBC 86/05 (8 MHz 8086) and ISBC 88/25 (5 MHz 8088). Intelligent, high performance microprocessor based boards such as the Ethernet * communications controller (ISBC 550 board), serial communications controller (ISBC 544 board) and analog measurement and control computer (ISBC 88/40 board) can greatly expand the capabilities and processing power of the SYSTEM 86/330.

INDEPENDENT SOFTWARE VENDOR SUPPORT — Through the use of the standard UDI (Universal Development Interface) a wide variety of language products, both compilers and interpreters, are now available for use on iRMX 86 from independent software vendors. COBOL, BASIC, CBASIC, and C are a few examples of the available languages. Contact your Intel sales representative for more information.

System Options

HARDWARE

Any Intel MULTIBUS board may be installed by the OEM into the two available expansion slots in the system chassis.

SOFTWARE

Optional language products are available from both Intel and independent software vendors. Operating system support for additional 8085, 8088 and 8086-based processor boards is available through the use of iRMX 80, iRMX 88 and iRMX 86 software. Multiprocessor software support, iMMX 800, is also available for the SYSTEM 86/330.

* Ethernet is a trademark of Xerox Corp.

SPECIFICATIONS

Word Size

Instruction — 8, 16, or 32 bits
Data — 8/16 bits

Instruction Cycle Time

400 nanoseconds for fastest executable instructions (assuming instruction is in the queue).
1.0 microseconds for fastest executable instructions (assuming instruction is not in the queue).

Memory Capacity

RAM — 320K bytes supplied with the base system. Memory may be expanded to 1 megabyte.

Interface

EIA Standard RS232C signals provided and supported.

Serial — Configurable from 110 to 19.2K baud (asynchronous)
Parallel — A parallel I/O port configured to interface with an industry standard Centronics interface printer

AC Requirements

6.5A @ 88 to 126 VAC, 60 Hz, single-phase (US only); 3.25A @ 176 to 252 VAC, 50 Hz, single-phase (Europe only). Maximum total power consumption 350W.

Product Safety Standards

The system is listed under UL standard 114 Safety of Electronic Data Processing Units and Systems. It is also certified by the Canadian Standards Association, standard C22.2 154-1975 Safety of Data Processing Equipment. The system complies with the International Electronics Commission standard IEC 435 Safety of Data Processing Equip-
ment. The system also conforms to the applicable RFI/EMI requirements of VDE 0871/6.78, VDE 0875/6.77 and FCC rule 47 CFR part 15 subpart J Emmission Limits for Computing Devices.

Environmental Requirements

OPERATING
Temperature — 15°C to 35°C
Relative Humidity — 20% to 80% non-condensing over the operating temperature range*
Altitude — Sea level to 6000 feet
Vibration — 1.0g @ 10 to 55 Hz

*NOTE: The environmental combination of humidity and temperature together cannot exceed 26°C wet bulb.

NON-OPERATING
Temperature — −25°C to 60°C
Relative Humidity — 20% to 80% non-condensing
Altitude — Sea level to 12,000 feet
Vibration — 1.0g for 5 ms shock

Physical Characteristics
Width — 16.75 in. (42.55 cm)
Height — 12.25 in. (31.12 cm)
Depth — 21.00 in. (53.34 cm)
Weight — 75 pounds (34.02 kg)

Extensive System Documentation
The SYSTEM 86/330 is shipped with six documentation binders containing over 28 in-depth manuals on all aspects of hardware and software operation. A system installation and maintenance manual, in addition to a system overview manual, are also included.

ORDERING INFORMATION

<table>
<thead>
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<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
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<td>SYS 86/330 PKG</td>
<td>Desk-top, 120V 60 Hz</td>
</tr>
<tr>
<td>SYS 86/330E PKG</td>
<td>Desk-top, 220V 50 Hz</td>
</tr>
<tr>
<td>SYS 86/331 PKG</td>
<td>Rack-mount, 120V 60 Hz</td>
</tr>
<tr>
<td>SYS 86/331E PKG</td>
<td>Rack-mount, 220V 50 Hz</td>
</tr>
<tr>
<td>SYS 86/330 DOC</td>
<td>Complete hardware and software documentation set (included with system; use this order code for additional sets)</td>
</tr>
</tbody>
</table>
Single Board Computers
iSBC 80/04
SINGLE BOARD COMPUTER

- 8085A CPU used as central processor
- 256 bytes of static read/write memory
- Sockets for 4K bytes of erasable reprogrammable read only memory
- 22 programmable parallel I/O lines with sockets for interchangeable line drivers and terminators
- Optimized for stand-alone applications with provisions for on-board +5 V regulator, heat sink, and mounting holes for attachment to user's equipment
- Programmable 14-bit binary timer
- TTL serial I/O interface with hole patterns for RS232C line drivers and receivers
- Four-level vectored interrupt
- Upward compatibility with iSBC 80/05
- Single +5V power supply

The iSBC 80/04 Single Board Computer is a member of Intel's complete line of OEM computer systems which take full advantage of Intel's LSI technology to provide economical, self-contained computer-based solutions for OEM applications. The iSBC 80/04 is a complete computer system on a single 6.75 x 7.85-inch printed circuit card. The CPU, system clock, read/write memory, nonvolatile read only memory, I/O ports and drivers, serial interface, priority interrupt logic, and programmable timer all reside on the board.
FUNCTIONAL DESCRIPTION

Intel's powerful 8-bit n-channel 8085A CPU, fabricated on a single LSI chip, is the central processor for the iSBC 80/04. The 8085A CPU is directly software compatible with the popular Intel 8080A CPU. The 8085A contains six 8-bit general purpose registers and an accumulator. The six general purpose registers may be addressed individually or in pairs, providing both single and double precision operators. Minimum on-board instruction execution time is 2.03 microseconds. A block diagram of iSBC 80/04 functional components is shown in Figure 1.

Memory Addressing

The 8085A CPU has a 16-bit program counter which allows addressing of up to 65,536 bytes of memory. An external stack, located within any portion of iSBC 80/04 read/write memory, may be used as a last-in/first-out storage area for the contents of the program counter, flags, accumulator, and all of the six general purpose registers. A 16-bit stack pointer controls the addressing of this external stack. This stack provides subroutine nesting bounded only by memory size.

Memory Capacity

The iSBC 80/04 contains 256 bytes of read/write memory using the Intel 8155 RAM/IO/Timer. Two sockets for up to 4K bytes of nonvolatile read only memory are provided on the board. Read only memory may be added in 2K-byte increments using Intel 2716 erasable and electrically reprogrammable ROMs (EPROMs). Optionally, if only 2K bytes are required, read only memory may be added in 1K-byte increments using Intel 2708 EPROMs.

Parallel I/O Interface

The iSBC 80/04 contains 22 programmable parallel I/O lines implemented using the I/O ports of the Intel 8155 RAM/IO/Timer. The system software is used to configure the I/O lines in any combination of unidirectional input or output ports as indicated in Table 1. The I/O interface may, therefore, be customized to meet specific peripheral requirements. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators. Hence, the flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. The 22 programmable I/O lines and signal ground lines are brought out to a 50-pin edge connector that mates with flat, woven, or round cable.

Stand-Alone Applications

The iSBC 80/04 is designed to be a cost-effective solution for applications requiring a self-contained computer on a single board without the need for external memory or I/O options. In order to help minimize power supply cost in small systems, the iSBC 80/04 includes provision for an on-board +5V regulator allowing unregulated voltage to be connected directly on the board. Regulated DC voltages are applied to the board through two 12-pin edge connectors which mate with flat, woven, or round cables. The iSBC 80/04 also includes pins that will accept MOLEX-type connectors for connection of regulated DC voltages. Mounting holes are provided in the corners of the iSBC 80/04 board which permit direct attachment to the user's equipment, thereby eliminating the need for card cage and backplane.

Compatibility with iSBC 80/05

The iSBC 80/04 is fully upward compatible with the iSBC 80/05 Single Board Computer. Pin assignments for parallel I/O, serial I/O, and regulated DC voltages are...
Programmable Timer

The iSBC 80/04 provides a fully programmable binary 14-bit interval timer utilizing the Intel 8155 RAM/IO/Timer. The systems designer simply configures the time via software to meet system requirements. Whenever a given timer delay is needed, software commands to the programmable timer select the desired functions. Four functions are available as shown in Table 2. The contents of the timer counter may be read at any time during system operation.

Table 2. Programmable Timer Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programmable pulse</td>
<td>Timer out goes low during the second half of count. Therefore, the count loaded in the count length register should be twice the pulse width desired.</td>
</tr>
<tr>
<td>Square wave rate generator</td>
<td>Timer out remains high until one-half the count has been completed, and goes low for the other half of the count. The count length is automatically reloaded when terminal count is reached.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. A repetitive timer out low pulse is generated and new timeout initiated every time terminal count is reached.</td>
</tr>
<tr>
<td>Programmable strobe</td>
<td>A single low pulse is generated upon reaching terminal count. This function is extremely useful for generation of real-time clocks.</td>
</tr>
</tbody>
</table>

Serial I/O Interface

The iSBC 80/04 provides serial I/O capability through the serial input data (SID) and serial output data (SOD) functions of the Intel 8085A CPU. These functions are controlled exclusively by software through execution of the 8085A RIM and SIM instructions. The baud rate for the serial I/O interface is determined by the system time available for execution of serial I/O support software. Hence, the maximum baud rate supported by the iSBC 80/04 is solely dependent on the overall system real-time software requirements. Serial I/O signals are TTL compatible, and hole patterns are provided on the board for optional installation of RS232C line drivers and receivers.

Interrupt Capability

The iSBC 80/04 takes advantage of the powerful interrupt processing capability of the 8085A CPU. Interrupt requests are routed to four interrupt inputs of the 8085A CPU (i.e., TRAP, RST 7.5, RST 6.5, and RST 5.5 in order of priority, TRAP highest), and each input generates a unique memory address (i.e., TRAP: 2616, RST 7.5: 3C16, RST 6.5: 3416, RST 5.5: 2C16). A single 8085A jump instruction at each of these addresses then provides linkage to locate each interrupt service routine independently anywhere in memory. All interrupt inputs with the exception of one (TRAP) may be masked via software. The trap interrupt should be used for conditions such as power-down sequences which require attention by the 8085A CPU.

Interrupt Generation — The iSBC 80/04 accepts interrupts from four sources. An interrupt is automatically generated by the programmable interval timer/event counter upon completion of the selected function. Two interrupts are automatically generated by the I/O port event section of the 8155 when ports 1 or 2 of the 8155 are programmed to operate in the “latched and strobed” mode (see Table 1). The fourth interrupt source is available to the user and should be used to inform the 8085A CPU of catastrophic errors such as power failure. This user-defined source is connected to the trap input of the 8085A CPU.
Systems Development Capability

The development cycle of the iSBC 80/04-based products may be significantly reduced using an Intellec microcomputer development system. The resident macroassembler, text editor, and system monitor greatly simplify the design, development, and debugging of iSBC 80/04 system software. An optional diskette operating system provides a relocating macroassembler, a relocating loader and linkage editor, and a library manager. A unique in-circuit emulator (ICE-85) option provides the capability of developing and debugging software directly on the iSBC 80/04.

Programming Capability

PL/M-80 — Intel's high level programming language, PL/M, is also available as a resident Intellec microcomputer development system option. PL/M provides the capability to program in a natural, algorithmic language and eliminates the need to manage register usage or allocate memory. PL/M programs can be written in a much shorter time than assembly language programs for a given application.

FORTRAN-80 — For applications requiring computational and formatted I/O capabilities, the high level FORTRAN-80 programming language is also available as a resident option of the Intellec system. The FORTRAN compiler produces relocatable object code that may be easily linked with PL/M or assembly language program modules. This gives the user a wide flexibility in developing software.

SPECIFICATIONS

Word Size

Instruction — 8, 16, or 24 bits
Data — 8 bits

Cycle Time

Basic Instruction Cycle — 2.03 μs, ± 0.1%

Note

Basic instruction cycle is defined as the fastest instruction (i.e., four clock cycles).

Memory Addressing

ROM/EPROM — 0-0FFH
RAM — 3F00H

Memory Capacity

ROM/EPROM — 4K bytes (sockets only)
RAM — 256 bytes

I/O Addressing

On-Board Programming I/O — see Table 1

I/O Capacity

Parallel — 22 programmable lines (see Table 1)

Serial Communications Characteristics

SID and SOD functions of the 8085 CPU are used for serial I/O. Controlled by software through RIM and SIM instructions of the 8085A CPU. Baud rate determined by system time available for serial I/O handling. On-board timer may be used to greatly ease serial I/O timing requirements.

Interrupts

Four-level interrupt routed to 8085 CPU interrupt inputs. Each interrupt automatically vectors the processor to a unique memory location.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Interrupt Input</th>
<th>Memory Address</th>
<th>Priority</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>User-defined</td>
<td>TRAP</td>
<td>3416</td>
<td>Highest</td>
<td>Non-maskable</td>
</tr>
<tr>
<td>Timer</td>
<td>RST 7.5</td>
<td>2416</td>
<td></td>
<td>Maskable</td>
</tr>
<tr>
<td>I/O Port 2</td>
<td>RST 6.5</td>
<td>3416</td>
<td></td>
<td>Maskable</td>
</tr>
<tr>
<td>I/O Port 1</td>
<td>RST 5.5</td>
<td>2C16</td>
<td></td>
<td>Maskable</td>
</tr>
</tbody>
</table>

Timer

Input Frequency Reference — 122.88 kHz ± 0.1% (8.14 μs period nominal)

Output Frequencies/Timing Intervals

<table>
<thead>
<tr>
<th>Function</th>
<th>Timer/Counter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programmable pulse</td>
<td>8.14 μs</td>
</tr>
<tr>
<td>Square wave rate generator</td>
<td>7.50 Hz</td>
</tr>
<tr>
<td>Rate generator</td>
<td>7.50 Hz</td>
</tr>
<tr>
<td>Programmable strobe</td>
<td>8.14 μs</td>
</tr>
</tbody>
</table>

Interfaces

Parallel I/O — All signals TTL compatible
Interrupt Request — All TTL compatible (active-low)
Serial I/O — TTL; hole patterns available for user installation of RS232C line drivers and receivers

System Clock (8085 CPU)

1.966 MHz ± 0.1%
Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (no.)</th>
<th>Center (in.)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5V, +12V, -5V</td>
<td>7</td>
<td>0.156</td>
<td>Molex 09-66-1071</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Connector</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Molex 09-50-7071</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Connector</td>
</tr>
<tr>
<td>+5V, -12V</td>
<td>7</td>
<td>0.166</td>
<td>Molex 09-66-1071</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Connector</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Molex 09-50-7071</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Connector</td>
</tr>
<tr>
<td>Unregulated +5V</td>
<td>2</td>
<td>0.156</td>
<td>Molex 09-66-1021</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Connector</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Molex 09-50-7021</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Connector</td>
</tr>
<tr>
<td>Parallel I/O</td>
<td>50</td>
<td>0.1</td>
<td>3M 3415-000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(flat cable)</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>7</td>
<td>0.156</td>
<td>Molex 09-66-1071</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Connector</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Molex 09-50-7071</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Connector</td>
</tr>
</tbody>
</table>

Notes
1. Connectors and pins from a given vendor may only be used with connectors and pins from the same vendor.
2. A single 86-contact edge-on connector may be used to connect the two groups of regulated voltages (i.e., +5V, +12V, -5V, and +5V, -12V).
3. Required only when RS232C line drivers and receivers are used.

Line Drivers and Terminators

I/O Drivers — The following line drivers are all compatible with the I/O driver sockets on the ISBC 80/04:

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I,OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

Note
I = inverting; NI = non-inverting; OC = open collector.

I/O Terminators — Intel provides 220Ω/330Ω divider and 1 kΩ pull-up resistive terminator packs for termination of I/O lines programmed as inputs. These options are as follows:

RS232C Drivers and Receivers

The following RS232C drivers and receivers are compatible with the RS232C socket on the ISBC 80/04:

- RS232C Driver — National DS1488 or TI SN75188
- RS232C Receiver — National DS1490 or TI SN75189

Sockets

Sockets may be installed in the hole patterns provided for the RS232C drivers and receivers. The following sockets are compatible with the ISBC 80/04: TI C93-14-02 and SCANBE US-2-14-160-N-B.

Compatible Voltage Regulator

- National LM 323 — 3A, 5V Positive Regulator
- Fairchild µA7805 KM — 1A, 5V Positive Regulator

Compatible Heat Sink

- IERC — LA Series or
- AAVID Engineering, Inc. — Series 5051

Physical Characteristics

- Width — 7.85 in. (19.94 cm)
- Height — 6.75 in. (17.15 cm)
- Depth — 0.50 in. (1.27 cm)
- Weight — 8.0 oz (169.9 gm)
iSBC 80/04

Electrical Characteristics

DC Power Requirements

<table>
<thead>
<tr>
<th>Voltage (±5%)</th>
<th>Without PROM¹ (max)</th>
<th>With 2716 EPROM² (max)</th>
<th>With 2708 EPROM³ (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC = +5V</td>
<td>Icc = 600 mA</td>
<td>1.45A</td>
<td>1.25A</td>
</tr>
<tr>
<td>VDD = +12V</td>
<td>IDD = 0</td>
<td>7 mA</td>
<td>137 mA</td>
</tr>
<tr>
<td>VBB = -5V</td>
<td>IBB = 0</td>
<td>0</td>
<td>90 mA</td>
</tr>
<tr>
<td>VAA = -12V</td>
<td>IAA = 0</td>
<td>23 mA</td>
<td>23 mA</td>
</tr>
</tbody>
</table>

Notes
1. Does not include power required for optional EPROM/ROM, I/O drivers, and I/O terminators.
2. With two Intel 2716 EPROMs and 220Q/330Q terminators installed for 22 input ports; all terminator inputs low.
3. With two Intel 2708 EPROMs and 220Q/330Q terminators installed for 22 input ports; all terminator inputs low.
4. Required for 2708 EPROMs.
5. Required only when RS232C capability required.

Environmental Characteristics

Operating Temperature — 0°C to +55°C

Reference Manual

9800482-02 - iSBC 80/04 Hardware Reference Manual (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 80/04</td>
<td>Single Board Computer</td>
</tr>
</tbody>
</table>
iSBC 80/05 (or pSBC 80/05*)
SINGLE BOARD COMPUTER

- 8085A CPU used as central processor
- 512 bytes of static read/write memory
- Sockets for 4K bytes of erasable reprogrammable or masked read only memory
- 22 programmable parallel I/O lines with sockets for interchangeable line drivers and terminators
- Full MULTIBUS control logic allowing up to 16 masters to share system bus
- Programmable 14-bit binary timer
- TTL serial I/O interface with sockets for RS232C line drivers and receivers
- Four-level vectored interrupt
- Fully compatible with optional iSBC expansion boards and peripherals
- Single +5V power supply

The iSBC 80/05 Single Board Computer is a member of Intel's complete line of OEM computer systems which take full advantage of Intel's LSI technology to provide economical, self-contained computer-based solutions for OEM applications. The iSBC 80/05 is a complete computer system on a single 6.75 x 12.00-inch printed circuit card. The CPU, system clock, read/write memory, nonvolatile read only memory, I/O ports and drivers, serial interface, priority interrupt logic, programmable timer, MULTIBUS control logic, and bus expansion buffers all reside on the board.

*Same product, manufactured by Intel Puerto Rico, Inc.
FUNCTIONAL DESCRIPTION

Intel's powerful 8-bit n-channel 8085 CPU, fabricated on a single LSI chip, is the central processor for the ISBC 80/05. The 8085A CPU is directly software compatible with the popular Intel 8080A CPU. The 8085A contains six 8-bit general purpose registers and an accumulator. The six general purpose registers may be addressed individually or in pairs, providing both single and double precision operators. Minimum on-board instruction execution time is 2.03 microseconds. A block diagram of ISBC 80/05 functional components is shown in Figure 1.

Memory Addressing

The 8085A CPU has a 16-bit program counter which allows direct addressing of up to 65,536 bytes of memory. An external stack, located within any portion of read/write memory, may be used as a last-in/first-out storage area for the contents of the program counter, flags, accumulator, and all of the six general purpose registers. A 16-bit stack pointer controls the addressing of this external stack. This stack provides subroutine nesting bounded only by memory size.

Memory Capacity

The ISBC 80/05 contains 512 bytes of read/write memory using Intel's low power static RAMs. Two sockets for up to 4K bytes of nonvolatile read only memory are provided on the board. Read only memory may be added in 2K-byte increments using Intel 2716 erasable and electrically reprogrammable ROMs (EPROMs). Optionally, if only 2K bytes are required, read only memory may be added in 1K-byte increments using Intel 2708 EPROMs.

Parallel I/O Interface

The ISBC 80/05 contains 22 programmable parallel I/O lines implemented using the I/O ports of the Intel 8155 RAM/I0/Timer. The system software is used to figure the I/O lines in any combination of unidirectional input or output ports as indicated in Table 1. The I/O interface may, therefore, be customized to meet specific peripheral requirements. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminations. Hence the flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. The 22 programmable I/O lines and signal ground lines are brought out to a 40-pin edge connector that mates with flat, woven, or round cable.

Multimaster Capability

The ISBC 8085A is a full computer on a single board with resources capable of supporting a great variety of OEM system requirements. For those applications requiring additional processing capacity and the benefits of multiprocessing (i.e., several CPUs and/or controllers logically share systems tasks with communication over the system bus), the ISBC 80/05 provides full MULTIBUS arbitration control logic. This control logic allows up to three bus masters (i.e., any combination of ISBC 80/05, ISBC 80/20-4, DMA controller, diskette controller, etc.) to share the system bus in serial (daisy-chain) priority fashion, and up to 16 masters may share the MULTIBUS with the addition of an external priority network. The MULTIBUS arbitration logic operates synchronously with a MULTIBUS clock (provided by the ISBC 80/05 or optionally connected directly to the MULTIBUS clock) while data is transferred via a handshake between the master and slave modules. This allows different speed controllers to share resources on the same bus, and for transfers via the bus to proceed asynchronously. Thus, transfer speed is dependent on transmitting and receiving devices only. This design prevents slow master modules from being handicapped in their attempts to

Figure 1. ISBC 80/05 Block Diagram Showing Functional Components
Table 1. Input/Output Modes of Operation

| Port | Lines (qty) | Mode of Operation | Unidirectional | | | | | Input | Output | Control |
|------|-------------|-------------------|----------------|---|---|---|---|---|---|---|---|
| 1    | 8           |                   | Unlatched       | X | X | X | X |
| 2    | 8           |                   | Unlatched       | X | X | X | X |
| 3    | 3           |                   | Latched &       | X | X | X | X |
| 4    | 3           |                   | Latched &       | X | X | X | X |

Notes
1. Port 3 must be used as a control port when port 1 is used as a latched and strobed input or a latched and strobed output port.
2. Port 4 must be used as a control port when port 2 is used as a latched and strobed input or a latched and strobed output port.

Programmable Timer
The iSSC 80/05 provides a fully programmable binary 14-bit interval timer utilizing the Intel 8155 RAM/IO Timer. The system designer simply configures the timer via software to meet system requirements. Whenever a given time delay is needed, software commands to the programmable timer select the desired function. Four functions are available as shown in Table 2. The contents of the timer counter may be read at any time during system operation.

Serial I/O Interface
The iSSC 80/05 provides serial I/O capability through the serial input data (SID) and serial output data (SOD) functions of the Intel 8085A CPU. These functions are controlled exclusively by software through execution of the 8085A RIM and SIM instructions. The baud rate for the serial I/O interface is determined by the system time available for execution of serial I/O support software. Hence, the maximum baud rate supported by the iSSC 80/05 is solely dependent on the overall system real-time software requirements. Serial I/O signals are TTL compatible and sockets are provided on the board for optional connection of RS232C line drivers and receivers.

Interrupt Capability
The iSSC 80/05 takes advantage of the powerful interrupt processing capability of the 8085A CPU. Interrupt requests are routed to the four interrupt inputs of the 8085A CPU (i.e., TRAP, RST 7.5, RST 6.5, and RST 5.5 in order of priority, TRAP highest), and each input generates a unique memory address (i.e., TRAP: $24_{16}$, RST 7.5: $3C_{16}$, RST 6.5: $34_{16}$, RST 5.5: $2C_{16}$). A single 8085A jump instruction at each of these addresses then provides linkage to locate each interrupt service routine independently anywhere in memory. All interrupt inputs with the exception of one (TRAP) may be masked via software. The trap interrupt should be used for conditions such as power-down sequences which require immediate attention by the 8085A CPU.

Expansion Capabilities
Memory and I/O capacity may be expanded and additional functions added using Intel MULTIBUS compatible expansion boards. High speed integer and floating-point arithmetic capabilities may be added by using the iSSC 310A High Speed Mathematics Unit. Memory may be expanded to 65,536 bytes by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capacity may be increased by adding digital I/O and analog I/O expansion boards. Mass storage capability may be achieved by adding...
single or double density diskette controllers as sub-systems. Modular expandable backplanes and card cages are available to support multiboard systems.

Systems Development Capability
The development cycle of iSBC 80/05-based products may be significantly reduced using an Intellec microcomputer development system. The resident macro-assembler, text editor, and system monitor greatly simplify the design, development, and debug of iSBC 80/05 system software. An optional diskette operating system provides a relocating macroassembler, a relocating loader and linkage editor, and a library manager.

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Instruction — 8, 16, or 24 bits
Data — 8 bits

Cycle Time
Basic Instruction Cycle — 2.03 μs, ± 0.1%

Note
Basic instruction cycle is defined as the fastest instruction (i.e., four clock cycles).

Memory Addressing
ROM/EPROM — 0-0FFFH
RAM — 3E00H

Memory Capacity
On-Board ROM/EPROM — 4K bytes (with Intel 2716) or 2K bytes (with Intel 2708)
On-Board RAM — 512 bytes
Off-Board Expansion — Up to 65,536 bytes in user specified combination of RAM, ROM, and PROM

I/O Addressing
On-Board Programmable I/O — see Table 1

<table>
<thead>
<tr>
<th>Port Control</th>
<th>8155 Port 1</th>
<th>8155 Port 2</th>
<th>8155 Ports 3 &amp; 4</th>
<th>8155 Port</th>
<th>8155 Timer Low-Order Byte</th>
<th>8155 Timer High-Order Byte</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>00</td>
<td>01</td>
<td>02</td>
<td>03</td>
<td>04</td>
<td>05</td>
</tr>
</tbody>
</table>

I/O Capacity
Parallel — 22 programmable lines (see Table 1)

Note
The iSBC 80/05 may be expanded to 1102 programmable input/output lines by using optional iSBC 80 I/O boards.

Serial Communications Characteristics
SID and SOD functions of the 8085A CPU are used for serial I/O. They are controlled by software through RIM and SIM instructions of the 8085A CPU. Baud rate is determined by system time available for serial I/O handling. On-board timer may be used to greatly ease serial I/O timing requirements.

Interrupts
Four-level interrupt routed to 8085A CPU interrupt inputs. Each interrupt automatically vectors the processor to a unique memory location.

<table>
<thead>
<tr>
<th>Interrupt</th>
<th>Memory Address</th>
<th>Priority</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAP</td>
<td>2416</td>
<td>Highest</td>
<td>Non-maskable</td>
</tr>
<tr>
<td>RST 7.5</td>
<td>3616</td>
<td></td>
<td>Maskable</td>
</tr>
<tr>
<td>RST 6.5</td>
<td>3416</td>
<td></td>
<td>Maskable</td>
</tr>
<tr>
<td>RST 5.5</td>
<td>2C16</td>
<td>Lowest</td>
<td>Maskable</td>
</tr>
</tbody>
</table>

Timer
Input Frequency Reference — 122.88 kHz ± 0.1% (8.14 μs period nominal)

Output Frequencies/Timing Intervals

<table>
<thead>
<tr>
<th>Function</th>
<th>Timer/Counter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programmable pulse</td>
<td>8.14 μs</td>
</tr>
<tr>
<td>Square wave rate generator</td>
<td>7.50 Hz</td>
</tr>
<tr>
<td>Rate generator</td>
<td>7.50 Hz</td>
</tr>
<tr>
<td>Programmable strobe</td>
<td>8.14 μs</td>
</tr>
</tbody>
</table>

Interfaces
Bus — All signals TTL compatible
Parallel I/O — All signals TTL compatible
Interrupt Request — All TTL compatible (active-low)
Serial I/O — TTL; sockets available for RS232C line drivers and receivers

System Clock (8085A CPU)
1.966 MHz ± 0.1%
iSBC 80/05

RS232C Drivers and Receivers
The following RS232C drivers and receivers are compatible with the RS232C socket on the iSBC 80/05:
RS232C Driver — National DS1488 or TI SN75188
RS232C Receiver — National DS1490 or TI SN75189

Physical Characteristics
Width — 12.00 in. (30.49 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 12.0 oz (339.8 gm)

Electrical Characteristics
DC Power Requirements

<table>
<thead>
<tr>
<th>Voltage (± 5%)</th>
<th>Without PROM1</th>
<th>With 2716 EPROM2</th>
<th>With 8708 EPROM3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(max)</td>
<td>(max)</td>
<td>(max)</td>
</tr>
<tr>
<td>VCC = +5V</td>
<td>ICC = 1.80 mA</td>
<td>2.65A</td>
<td>2.45A</td>
</tr>
<tr>
<td>VDD = +12V</td>
<td>IDD = 0</td>
<td>7 mA</td>
<td>137 mA</td>
</tr>
<tr>
<td>VBB = -5V</td>
<td>IBB = 0</td>
<td>0</td>
<td>90 mA</td>
</tr>
<tr>
<td>VAA = -12V</td>
<td>IAA = 0</td>
<td>23 mA</td>
<td>23 mA</td>
</tr>
</tbody>
</table>

Notes
1. Does not include power required for optional EPROM/ROM, I/O drivers, and I/O terminators.
2. With two Intel 2716 EPROMs and 220Ω/330Ω terminators installed for 22 input ports; all terminator inputs low.
3. With two Intel 2708 EPROMs and 220Ω/330Ω terminators installed for 22 input ports; all terminator inputs low.
4. Required for 2708 EPROMs.
5. Required only when RS232C capability required.

Environmental Characteristics
Operating Temperature — 0°C to +55°C.

Reference Manual
9800483D — iSBC 80/05 Hardware Reference Manual (NOT SUPPLIED)
Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.
iSBC™ 80/10B (or pSBC 80/10B*)
SINGLE BOARD COMPUTER

- Upward compatible with iSBC™ 80/10A Single Board Computer
- 8080A CPU used as central processing unit
- One iSBX™ bus connector for iSBX™ MULTIMODULE™ board expansion
- 1K byte of read/write memory with sockets for expansion up to 4K bytes
- Sockets for up to 16K bytes of read only memory
- 48 programmable parallel I/O lines with sockets for interchangeable line drivers and terminators
- Programmable synchronous/asynchronous communications interface with selectable RS232C or teletypewriter compatibility
- Single level interrupt with 11 interrupt sources
- Auxiliary power bus and power-fail interrupt control logic for RAM battery backup
- 1.04 millisecond interval timer
- Limited master MULTIBUS® interface

The Intel® iSBC 80/10B board is a member of Intel's complete line of OEM microcomputer systems which take full advantage of Intel's LSI technology to provide economical, self-contained computer-based solutions for OEM applications. The iSBC 80/10B board is a complete computer system on a single 6.75 x 12.00-inch printed circuit card. The CPU, system clock, iSBX bus interface, read/write memory, read only memory sockets, I/O ports and drivers, serial communications interface, bus control logic, and drivers all reside on the board.

*Same product, manufactured by Intel Puerto Rico, Inc.*
**FUNCTIONAL DESCRIPTION**

Intel's powerful 8-bit n-channel MOS 8080A CPU, fabricated on a single LSI chip, is the central processor for the iSBC 80/10B board. The 8080A contains six 8-bit general purpose registers and an accumulator. The six general purpose registers may be addressed individually or in pairs, providing both single and double precision operators. A block diagram of iSBC 80/10B board functional components is shown in Figure 1.

**iSBX Bus MULTIMODULE Board Expansion**

The new iSBX bus interface brings an entirely new dimension to system design offering incremental on-board expansion with small iSBX boards. One iSBX bus connector interface is provided to accomplish plug-in expansion with any iSBX MULTIMODULE board. iSBX boards are available to provide expansion equivalent to the I/O available on the iSBC 80/10B board or the user may configure entirely new functionality such as math directly on-board. The iSBX 350 programmable I/O MULTIMODULE board provides 24 I/O lines using an 8255A programmable peripheral interface. Therefore, the iSBX 350 module together with the iSBC 80/10B board may offer 72 lines of programmable I/O. Alternately, a serial port may be added using the iSBX 351 serial I/O multimodule board or math may be configured on-board with the iSBX 332 floating point math MULTIMODULE board.

---

**Figure 1. iSBC™ 80/10B Single Board Computer Block Diagram**
The iSBX board is a logical extension of the onboard programmable I/O and is accessed by the iSBC 80/10B single board computer as common I/O port locations. The iSBX board is coupled directly to the 8080A CPU and therefore becomes an integral element of the iSBC 80/10B single board computer providing optimum performance.

Memory Addressing
The 8080A has a 16-bit program counter which allows direct addressing of up to 64K bytes of memory. An external stack, located within any portion of read/write memory, may be used as a last-in/first-out storage area for the contents of the program counter, flags, accumulator, and all of the six general purpose registers. A 16-bit stack pointer controls the addressing of this external stack. This stack provides subroutine nesting bounded only by memory size.

Memory Capacity
The iSBC 80/10B board contains 1K bytes of read/write static memory. In addition, sockets for up to 4K bytes of RAM memory are provided on board. Read/write memory may be added in 1K byte increments using two 1K x 4 Intel 2114A-5 static RAMs. All on-board RAM read and write operations are performed at maximum processor speed. Sockets for up to 16K bytes of nonvolatile read-only-memory are provided on the board. Read-only-memory may be added in 1K byte increments up to 4K bytes (using Intel 2708 or 2758); in 2K byte increments up to 8K bytes (using Intel 2716); or in 4K byte increments up to 16K bytes (using Intel 2732). All on-board ROM or EPROM read operations are performed at maximum processor speed.

Parallel I/O Interface
The iSBC 80/10B board contains 48 programmable parallel I/O lines implemented using two Intel 8255A programmable peripheral interfaces. The system software is used to configure the I/O lines in any combination of unidirectional input/output, and bidirectional ports indicated in Table 1. Therefore, the I/O interface may be customized to meet specific peripheral requirements. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators. Hence, the flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. The 48 programmable I/O lines and signal ground lines are brought out to two 50-pin edge connectors that mate with flat cable or round cable.

Serial I/O Interface
A programmable communications interface using the Intel® 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) is contained on the board. A jumper selectable baud rate

Table 1. Input/Output Port Modes of Operation

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unidirectional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unlatched</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>X</td>
</tr>
</tbody>
</table>

Notes
Port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
generator provides the USART with all common communications frequencies. The USART can be programmed by the system software to select the desired synchronous or asynchronous serial data transmission technique (including IBM Bi-Sync). The mode of operation (i.e., synchronous or asynchronous), data format, control character format and parity are all under program control. The 8251A provides full duplex, double-buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the USART. The inclusion of jumper selectable TTY or RS232C compatible interfaces on the board, in conjunction with the USART, provides a direct interface to teletypes, CRTs, RS232C compatible cassettes, and asynchronous and synchronous modems. The RS232C or TTY command lines, serial data lines, and signal ground lines are brought out to a 26-pin edge connector that mates with RS232C compatible flat or round cable.

**Interrupt Capability**

Interrupt requests may originate from 11 sources. Two jumper selectable interrupt requests can be automatically generated by the programmable peripheral interface when a byte of information is ready to be transferred to the CPU (i.e., input buffer is full) or a byte of information has been transferred to a peripheral device (i.e., output buffer is empty). Three jumper selectable interrupt requests can be automatically generated by the USART when a character is ready to be transferred to the CPU (i.e., receive channel buffer is full), a character is ready to be transmitted (i.e., the USART is ready to accept a character from the CPU), or when the transmitter is empty (i.e., the USART has no character to transmit). These five interrupt request lines are all maskable under program control. Two interrupt request lines may be interfaced directly to user designated peripheral devices; one via the MULTIBUS system bus and the other via the I/O edge connector. One jumper selectable interrupt request may be interfaced to the power-fail interrupt control logic. One jumper selectable interrupt request may originated from the interval timer. Two general purpose interrupt requests are jumper selectable from the iSBX interface. These two signals permit a user installed MULTIMODULE board to interrupt the 8080A CPU. The eleven interrupt request lines share a single CPU interrupt level. When an interrupt request is recognized, a restart instruction (RESTART 7) is generated. The processor responds by suspending program execution and executing a user defined interrupt service routine originating at location 38_{16}.

**Power-Fail Control**

A power-fail interrupt may be detected through the AC-low signal generated by the power supply. This signal may be configured to interrupt the 8080A CPU to initiate an orderly power down instruction sequence.

**Interval Timer**

A 1.04 millisecond timer is available for interval interrupts or as a clock output to the parallel I/O connector. The timer output is jumper selectable to the programmable parallel interface, the parallel I/O connector (J1), or directly to the 8080A CPU.

**MULTIBUS® System Expansion Capabilities**

Memory and I/O capacity may be expanded and additional functions added using Intel MULTIBUS™ system compatible expansion boards. Memory may be expanded to 65,536 bytes by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capacity may be increased by adding digital I/O and analog I/O expansion boards. In addition, the iSBC 80/10B board performs as a limited bus master in that it must occupy the lowest priority when used with other MULTIBUS masters. The bus master may take control of the MULTIBUS system bus by halting the iSBC 80/10B board program execution. Mass storage capability may be achieved by adding single density diskette, double density diskette, or hard disk controllers. Modular expandable backplanes and cardcages are available to support multiboard systems.

**Real-Time Software**

The iRMX 80 executive, which contains all major real-time facilities including priority-based system resource allocation, intertask communication and control, interrupt driven control for standard I/O devices, and interrupt handling, occupies 2K bytes of memory which can be stored on-board in EPROM. Optional linkable and relocatable modules for console control (CRT or TTY), disk file system, and analog subsystems are provided with the iRMX 80 package. User configurability is aided on the Intel iRMX microcomputer development system by the Interactive Configuration Utility program provided with the iRMX 80 package.

**System Development Capability**

The development cycle of iSBC 80/10B-based products may be significantly reduced using Intel's system development tools available today. The
Intellec Series II family of compatible microcomputer development systems provides a range of capability from a low cost disk-based edit debug workstation to a high performance, fully compatible hard-disk-based software development system. Also, a unique in-circuit emulator (ICE-80) option provides the capability of developing and debugging software directly on the iSBC 80/10B board.

**Programming Capability**

**PL/M-80** — Intel's high level programming language, PL/M, is also available as a resident Intellec microcomputer development system option. PL/M provides the capability to program in a natural, algorithmic language and eliminates the need to manage register usage or allocate memory. PL/M programs can be written in a much shorter time than assembly language programs for a given application.

**FORTRAN-80** — For applications requiring computational and formatted I/O capabilities, the ANSI 77 standard high level FORTRAN-80 programming language is available as a resident option of the Intellec system. The FORTRAN compiler produces relocatable object code that may be easily linked with PL/M or assembly language program modules. In addition, the iSBC 801 FORTRAN-80 run-time package is a complete, ready-to-use set of linkable object modules which are fully compatible with iRMX 80 systems. The modules, when combined with the FORTRAN-80 coded application, provide the appropriate interfaces to the disk file and terminal I/O of iRMX 80, and to the iSBC 310A Math Unit for applications requiring high speed math.

**BASIC-80** — A high level language interpreter is available with extended disk capabilities which operates under the iRMX 80 Real-Time Multitasking Executive and translates BASIC-80 source programs into an internally executable form. This language interpreter, provided as a set of linkable object modules, is ideally suited to the OEM who requires a pass through programming language. The BASIC-80 programs may be created, stored, and interpreted on the iSBC 80 based systems using the iSBC 802 BASIC-80 Configurable iRMX 80 Disk-Based Interpreter. The iSBC 802 Interpreter has a complete ready-to-use set of linkable object modules which are fully compatible with Intel's iRMX 80 Real-Time Multitasking Executive Software. The modules provide interfaces to disk file and terminal I/O, software floating point, or interface to other routines provided by the user.

---

**SPECIFICATIONS**

**Word Size**
- Instruction — 8, 16, or 24 bits
- Data — 8 bits

**Cycle Time**
- Basic Instruction Cycle — 1.95 μsec

**Memory Addressing**

**On-Board ROM/EPROM**
- 0-0FF using 2708, 2758
- 0-1FF using 2716
- 0-3FF using 2732

**On-Board RAM**
- 3C00-3FFF with no RAM expansion
- 3000-3FFF with 2114A-5 expansion

**On-Board RAM**
- 1K byte with user expansion in 1K increments to 4K bytes using Intel 2114A-5 RAMs

**Off-Board Expansion**
- Up to 64K bytes using user specified combinations of RAM, ROM, and EPROM.

**I/O Addressing**

**On-Board Programmable I/O**

<table>
<thead>
<tr>
<th>Device</th>
<th>I/O Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>8255A No. 1</td>
<td>E4</td>
</tr>
<tr>
<td>Port A</td>
<td>E5</td>
</tr>
<tr>
<td>Port B</td>
<td>E6</td>
</tr>
<tr>
<td>Port C</td>
<td>E7</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>8255A No. 2</td>
<td>EB</td>
</tr>
<tr>
<td>Port A</td>
<td>EA</td>
</tr>
<tr>
<td>Port B</td>
<td>EB</td>
</tr>
<tr>
<td>Port C</td>
<td>ED</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>8251A</td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>EC</td>
</tr>
<tr>
<td>Control</td>
<td>ED</td>
</tr>
<tr>
<td>ISBO Multimodule</td>
<td></td>
</tr>
<tr>
<td>MCS0</td>
<td>F0-F7</td>
</tr>
<tr>
<td>MCS1</td>
<td>F8-FF</td>
</tr>
</tbody>
</table>

---

1K byte with user expansion in 1K increments to 4K bytes using Intel 2114A-5 RAMs

On-Board RAM

Off-Board Expansion

Up to 64K bytes using user specified combinations of RAM, ROM, and EPROM.

I/O Addressing

On-Board Programmable I/O

---

2-16

AFN-01688A
I/O Capacity
Parallel — 48 programmable lines
Serial — 1 transmit, 1 receive
MULTIMODULE — 1 iSBX Bus MULTIMODULE Board

Serial Baud Rates

<table>
<thead>
<tr>
<th>Frequency (kHz) (Jumper Selectable)</th>
<th>Baud Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Synchronous</td>
</tr>
<tr>
<td>307.2</td>
<td>19200</td>
</tr>
<tr>
<td>153.6</td>
<td>9600</td>
</tr>
<tr>
<td>76.8</td>
<td>4800</td>
</tr>
<tr>
<td>38.4</td>
<td>2400</td>
</tr>
<tr>
<td>19.2</td>
<td>1200</td>
</tr>
<tr>
<td>9.6</td>
<td>600</td>
</tr>
<tr>
<td>6.98</td>
<td>300</td>
</tr>
</tbody>
</table>

Serial Communications Characteristics
Synchronous — 5-8 bit characters; internal or external character synchronization; automatic sync insertion
Asynchronous — 5-8 bit characters; break character generation; 1, 1½, or 2 stop bits; false start bit detectors

Interrupts
Single-level with on-board logic that automatically vectors the processor to location 38H using a restart instruction (RESTART7). Interrupt requests may originate from user specified I/O (2); the programmable peripheral interface (2); the iSBX MULTIMODULE board (2); the programmable communications interface (3); the power fail interrupt (1); or the interval timer (1).

Electrical Characteristics
DC Power Requirements

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Without EPROM 1</th>
<th>With 2708 EPROM 2</th>
<th>With 2758, 2716, or 2732 EPROM 3</th>
<th>Power Down Requirements (RAM and Support Circuit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vcc</td>
<td>±5V ±5%</td>
<td>Icc = 2.0A</td>
<td>3.1 A</td>
<td>84 mA ± 140 mA/K (2114A-5)</td>
</tr>
<tr>
<td>VDD</td>
<td>+12V ±5%</td>
<td>Idd = 150 mA</td>
<td>400 mA</td>
<td>Not Required</td>
</tr>
<tr>
<td>VAB</td>
<td>−5V ±5%</td>
<td>Iab = 2 mA</td>
<td>200 mA</td>
<td>Not Required</td>
</tr>
<tr>
<td>VAA</td>
<td>−12V ±5%</td>
<td>Iaa = 175 mA</td>
<td>175 mA</td>
<td>Not Required</td>
</tr>
</tbody>
</table>

NOTES:
1. Does not include power required for optional ROM/EPROM, I/O drivers, or I/O terminators.
2. With four Intel 2708 EPROMs and 220Ω/330Ω for terminators, installed for 48 input lines. All terminator inputs low.
3. Same as #2 except with four 2758s, 2716s, or 2732s installed.
4. Icc shown without RAM supply current. For 2114A-5 add 140 mA per K byte to a maximum of 560 mA.
Line Drivers and Terminators

I/O Drivers — The following line drivers and terminators are all compatible with the I/O driver sockets on the iSBC 80/10B Board:

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I,OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

Note
I - inverting, NI - non-inverting, OC - open collector.

Port 1 has 25 nA totem pole drivers and 1 kΩ terminators.

I/O Terminators — 220Ω/330Ω divider or 1 kΩ pull up.

MULTIBUS Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-State</td>
<td>25</td>
</tr>
<tr>
<td>Address</td>
<td>Tri-State</td>
<td>25</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-State</td>
<td>25</td>
</tr>
</tbody>
</table>

Environmental Characteristics

Operating Temperature — 0°C to 55°C

Equipment Supplied

iSBC 80/10B Single Board Computer
iSBC 80/10B Schematics

Reference Manual


Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 80/10B</td>
<td>Single Board Computer</td>
</tr>
</tbody>
</table>
The iSBC 80/20-4 Single Board Computer is a member of Intel's complete line of OEM computer systems which take full advantage of Intel's LSI technology to provide economical, self-contained computer-based solutions for OEM applications. Each iSBC 80/20-4 is a complete computer system on a single 6.75 x 12.00-inch printed circuit card. The CPU, system clock, read/write memory, nonvolatile read only memory, I/O ports and drivers, serial communications interface, priority interrupt logic, two programmable timers, MULTIBUS control logic, and bus expansion drivers all reside on each board.
FUNCTIONAL DESCRIPTION

Intel's powerful 8-bit n-channel MOS 8080A CPU, fabricated on a single LSI chip, is the central processor for the iSBC 80/20-4. The 8080A contains six 8-bit general purpose registers and an accumulator. The six general purpose registers may be addressed individually or in pairs, providing both single and double precision operations. Minimum instruction execution time is 1.86 microseconds. A block diagram of iSBC 80/20-4 functional components is shown in Figure 1.

Memory Addressing

The 8080A has a 16-bit program counter which allows direct addressing of up to 65,536 bytes of memory. An external stack, located within any portion of read/write memory, may be used as a last-in/first-out storage area for the contents of the program counter, flags, accumulator, and all of the six general purpose registers. A 16-bit stack pointer controls the addressing of this external stack. This stack provides subroutine nesting bounded only by memory size.

Memory Capacity

The iSBC 80/20-4 contains 4K bytes of static read/write memory using Intel low power static RAMs. All on-board RAM read and write operations are performed at maximum processor speed. Power for on-board RAM memory is provided on an auxiliary power bus, and memory protect logic is included for battery backup RAM requirements. Sockets for up to 8K bytes of nonvolatile read only memory are provided on the board. Read only memory may be added in 1K-byte increments using Intel 2708 erasable and electrically reprogrammable ROMs (EPROMs), or read only memory may be added in 2K-byte increments using Intel 2716 EPROMs. All on-board ROM read operations are performed at maximum processor speed.

Parallel I/O Interface

The iSBC 80/20-4 contains 48 programmable parallel I/O lines implemented using two Intel 8255 programmable peripheral interfaces. The system software is used to configure the I/O lines in any combination of the unidirectional input/output, and bidirectional ports indicated in Table 1. Therefore, the I/O interface may be customized to meet specified peripheral requirements. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators. Hence, the flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. The 48 programmable I/O lines and signal ground lines are brought out to two 50-pin edge connectors that mate with flat, woven, or round cable.

Serial I/O Interface

A programmable communications interface using Intel's 8251 Universal Synchronous/Asynchronous Receiver/Transmitter (USART) is contained on the iSBC
80/20-4 board. A software selectable baud rate generator provides the USART with all common communications frequencies. The USART can be programmed by the system software to select the desired asynchronous or synchronous serial data transmission technique (including IBM Bi-Sync). The mode of operation (i.e., synchronous or asynchronous), data format, control character parity, and baud rate are all under program control. The 8251 provides full duplex, double-buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the USART. The RS232C compatible interface on each board, in conjunction with the USART, provides a direct interface to RS232C compatible terminals, cassettes, and asynchronous and synchronous modems. The RS232C command lines, serial data lines, and signal ground line are brought out to a 26-pin edge connector that mates with RS232C compatible flat or round cable.

**Multimaster Capability**

The iSBC 80/20-4 is a full computer on a single board with resources capable of supporting the majority of OEM system requirements. For those applications requiring additional processing capacity and the benefits of multiprocessing (i.e., several CPUs and/or controllers logically share system tasks with communication over the system bus), the iSBC 80/20-4 provides full MULTIBUS arbitration control logic. This control logic allows up to three iSBC 80/20-4 or high speed controllers to share the system bus in serial (daisy chain) priority fashion, and up to 16 masters may share the system bus with the addition of an external priority network. Once bus control is attained, a bus bandwidth of up to 5M bytes/sec may be achieved.

The bus controller provides its own clock which is derived independently from the processor clock. This allows different speed controllers to share resources on the same bus, and transfers via the bus proceed asynchronously. Thus, transfer speed is dependent on transmitting and receiving devices only. This design prevents slow master modules from being handicapped in their attempts to gain control of the bus, but does not restrict the speed at which faster modules can transfer data via the same bus. Once a bus request is granted, single or multiple read/write transfers can proceed at a maximum rate of 5 million data words per second. The most obvious applications for the master-slave capabilities of the bus are multiprocessor configurations, high speed direct-memory-access (DMA) operations and high speed peripheral control, but are by no means limited to these three.

**Programmable Timers**

The iSBC 80/20-4 board provides three fully programmable and independent BCD and binary 16-bit interval timers/event counters utilizing an Intel 8253 Programmable Interval Timer. Two of these timers/counters are available to the systems designer to generate accurate time intervals under software control. Routing of these counters is jumper selectable. Each may be independently routed to the programmable interrupt controller, the I/O line drivers and terminators, or outputs from the 8255 programmable peripheral interfaces. The third interval timer in the 8253 provides the programmable baud

### Table 1. Input/Output Port Modes of Operation

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode of Operation</th>
<th>Bidirectional</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unidirectional</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Unlatched</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Latched &amp; Strobed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Latched</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Latched &amp; Strobed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes**

1. Part of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.

2. Part of port 6 must be used as a control port when either port 4 or port 5 are used as a latched and strobed input or a latched and strobed output port or port 4 is used as a bidirectional port.
rate generator for the iSBC 80/20-4 RS232C USART serial port. In utilizing the iSBC 80/20-4, the systems designer simply configures, via software, each timer independently to meet system requirements. Whenever a given time delay or count is needed, software commands to the programmable timers/event counters select the desired function. Seven functions are available, as shown in Table 2. The contents of each counter may be read at any time during system operation with simple read operations for event counting applications, and special commands are included so that the contents of each counter can be used "on the fly".

Table 2. Programmable Timer Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal count</td>
<td>When terminal count is reached, an interrupt request is generated. This function is extremely useful for generation of real-time clocks.</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>Output goes low upon receipt of an external trigger edge or software command and returns high when terminal count is reached. This function is retriggerable.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle, and the period from one low-going pulse to the next is N times the input clock period.</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>Output will remain high until one half of the count has been completed, and go low for the other half of the count.</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>Output remains high until software loads count (N). N counts after count is loaded, output goes low for one input clock period.</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>Output goes low for one clock period N counts after rising edge on counter trigger input. The counter is retriggerable.</td>
</tr>
<tr>
<td>Event counter</td>
<td>On a jumper selectable basis, the clock input becomes an input from the external system. CPU may read the number of events occurring after the counting &quot;window&quot; has been enabled or an interrupt may be generated after N events occur in the system.</td>
</tr>
</tbody>
</table>

Interrupt Capability

Operation and Priority Assignments — An Intel 8259 Programmable Interrupt Controller (PIC) provides vectoring for eight interrupt levels. As shown in Table 3, a selection of four priority processing modes is available to the systems designer so that the manner in which requests are processed may be configured to match system requirements. Operating mode and priority assignments may be reconfigured dynamically via software at any time during system operation. The PIC accepts interrupt requests from the programmable parallel and serial I/O interfaces, the programmable timers, the system bus, or directly from peripheral equipment. The PIC then determines which of the incoming requests is of the highest priority, determines whether this request is of higher priority than the level currently being serviced, and if appropriate, issues an interrupt to the CPU. Any combination of interrupt levels may be masked through storage via software, of a single byte to the interrupt register of the PIC.

Table 3. Programmable Interrupt Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully nested</td>
<td>Interrupt request line priorities fixed at 0 as highest, 7 as lowest.</td>
</tr>
<tr>
<td>Auto-rotating</td>
<td>Equal priority. Each level, after receiving service, becomes the lowest priority level until the next interrupt occurs.</td>
</tr>
<tr>
<td>Specific priority</td>
<td>System software assigns lowest priority level. Priority of all other levels based in sequence numerically on this assignment.</td>
</tr>
<tr>
<td>Polled</td>
<td>System software examines priority-encoded system interrupt status via interrupt status register.</td>
</tr>
</tbody>
</table>

Interrupt Addressing — The PIC generates a unique memory address for each interrupt level. These addresses are equally spaced at intervals of 4 or 8 (software selectable) bytes. This 32- or 64-byte block may be located to begin at any 32- or 64-byte boundary in the 65,536-byte memory space. A single 8080 jump instruction at each of these addresses then provides linkage to locate each interrupt service routine independently anywhere in memory.

Interrupt Request Generation — Interrupt requests may originate from 26 sources. Four jumper selectable interrupt requests can be automatically generated by the programmable peripheral interface when a byte of information is ready to be transferred to the CPU (i.e., input buffer is full) or a byte of information has been transferred to a peripheral device (i.e., output buffer is empty). Two jumper selectable interrupt requests can be automatically generated by the USART when a character is ready to be transfer to the CPU (i.e., receive channel buffer is full), or a character is ready to be transmitted (i.e., transmit channel data buffer is empty). A jumper selectable request can be generated by each of the programmable timers. Nine additional interrupt request lines are available to the user for direct interface to user designated peripheral devices via the system bus, and eight interrupt request lines may be jumper routed directly from peripherals via the parallel I/O driver/terminator section.

Power-Fail Control — Control logic is also included for generation of a power-fail interrupt which works in conjunction with the AC-low signal from iSBC 635 Power Supply or equivalent.
Expansion Capabilities

Memory and I/O capacity may be expanded and additional functions added using Intel MULTIBUS compatible expansion boards. High speed integer and floating-point arithmetic capabilities may be added by using the iSBC 310A High Speed Mathematics Unit. Memory may be expanded to 65,536 bytes by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capacity may be increased by adding digital I/O and analog I/O expansion boards. Mass storage capability may be achieved by adding single or double density diskette controllers as subsystems. Modular expandable backplanes and cardcages are available to support multiboard systems.

Real-Time Software

The iSBC 80/20-4 is totally compatible with Intel’s iRMX 80 Real-Time Multi-Tasking Executive. iSBC 80/20-4 based user programs (tasks) can take advantage of the iRMX 80 executive to do all necessary scheduling, inter-task communication, and memory space allocation. iRMX 80 also provides standard I/O support software such as disk file handling, Intel analog board handling, and terminal handling.

System Development Capability

The development cycle of iSBC 80/20-4 based products may be significantly reduced using an Intellic microcomputer development system. The resident macroassembler, text editor, and system monitor greatly simplify the design, development, and debug of iSBC 80/20-4 system software. An optional diskette operating system provides a relocating macroassembler, a relocating loader and linkage editor, and a library manager. A unique in-circuit emulator (ICE-80) option provides the capability of developing and debugging software directly on the iSBC 80/20-4 single board computer.

Programming Capability

PL/M-80 — Intel's high level programming language, PL/M, is also available as a resident Intellic microcomputer development system option. PL/M provides the capability to program in a natural, algorithmic language and eliminates the need to manage register usage or allocate memory. PL/M programs can be written in a much shorter time than assembly language programs for a given application.

FORTRAN-80 — For applications requiring computational and formatted I/O capabilities, the high level FORTRAN-80 programming language is also available as a resident option of the Intellic system. The FORTRAN compiler produces relocatable object code that may be easily linked with PL/M or assembly language program modules. This gives the user a wide flexibility in developing software.

BASIC-80 — A high level language interpreter with extended disk capabilities which operates under the RMX/80 Real-Time Multi-Tasking Executive and translates BASIC-80 source programs into an internally executable form. This language interpreter, provided as a set of linkable object modules, is ideally suited to the OEM who requires a pass through programming language. The BASIC-80 programs may be created, stored and interpreted on the iSBC 80 based system. The BASIC-80 language has a rich complement of statements, functions, and commands to program applications requiring a full range of 1) string manipulation and disk I/O for data processing, 2) single and double precision floating point and array handling for numeric analysis, or 3) port I/O with mask operations controlled through bit-wise Boolean logical operators.

SPECIFICATIONS

Word Size

Instruction — 8, 16, or 24 bits
Data — 8 bits

Cycle Time

Basic Instruction Cycle — 1.86 μs

Note

Basic instruction cycle is defined as the fastest instruction (i.e., four clock cycles).

Memory Addressing

On-Board ROM/EPROM — 0–0FFF (2708) or 0–1FFF (2716)
On-Board RAM — 4K bytes ending on a 16K boundary (e.g., 3FFFH, 7FFFH, BFFFH, ... FFFFH)

Memory Capacity

On-Board ROM/EPROM — 8K bytes (sockets only)
On-Board RAM — 4K bytes

Off-Board Expansion — Up to 65,536 bytes in user specified RAM, ROM, and EPROM

Note

ROM/EPROM may be added in 1K or 2K-byte increments.

I/O Addressing

On-Board Programmable I/O (see Table 1)

<table>
<thead>
<tr>
<th>Port</th>
<th>8255 No. 1</th>
<th>8255 No. 2</th>
<th>8255 No. 1 Control</th>
<th>8255 No. 2 Control</th>
<th>USART Data</th>
<th>USART Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>E4</td>
<td>E5</td>
<td>E6</td>
<td>E8</td>
<td>E9</td>
<td>EA</td>
</tr>
</tbody>
</table>
I/O Capacity

Parallel — 48 programmable lines (see Table 1)

Note

Expansion to 504 input and 504 output lines can be accomplished using optional I/O boards.

Serial Communications Characteristics

Synchronous — 5–8 bit characters; internal or external character synchronization; automatic sync insertion

Asynchronous — 5–8 bit characters; break character generation; 1, 1 ½, or 2 stop bits; false start bit detection

Baud Rates

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Baud Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Software Selectable)</td>
<td>Synchronous</td>
</tr>
<tr>
<td>153.6</td>
<td>—</td>
</tr>
<tr>
<td>76.8</td>
<td>—</td>
</tr>
<tr>
<td>38.4</td>
<td>36400</td>
</tr>
<tr>
<td>19.2</td>
<td>19200</td>
</tr>
<tr>
<td>9.6</td>
<td>9600</td>
</tr>
<tr>
<td>4.8</td>
<td>4800</td>
</tr>
<tr>
<td>2.4</td>
<td>2400</td>
</tr>
<tr>
<td>1.76</td>
<td>1760</td>
</tr>
</tbody>
</table>

Note

Frequency selected by I/O write of appropriate 16-bit frequency factor to baud rate register.

Register Address (hex notation, I/O address space)

DE Baud rate register

Note

Baud rate factor (16 bits) is loaded as two sequential output operations to same address (DEH).

Interrupts

Register Addresses (hex notation, I/O address space)

DA Interrupt request register

DA In-service register

DB Mask register

DA Command register

DB Block address register

DA Status (polling register)

Note

Several registers have the same physical address; sequence of access and one data bit of control word determine which register will respond.

Timers

Register Addresses (hex notation, I/O address space)

DF Control register

DC Timer 1

DD Timer 2

Note

Timer counts loaded as two sequential output operations to same address, as given.

Input Frequencies

<table>
<thead>
<tr>
<th>Reference</th>
<th>Event Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0752 MHz ± 10% (0.930 μs period, nominal)</td>
<td>1.1 MHz max</td>
</tr>
</tbody>
</table>

Note

Maximum rate for external events in event counter function.

Output Frequencies/Timing Intervals

<table>
<thead>
<tr>
<th>Function</th>
<th>Single Timer/Counter</th>
<th>Dual Timer/Counter</th>
<th>Dual Timer/Counter (Two Timers Cascaded)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>Real-time interrupt</td>
<td>1.86 μs</td>
<td>60.948 ms</td>
<td>3.72 μs</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>1.86 μs</td>
<td>60.948 ms</td>
<td>3.72 μs</td>
</tr>
<tr>
<td>Rate generator</td>
<td>16.407 Hz</td>
<td>537.61 kHz</td>
<td>0.00025 Hz</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>16.407 Hz</td>
<td>537.61 kHz</td>
<td>0.00025 Hz</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>1.86 μs</td>
<td>60.948 ms</td>
<td>3.72 μs</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>1.86 μs</td>
<td>60.948 ms</td>
<td>3.72 μs</td>
</tr>
</tbody>
</table>

Interfaces

Bus — All signals TTL compatible

Parallel I/O — All signals TTL compatible

Interrupt Requests — All TTL compatible

Timer — All signals TTL compatible

Serial I/O — RS232C compatible, data set configuration

System Clock (8080A CPU)

2.1504 MHz ± 0.1%

Auxiliary Power

An auxiliary power bus is provided to allow separate power to RAM for systems requiring battery backup of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

Memory Protect

An active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during system power-down sequences.

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Double-Sided Pins (qty)</th>
<th>Centers (in.)</th>
<th>Mating Connectors*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIBUS System Bus</td>
<td>86</td>
<td>0.156</td>
<td>ELFAB BS1562043PBB Viking 2KH43/9AMK12 Soldered PCB Mount EDAC 33708540201 ELFAB BW1562D43PBB EDAC 33708540202 ELFAB BW1562A43PBB Wire Wrap EDAC 3450652402 EDAC 34506540201 EDAC 34506540202 ELFAB BW1020D30PBB Wire Wrap 3M 3415-001 Flat Crimp GTE Sylvania 6AD01251A1DD Soldered EDAC 345026520202 EDAC 34502652001 EDAC 34502652002 AMP BW373-5 Flat Crimp</td>
</tr>
<tr>
<td>Auxiliary Bus</td>
<td>60</td>
<td>0.100</td>
<td>EDAC 3450652402 EDAC 34506540201 EDAC 34506540202 ELFAB BW1020D30PBB Wire Wrap 3M 3415-001 Flat Crimp GTE Sylvania 6AD01251A1DD Soldered EDAC 3450652402 EDAC 34506540201 EDAC 34506540202 ELFAB BW1020D30PBB Wire Wrap 3M 3415-001 Flat Crimp GTE Sylvania 6AD01251A1DD Soldered</td>
</tr>
<tr>
<td>Parallel I/O (2)</td>
<td>50</td>
<td>0.100</td>
<td>AMP 15837151 EDAC 345026520202 PCB Soldered 3M 3462-0001 AMP B8373-5 Flat Crimp</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>26</td>
<td>0.100</td>
<td>AMP 15837151 EDAC 345026520202 PCB Soldered 3M 3462-0001 AMP B8373-5 Flat Crimp</td>
</tr>
</tbody>
</table>

*Note: Connectors compatible with those listed may also be used.
iSBC 80/20-4

Line Drivers and Terminators
I/O Drivers — The following line drivers are all compatible with the I/O driver sockets on the iSBC 80/20-4.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I,OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>

Note
I = inverting; NI = non-inverting; OC = open collector.

Ports 1 and 4 have 20 mA totem-pole bidirectional drivers and 1 kΩ terminators.

I/O Terminators — 220Ω/330Ω divider or 1 kΩ pull-up

Physical Characteristics
Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.26 cm)
Weight — 14 oz (397.6 gm)

Electrical Characteristics
DC Power Requirements

<table>
<thead>
<tr>
<th>Voltage (± 5%)</th>
<th>Without PROM1 (max)</th>
<th>With 4K PROM2 (max)</th>
<th>With ISBC 5303 (max)</th>
<th>RAM Only4 (max)</th>
<th>With 8K PROM5 (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC = +5V</td>
<td>ICC = 4.0A</td>
<td>4.9A</td>
<td>4.9A</td>
<td>1.1A</td>
<td>5.2A</td>
</tr>
<tr>
<td>VDD = +12V</td>
<td>IDD = 90 mA</td>
<td>350 mA</td>
<td>450 mA</td>
<td>—</td>
<td>90 mA</td>
</tr>
<tr>
<td>VBB = -5V</td>
<td>IBB = 2 mA</td>
<td>180 mA</td>
<td>180 mA</td>
<td>—</td>
<td>2 mA</td>
</tr>
<tr>
<td>VAA = -12V</td>
<td>IAA = 20 mA</td>
<td>20 mA</td>
<td>120 mA</td>
<td>—</td>
<td>20 mA</td>
</tr>
</tbody>
</table>

Notes
1. Does not include power required for optional PROM, I/O drivers, and I/O terminators.
2. With four 2708 EPROMs and 220Ω/330Ω input terminators installed for 32 I/O lines, all terminator inputs low.
3. With four 2708 EPROMs, 220Ω/330Ω input terminators installed for 32 I/O lines, all terminator inputs low, and iSBC 530 Teletypewriter Adapter drawing power from serial port connector.
4. RAM chips powered via auxiliary power bus.
5. With four 2716 EPROMs and eight 220Ω/330Ω input terminators installed, all terminator inputs low.

Environmental Characteristics
Operating Temperature — 0°C to 55°C

Reference Manual
9800317D — iSBC 80/20-5 Hardware Reference Manual (NOT SUPPLIED)
Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 80/20-4</td>
<td>Single Board Computer with 4K bytes RAM</td>
</tr>
</tbody>
</table>

AFN-01499A 2-25
iSBC™ 80/24 (or pSBC 80/24*)
SINGLE BOARD COMPUTER

- Upward compatible with iSBC 80/20-4 Single Board Computer
- 8085A-2 CPU operating at 4.8 or 2.4 MHz
- Two iSBX™ bus connectors for iSBX MULTIMODULE™ board expansion
- 4K bytes of static read/write memory expandable on-board to 8K bytes using the iSBC 301 MULTIMODULE Board
- Sockets for up to 32K bytes of read only memory
- 48 programmable parallel I/O lines with sockets for interchangeable line drivers and terminators
- Programmable synchronous/asynchronous RS232C compatible serial interface with software selectable baud rates
- Full MULTIBUS® control logic for multimaster configurations and system expansion
- Two programmable 16-bit BCD or binary timers/event counters
- 12 levels of programmable interrupt control
- Auxiliary power bus, memory protect, and power-fail interrupt control logic provided for battery backup RAM requirements

The Intel® iSBC 80/24 Single Board Computer is a member of Intel's complete line of OEM microcomputer systems which take full advantage of Intel's LSI technology to provide economical, self-contained computer-based solutions for OEM applications. The iSBC 80/24 board is a complete computer system on a single 6.75 x 12.00-inch printed circuit card. The CPU, system clock, iSBX bus interface, read/write memory, read only memory sockets, I/O ports and drivers, serial communications interface, priority interrupt logic, and programmable timers all reside on the board. Full MULTIBUS interface logic is included to offer compatibility with the Intel OEM Microcomputer Systems family of Single Board Computers, expansion memory options, digital and analog I/O expansion boards, and peripheral and communications controllers.
FUNCTIONAL DESCRIPTION

Central Processing Unit

Intel's powerful 8-bit N-channel 8085A-2 CPU fabricated on a single LSI chip, is the central processor for the iSBC 80/24 board operating at either 4.8 or 2.4 MHz (jumper selectable). The 8085A-2 CPU is directly software compatible with the Intel 8080A CPU. The 8085A-2 contains six 8-bit general purpose registers and an accumulator. The six general purpose registers may be addressed individually or in pairs, providing single and double precision operators. Minimum instruction execution time is 826 nanoseconds. A block diagram of the iSBC 80/24 functional components is shown in Figure 1.

MULTIMODULE Board Expansion

The new iSBX bus interface brings an entirely new dimension to system design offering incremental on-board expansion at minimal cost. Two iSBX bus MULTIMODULE connectors are provided for plug-in expansion of any iSBX MULTIMODULE board. The iSBX MULTIMODULE concept provides the ability to adapt quickly to new technology, the economy of buying only what is needed, and the ready availability of a spectrum of functions for greater application potential. iSBX boards are available to provide expansion equivalent to the I/O available on the iSBC 80/24 board or the user may configure entirely new functionality, such as math, directly on board. The iSBX 350 Parallel I/O MULTIMODULE board provides 24 I/O lines using an 8255A Programmable Peripheral Interface. Therefore, two iSBX 350 modules together with the iSBC 80/24 board may offer 96 lines of programmable I/O. Alternately, a serial port may be added using the iSBX 351 Serial I/O MULTIMODULE board and math may be configured on-board with the iSBX 332 Floating Point Math or iSBX 331 Fixed/Floating Point Math MULTIMODULE board. Future iSBX products are also planned. The iSBX MULTIMODULE board is a logical extension of the on-board programmable I/O and is accessed by the iSBC 80/24 single board computer as common I/O port locations. The iSBX board is coupled directly to the 8085A-2 CPU and therefore becomes an integral element of the iSBC 80/24 single board computer providing optimum performance. In addition, RAM memory capacity may be expanded to 8K bytes using the iSBC 301 4K Byte RAM MULTIMODULE board. All MULTIMODULE boards ranging from the iSBC 301 module to the iSBX modules offer incremental expansion, optimum performance, and minimal cost.

Figure 1. iSBC 80/24 Single Board Computer Block Diagram
Memory Addressing
The 8085A-2 has a 16-bit program counter which allows direct addressing of up to 64K bytes of memory. An external stack, located within any portion of read/write memory, may be used as a last-in/first-out storage area for the contents of the program counter, flags, accumulator, and all of the six general purpose registers. A 16-bit stack pointer controls the addressing of this external stack. This stack provides subroutine nesting bounded only by memory size.

Memory Capacity
The iSBC 80/24 board contains 4K bytes of static read/write memory using Intel 8185-2 RAMs. In addition, the on-board RAM capacity may be expanded to 8K bytes with the iSBC 301 4K byte RAM MULTIMODULE board. All RAM read and write operations are performed at maximum processor speed. Power for the on-board RAM may be provided on an auxiliary power bus, and memory protect logic is included for RAM battery backup requirements.

Four sockets are provided for up to 32K bytes of nonvolatile read only memory on the iSBC 80/24 board. EPROM may be added in 1K byte increments up to 4K bytes (using Intel 2708 or 2758); in 2K byte increments up to 8K bytes (using Intel 2716); in 4K byte increments up to 16K bytes (using Intel 2732); or in 8K byte increments up to 32K bytes (using Intel 2764).

Table 1. Input/Output Port Modes of Operation

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
<th>Bidirectional</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unidirectional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input</td>
<td>Output</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unlatched</td>
<td>Latched</td>
<td>Latched</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latched &amp; Strobed</td>
<td></td>
<td>Strobed</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X²</td>
</tr>
</tbody>
</table>

NOTES:
1. Part of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
2. Part of port 6 must be used as a control port when either port 4 or port 5 are used as a latched and strobed input or a latched and strobed output port or port 4 is used as a bidirectional port.

Serial I/O Interface
A programmable communications interface using the Intel 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) is contained on the iSBC 80/24 board. A software selectable baud rate generator provides the USART with all common communication frequencies. The USART can be programmed by the system software to select the desired asynchronous or synchronous serial data transmission technique (including IBM...
Bi-Sync). The mode of operation (i.e. synchronous or asynchronous), data format, control character format, parity, and baud rate are all under program control. The 8251A provides full duplex, double buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the USART. The RS232C compatible interface, in conjunction with the USART, provides a direct interface to RS232C compatible terminals, cassettes, and asynchronous and synchronous modems. The RS232C command lines, serial data lines, and signal ground line are brought out to a 26-pin edge connector that mates with RS232C compatible flat or round cable.

Multimaster Capability
The iSBC 80/24 board is a full computer on a single board with resources capable of supporting a large variety of OEM system requirements. For those applications requiring additional processing capacity and the benefits of multiprocessing (i.e. several CPUs and/or controllers logically sharing system tasks through communication over the system bus), the iSBC 80/24 board provides full MULTIBUS arbitration control logic. This control logic allows up to three iSBC 80/24 boards or other bus masters to share the system bus in serial (daisy chain) priority fashion, and up to 16 masters to share the MULTIBUS system bus with the addition of an external priority network. The MULTIBUS arbitration logic operates synchronously with a MULTIBUS clock (provided by the iSBC 80/24 board or optionally connected directly to the MULTIBUS clock) while data is transferred via a handshake between the master and slave modules. This allows different speed controllers to share resources on the same bus since transfers via the bus proceed asynchronously. Thus, transfer speed is dependent on transmitting and receiving devices only. This design provides slow master modules from being handicapped in their attempts to gain control of the bus, but does not restrict the speed at which faster modules can transfer data via the same bus. The most obvious applications for the master-slave capabilities of the bus are multiprocessor configurations, high speed direct memory access (DMA) operations, and high speed peripheral control, but are by no means limited to these three.

Programmable Timers
The iSBC 80/24 board provides three independent, fully programmable 16-bit interval timers/event counters utilizing the Intel 8253 Programmable Interval Timer. Each counter is capable of operating in either BCD or binary modes. Two of these timers/counters are available to the systems designer to generate accurate time intervals under software control. Routing for the outputs and gate/trigger inputs of two of these counters is jumper selectable. The outputs may be independently routed to the 8259A Programmable Interrupt Controller, to the I/O line drivers associated with the 8255A Programmable Peripheral Interface, or may be routed as inputs to the 8255A chip. The gate/trigger inputs may be routed to I/O terminators associated with the 8255A or as output connections from the 8255A. The third interval timer in the 8253 provides the programmable baud rate generator for the RS232C USART serial port. In utilizing the iSBC 80/24 board, the systems designer simply configures, via software, each timer independently to meet system require-

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal</td>
<td>When terminal count is reached, an interrupt request is generated. This</td>
</tr>
<tr>
<td>count</td>
<td>function is extremely useful for generation of real-time clocks.</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>Output goes low upon receipt of an external trigger edge or software</td>
</tr>
<tr>
<td></td>
<td>command and returns high when terminal count is reached. This function</td>
</tr>
<tr>
<td></td>
<td>is retriggerable.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle,</td>
</tr>
<tr>
<td></td>
<td>and the period from one low-going pulse to the next is N times the input</td>
</tr>
<tr>
<td></td>
<td>clock period.</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>Output will remain high until one-half the count has been completed, and</td>
</tr>
<tr>
<td></td>
<td>go low for the other half of the count.</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>Output remains high until software loads count (N). N counts after count</td>
</tr>
<tr>
<td></td>
<td>is loaded, output goes low for one input clock period.</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>Output goes low for one clock period N counts after rising edge on</td>
</tr>
<tr>
<td></td>
<td>counter trigger input. The counter is retriggerable.</td>
</tr>
<tr>
<td>Event counter</td>
<td>On a jumper selectable basis, the clock input becomes an input from the</td>
</tr>
<tr>
<td></td>
<td>external system. CPU may read the number of events occurring after the</td>
</tr>
<tr>
<td></td>
<td>counting “window” has been enabled or an interrupt may be generated after</td>
</tr>
<tr>
<td></td>
<td>N events occur in the system.</td>
</tr>
</tbody>
</table>
mments. Whenever a given time delay or count is needed, software commands to the programmable timers/event counters select the desired function. Seven functions are available, as shown in Table 2. The contents of each counter may be read at any time during system operation with simple read operations for event counting applications, and special commands are included so that the contents of each counter can be read “on the fly”.

Interrupt Capability

The iSBC 80/24 board provides vectoring for 12 interrupt levels. Four of these levels are handled directly by the interrupt processing capability of the 8085A-2 CPU and represent the four highest priority interrupts of the iSBC 80/24 board. Requests are routed to the 8085A-2 interrupt inputs—TRAP, RST 7.5, RST 6.5, and RST 5.5 (in decreasing order of priority), each of which generates a call instruction to a unique address (TRAP: 24H; RST 7.5: 3CH; RST 6.5: 34H; and RST 5.5: 2CH). An 8085A-2 JMP instruction at each of these addresses then provides linkage to interrupt service routines located independently anywhere in memory. All interrupt inputs with the exception of the trap interrupt may be masked via software. The trap interrupt should be handled via software at any time during system operation. The PIC accepts interrupt requests from the programmable parallel and serial I/O interfaces, the programmable timers, the system bus, and directly from peripheral equipment. The PIC then determines which of the incoming requests is of the highest priority, determines whether this request is of higher priority than the level currently being serviced, and, if appropriate, issues an interrupt to the CPU. Any combination of interrupt levels may be masked, via software, by storing a single byte in the interrupt mask register of the PIC. The PIC generates a unique memory address for each interrupt level. These addresses are equally spaced at intervals of 4 or 8 (software selectable) bytes. This 32 or 64-byte block may be located to begin at any 32 or 64-byte boundary in the 65,536-byte memory space. A single 8085A-2 JMP instruction at each of these addresses then provides linkage to locate each interrupt service routine independently anywhere in memory.

| Table 3. Programmable Interrupt Modes |
|-------------------------------|------------------|
| Mode                      | Operation                                      |
| Fully nested              | Interrupt request line priorities fixed at 0 as highest, 7 as lowest. |
| Autorotating              | Equal priority. Each level, after receiving service, becomes the lowest priority level until next interrupt occurs. |
| Specific priority         | System software assigns lowest priority level. Priority of all other levels based in sequence numerically on this assignment. |
| Polled                    | System software examines priority-encoded system interrupt status via interrupt status register. |

Interrupt Request Generation

Interrupt requests may originate from 23 sources. Two jumper selectable interrupt requests can be generated by each iSBC MULTIMODULE board. Two jumper selectable interrupt requests can be automatically generated by each programmable peripheral interface when a byte of information is ready to be transferred to the CPU (i.e., input buffer is full) or a byte of information has been transferred to a peripheral device (i.e., output buffer is empty). Three jumper selectable interrupt requests can be automatically generated by the USART when a character is ready to be transferred to the CPU (i.e., receiver channel buffer is full), a character is ready to be transmitted (i.e., the USART is ready to accept a character from the CPU), or when the transmitter is empty (i.e., the USART has no character to transmit). A jumper selectable request can be generated by each of the programmable timers. Nine interrupt request lines are available to the user for direct interface to user designated peripheral devices via the MULTIBUS system bus. A power-fail signal can also be selected as an interrupt source.

Power-Fail Control

A power-fail interrupt may be detected through the AC-low signal generated by the power supply. This signal may be configured to interrupt the 8085A-2 CPU to initiate an orderly power down instruction sequence.

MULTIBUS System Expansion Capabilities

Memory and I/O capacity may be expanded and additional functions added using Intel MULTIBUS system compatible expansion boards. Memory may be expanded to 65,536 bytes by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capa-
city may be increased by adding digital I/O and analog I/O expansion boards. Mass storage capability may be achieved by adding single or double density diskette or hard disk controllers as subsystems. Expanded communication needs can be handled by communication controllers. Modular expandable backplanes and card cages are available to support multiboard systems.

Real-Time Software
The iRMX™ 80 executive, which contains all major real-time facilities including priority-based system resource allocation, intertask communication and control, interrupt driven control for standard I/O devices, and interrupt handling, occupies 2K bytes of memory which can be stored on-board in EPROM. Optional linkable and relocatable modules for console control (CRT or TTY), disk file system, and analog subsystems are provided with the iRMX 80 package. These facilities eliminate the need for users to design and implement application specific executives, greatly simplifying application design and reducing development time and risk.

System Development Capability
The development cycle of iSBC 80/24-based products may be significantly reduced using Intel's system development tools available today. The Intellec Series II family of compatible microcomputer development systems provides a range of capability from a low cost disk-based edit debug workstation to a high performance, fully compatible hard-disk-based software development system. Also, a unique in-circuit emulator (ICE-85A) option provides the capability of developing and debugging software directly on the iSBC 80/24 board.

Programming Capability
PL/M-80—Intel's high level system programming language, PL/M, is also available as a resident Intellic microcomputer development system option. PL/M provides the capability to program in a natural, algorithmic language and eliminates the need to manage register usage or allocate memory. PL/M programs can be written in a much shorter time than assembly language programs.

FORTRAN-80—For applications requiring computational and formatted I/O capabilities, the ANSI 77 standard high level FORTRAN-80 programming language is available as a resident option of the Intellec system. The FORTRAN compiler produces relocatable object code that may be easily linked with PL/M or assembly language program modules. In addition, the iSBC 801 FORTRAN-80 Run-Time Package is a complete, ready-to-use set of linkable object modules which are fully compatible with iRMX 80 systems. The modules, when combined with the FORTRAN-80 coded application, provide the appropriate interfaces to the disk file and terminal I/O of iRMX 80, and to the iSBC 310A Math Unit for applications requiring high speed math.

BASIC-80—A high level language interpreter is available with extended disk capabilities which operates under the iRMX 80 Real-Time Multitasking Executive and translates BASIC-80 source programs into an internally executable form. This language interpreter, provided as a set of linkable object modules, is ideally suited to the OEM who requires a pass through programming language. The BASIC-80 programs may be created, stored, and interpreted on the iSBC 80-based systems using the iSBC 802 BASIC-80 Configurable iRMX 80 Disk-Based Interpreter. The iSBC 802 Interpreter has a complete ready-to-use set of linkable object modules which are fully compatible with Intel's iRMX 80 Real-Time Multitasking Executive Software. The modules provide interfaces to disk file and terminal I/O, software floating point, or interface to other routines provided by the user.

SPECIFICATIONS

Word Size
Instruction—8, 16, or 24 bits
Data—8 bits

Cycle Time
Basic Instruction Cycle
826 nsec (4.84 MHz operating frequency)
1.65 μsec (2.42 MHz operating frequency)

NOTE:
Basic instruction cycle is defined as the fastest instruction (i.e., four clock cycles).

Memory Addressing
On-Board EPROM
0–0FFF using 2708, 2758 (1 wait state)
0–1FFF using 2716 (1 wait state)
0–3FFF using 2732 (1 wait state)
using 2732A (no wait states)
0–7FFF using 2764A (no wait states)

On-Board RAM
3000–3FFF with no RAM expansion
2000–3FFF with optional RAM (iSBC 301 board)

NOTE:
Default configuration—may be reconfigured to top end of any 16K boundary.
Memory Capacity

On-Board EPROM
32K bytes (sockets only)
May be added in 1K (using Intel 2708 or 2758), 2K (using Intel 2716), 4K (using Intel 2732), or 8K (using Intel 2764) byte increments.

On-Board RAM
4K bytes (8K bytes using iSBC 301 4K byte RAM MULTIMODULE Board)

Off-Board Expansion
Up to 64K bytes using user specified combinations of RAM, ROM, and EPROM.
Up to 128K bytes using bank select control via I/O port and 2 jumper options.
May be disabled using PROM ENABLE via I/O port and jumper option, resulting in off-board RAM overlay capability.

I/O Addressing

On-Board Programmable I/O

<table>
<thead>
<tr>
<th>Device</th>
<th>I/O Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>8255A No. 1</td>
<td></td>
</tr>
<tr>
<td>Port A</td>
<td>E4</td>
</tr>
<tr>
<td>Port B</td>
<td>E5</td>
</tr>
<tr>
<td>Port C</td>
<td>E6</td>
</tr>
<tr>
<td>Control</td>
<td>E7</td>
</tr>
<tr>
<td>8255A No. 2</td>
<td></td>
</tr>
<tr>
<td>Port A</td>
<td>E8</td>
</tr>
<tr>
<td>Port B</td>
<td>E9</td>
</tr>
<tr>
<td>Port C</td>
<td>EA</td>
</tr>
<tr>
<td>Control</td>
<td>EB</td>
</tr>
<tr>
<td>8251A</td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>EC, EE</td>
</tr>
<tr>
<td>Control</td>
<td>ED, EF</td>
</tr>
<tr>
<td>iSBC MULTIMODULE J5</td>
<td></td>
</tr>
<tr>
<td>MCS0</td>
<td>C0-C7</td>
</tr>
<tr>
<td>MCS1</td>
<td>C8-CF</td>
</tr>
<tr>
<td>iSBC MULTIMODULE J6</td>
<td></td>
</tr>
<tr>
<td>MCS0</td>
<td>F0-F7</td>
</tr>
<tr>
<td>MCS1</td>
<td>F8-FF</td>
</tr>
</tbody>
</table>

I/O Capacity

Parallel—48 programmable lines
Serial—1 transmit, 1 receive, 1 SID, 1 SOD

iSBC MULTIMODULE — 2 iSBC MULTIMODULE Boards

Serial Communications Characteristics

Synchronous—5-8 bit characters; internal or external character synchronization; automatic sync insertion
Asynchronous—5-8 bit characters; break character generation; 1, 1 1/2, or 2 stop bits; false start bit detectors

Baud Rates

<table>
<thead>
<tr>
<th>Output Frequency in kHz</th>
<th>Synchronous</th>
<th>Asynchronous</th>
</tr>
</thead>
<tbody>
<tr>
<td>153.6</td>
<td>—</td>
<td>+64</td>
</tr>
<tr>
<td>76.8</td>
<td>—</td>
<td>9600</td>
</tr>
<tr>
<td>38.4</td>
<td>38400</td>
<td>2400</td>
</tr>
<tr>
<td>19.2</td>
<td>19200</td>
<td>1200</td>
</tr>
<tr>
<td>9.6</td>
<td>9600</td>
<td>600</td>
</tr>
<tr>
<td>4.8</td>
<td>4800</td>
<td>300</td>
</tr>
<tr>
<td>2.4</td>
<td>2400</td>
<td>150</td>
</tr>
<tr>
<td>1.76</td>
<td>1760</td>
<td>110</td>
</tr>
</tbody>
</table>

NOTE:
Frequency selected by I/O write of appropriate 16-bit frequency factor to baud rate register.

Register Address (hex notation, I/O address space)
DE Baund rate register

NOTE:
Baud rate factor (16 bits) is loaded as two sequential output operations to same address (DEH).

Interrupts

Addresses for 829A Registers (hex notation, I/O address space)

DA or D8 Interrupt request register
DA or D8 In-service register
DB or D9 Mask register
DA or D8 Command register
DB or D9 Block address register
DA or D8 Status (polling register)

NOTE:
Several registers have the same physical address; sequence of access and one data bit of control word determine which register will respond.

Interrupt levels routed to 8085A-2 CPU automatically vector the processor to unique memory locations:

<table>
<thead>
<tr>
<th>Interrupt Input</th>
<th>Memory Address</th>
<th>Priority</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAP</td>
<td>24</td>
<td>Highest</td>
<td>Non-maskable</td>
</tr>
<tr>
<td>RST 7.5</td>
<td>3C</td>
<td></td>
<td>Maskable</td>
</tr>
<tr>
<td>RST 6.5</td>
<td>34</td>
<td></td>
<td>Maskable</td>
</tr>
<tr>
<td>RST 5.5</td>
<td>2C</td>
<td>Lowest</td>
<td>Maskable</td>
</tr>
</tbody>
</table>
Timers

Register Addresses (hex notation, I/O address space)

- DF  Control register
- DC  Timer 0
- DD  Timer 1
- DE  Timer 2

**NOTE:**
Timer counts loaded as two sequential output operations to same address as given.

Input Frequencies

Reference: 1.0752 MHz ± 0.1% (0.930 μsec period, nominal)
Event Rate: 1.1 MHz max.

Output Frequencies/Timing Intervals

<table>
<thead>
<tr>
<th>Function</th>
<th>Single Timer/Counter</th>
<th>Dual Timer/Counter (Two Timers Cascaded)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>Real-Time Interrupt</td>
<td>1.86μsec</td>
<td>60.948msec</td>
</tr>
<tr>
<td>Programmable One-Shot Rate Generator</td>
<td>16.407Hz</td>
<td>537.61kHz</td>
</tr>
<tr>
<td>Square-Wave Rate Generator</td>
<td>15.407Hz</td>
<td>537.61kHz</td>
</tr>
<tr>
<td>Software Triggered Strobe</td>
<td>1.86μsec</td>
<td>60.948msec</td>
</tr>
<tr>
<td>Hardware Triggered Strobe</td>
<td>1.86μsec</td>
<td>60.948msec</td>
</tr>
</tbody>
</table>

**NOTE:**
Input frequency to timers is 1.0752 MHz (default configuration).

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Double-Sided Pins (qty)</th>
<th>Centers (in.)</th>
<th>Mating Connectors*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIBUS</td>
<td>86</td>
<td>0.156</td>
<td>ELFAB BS1562043PBB</td>
</tr>
<tr>
<td>System Bus</td>
<td></td>
<td></td>
<td>Viking 2KH439AMK12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Soldered PCB Mount</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EDAC 337086540201</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ELFAB BW1562043PBB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EDAC 337086540202</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ELFAB BW15624A3PBB</td>
</tr>
<tr>
<td>Auxiliary Bus</td>
<td>60</td>
<td>0.100</td>
<td>Wire Wrap</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EDAC 345065024802</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ELFAB BS1020A30PBB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EDAC 345065040201</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ELFAB BW1020D30PBB</td>
</tr>
<tr>
<td>iSBX Bus (2)</td>
<td>36</td>
<td>0.100</td>
<td>Flat Crimp</td>
</tr>
<tr>
<td>Parallel I/O (2)</td>
<td>50</td>
<td>0.100</td>
<td>3M 3415-001</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>28</td>
<td>0.100</td>
<td>Flat Crimp</td>
</tr>
</tbody>
</table>

*Note: Connectors compatible with those listed may also be used.

Memory Protect

An active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during system power-down sequences.

Line Drivers and Terminators

I/O Drivers—The following line drivers and terminators are all compatible with the I/O driver sockets on the ISBC 80/24 Board:

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I, OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I, OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI, OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I, OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

**NOTE:**
I = inverting; NI = non-inverting; OC = open collector.

Auxiliary Power

An auxiliary power bus is provided to allow separate power to RAM for systems requiring battery backup of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.
Bus Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-State</td>
<td>32</td>
</tr>
<tr>
<td>Address</td>
<td>Tri-State</td>
<td>32</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-State</td>
<td>32</td>
</tr>
</tbody>
</table>

Physical Characteristics

Width—12.00 in. (30.48 cm)
Height—6.75 in. (17.15 cm)
Depth—0.50 in. (1.27 cm)
Weight—12.64 oz. (354 gm)

Electrical Characteristics

DC Power Requirements

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Current Requirements</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_{CC} = +5V$</td>
<td>$V_{DD} = +12V$</td>
<td>$V_{BB} = -5V$</td>
<td>$V_{AA} = -12V$</td>
</tr>
<tr>
<td>Without EPROM$^1$</td>
<td>3.34A</td>
<td>40 mA</td>
<td>—</td>
<td>20 mA</td>
</tr>
<tr>
<td>RAM Only$^2$</td>
<td>0.14A</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>With iSBC 530$^3$</td>
<td>3.34A</td>
<td>140 mA</td>
<td>—</td>
<td>120 mA</td>
</tr>
<tr>
<td>With 4K EPROM$^4$</td>
<td>3.74A</td>
<td>300 mA</td>
<td>180 mA</td>
<td>20 mA</td>
</tr>
<tr>
<td>(using 2708)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With 4K EPROM$^4$</td>
<td>4.43A</td>
<td>40 mA</td>
<td>—</td>
<td>20 mA</td>
</tr>
<tr>
<td>(using 2758)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With 8K EPROM$^5$</td>
<td>4.43A</td>
<td>40 mA</td>
<td>—</td>
<td>20 mA</td>
</tr>
<tr>
<td>(using 2716)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With 16K EPROM$^6$</td>
<td>4.71A</td>
<td>40 mA</td>
<td>—</td>
<td>20 mA</td>
</tr>
<tr>
<td>(using 2732)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With 32K EPROM$^7$</td>
<td>4.71A</td>
<td>40 mA</td>
<td>—</td>
<td>20 mA</td>
</tr>
<tr>
<td>(using 2764)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
1. Does not include power for optional EPROM, I/O drivers, and I/O terminators.
2. RAM chips powered via auxiliary power bus.

ORDERING INFORMATION

Part Number  Description
SBC 80/24    Single Board Computer

Environmental Characteristics

Operating Temperature—0°C to 55°C

Reference Manual

142648-001—iSBC 80/24 Single Board Computer Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.
iSBC™ 80/30 (or pSBC 80/30*)
SINGLE BOARD COMPUTER

- 8085A CPU used as central processing unit
- 16K bytes of dual port dynamic read/write memory with on-board refresh
- Sockets for up to 8K bytes of read only memory
- Sockets for 8041A/8741A Universal Peripheral Interface and interchangeable line drivers and line terminators
- 24 programmable parallel I/O lines with sockets for interchangeable line drivers and terminators
- Programmable synchronous/asynchronous RS232C compatible serial interface with fully software selectable baud rate generation
- Full MULTIBUS® control logic allowing up to 16 masters to share the system
- 12 levels of programmable interrupt control
- Two programmable 16-bit BCD or binary counters
- Auxiliary power bus, memory protect, and power-fail interrupt control logic for RAM battery backup
- Compatible with optional iSBC 80 CPU, memory, and I/O expansion boards

The iSBC 80/30 Single Board Computer is a member of Intel's complete line of OEM computer systems which take full advantage of Intel's LSI technology to provide economical self-contained computer-based solutions for OEM applications. The iSBC 80/30 is a complete computer system on a single 6.75 x 12.00-inch printed circuit card. The CPU, system clock, read/write memory, nonvolatile read only memory, universal peripheral interface capability, I/O ports and drivers, serial communications interface, priority interrupt logic, programmable timers, MULTIBUS control logic, and bus expansion drivers all reside on the board.
FUNCTIONAL DESCRIPTION

Central Processing Unit

Intel's powerful 8-bit n-channel 8085A CPU, fabricated on a single LSI chip, is the central processor for the iSBC 80/30. The 8085A CPU is directly software compatible with the Intel 8080A CPU. The 8085A contains six 8-bit general purpose registers and an accumulator. The six general purpose registers may be addressed individually or in pairs, providing both single and double precision operators. The minimum instruction execution time is 1.45 microseconds. The 8085A CPU has a 16-bit program counter. An external stack, located within any portion of iSBC 80/30 read/write memory, may be used as a last-in/first-out storage area for the contents of the program counter, flags, accumulator, and all of the six general purpose registers. A 16-bit stack pointer controls the addressing of this external stack. This stack provides subroutine nesting bounded only by memory size.

Bus Structure

The iSBC 80/30 has an internal bus for all on-board memory and I/O operations and a system bus (i.e., the MULTIBUS) for all external memory and I/O operations. Hence, local (on-board) operations do not tie up the system bus, and allow true parallel processing when several bus masters (i.e., DMA devices, other single board computers) are used in a multilayer scheme. A block diagram of the iSBC 80/30 functional components is shown in Figure 1.

RAM Capacity

The iSBC 80/30 contains 16K bytes of dynamic read/write memory using Intel 2117 RAMs. All RAM read and write operations are performed at maximum processor speed. Power for the on-board RAM may be provided on an auxiliary power bus, and memory protect logic is included for RAM battery backup requirements. The iSBC 80/30 contains a dual port controller, which provides dual port capability for the on-board RAM memory. RAM accesses may occur from either the iSBC 80/30 or from any other bus master interfaced via the

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Figure 1. iSBC 80/30 Single Board Computer Block Diagram
MULTIBUS. Since on-board RAM accesses do not require the MULTIBUS, the bus is available for any other concurrent operations (e.g., DMA data transfers) requiring the use of the MULTIBUS. Dynamic RAM refresh is accomplished automatically by the iSBC 80/30 for accesses originating from either the CPU or via the MULTIBUS. Memory space assignment can be selected independently for on-board and MULTIBUS RAM accesses. The on-board RAM, as seen by the 8085A CPU, may be placed anywhere within the 0- to 64K-address space. The iSBC 80/30 provides extended addressing jumpers to allow the on-board RAM to reside within a one megabyte address space when accessed via the MULTIBUS. In addition, jumper options are provided which allow the user to reserve 8K- and 16K-byte segments of on-board RAM for use by the 8085A CPU only. This reserved RAM space is not accessible via the MULTIBUS and does not occupy any system address space.

EPROM/ROM Capacity
Sockets for up to 8K bytes of nonvolatile read only memory are provided on the iSBC 80/30 board. Read only memory may be added in 1K-byte increments up to a maximum of 2K bytes using Intel 2708 or 2758 erasable and electrically reprogrammable ROMs (EPROMs); in 2K-byte increments up to a maximum of 4K bytes using Intel 2716 EPROMs; or in 4K-byte increments up to 8K bytes maximum using Intel 2732 EPROMs. All on-board EPROM/ROM operations are performed at maximum processor speed.

Parallel I/O Interface
The iSBC 80/30 contains 24 programmable parallel I/O lines implemented using the Intel 8255A Programmable Peripheral Interface. The system software is used to configure the I/O lines in any combination of unidirectional input/output and bidirectional ports indicated in Table 1. Therefore, the I/O interface may be customized to meet specific peripheral requirements. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators. Hence, the flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. The 24 programmable I/O lines and signal ground lines are brought out to a 50-pin edge connector that mates with flat, woven, or round cable.

Universal Peripheral Interface (UPI)
The iSBC 80/30 provides sockets for a user supplied Intel 8041A/8741A Universal Peripheral Interface (UPI) chip and the associated line drivers and terminators for the UPI's I/O ports. The 8041A/8741A is a single chip microcomputer containing a CPU, 1K bytes of ROM (8041A) or EPROM (8741A), 64 bytes of RAM, 18 programmable I/O lines, and an 8-bit timer. Special interface registers included in the chip allow the 8041A to function as a slave processor to the iSBC 80/30's 8085A CPU. The UPI allows the user to specify algorithms for controlling user peripherals directly in the chip, thereby relieving the 8085A for other system functions. The iSBC 80/30 provides an RS232C receiver and an RS232C receiver for optional connection to the 8041A/8741A in applications where the UPI is programmed to handle simple serial interfaces. For additional information, including 8041A/8741A instructions, refer to the UPI-41A User's Manual and application note AP-41.

Serial I/O
A programmable communications interface using the Intel 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) is contained on the iSBC 80/30. A software selectable baud rate generator provides the USART with all common communication frequencies. The USART can be programmed by the system software to select the desired asynchronous or synchronous serial data transmission technique (including IBM By-Sync). The mode of operation (i.e., synchronous or asynchronous), data format, control character format, parity, and baud rate are all under program control. The 8251A provides full duplex, double buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unidirectional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unlatched</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latched</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bidirectional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Note
1. Part of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
USART. The RS232C compatible interface on each board, in conjunction with the USART, provides a direct interface to RS232C compatible terminals, cassettes, and asynchronous and synchronous modems. The RS232C command lines, serial data lines, and signal ground line are brought out to a 26-pin edge connector that mates with RS232C compatible flat or round cable.

**Multimaster Capability**

The iSBC 80/30 is a full computer on a single board with resources capable of supporting a great variety of OEM system requirements. For those applications requiring additional processing capacity and the benefits of multiprocessing (i.e., several CPUs and/or controllers logically sharing system tasks through communication over the system bus), the iSBC 80/30 provides full MULTIBUS arbitration control logic. This control logic allows up to three iSBC 80/30's or other bus masters to share the system bus in serial (daisy chain) priority fashion, and up to 16 masters to share the MULTIBUS with the addition of an external priority network. The MULTIBUS arbitration logic operates synchronously with a MULTIBUS clock (provided by the iSBC 80/30 or optionally connected directly to the MULTIBUS clock) while data is transferred via a handshake between the master and slave modules. This allows different speed controllers to share resources on the same bus, and transfers via the bus proceed asynchronously. Thus, transfer speed is dependent on transmitting and receiving devices only. This design prevents slow master modules from being handicapped in their attempts to gain control of the bus, but does not restrict the speed at which faster modules can transfer data via the same bus. The most obvious applications for the master-slave capabilities of the bus are multiprocessor configurations, high speed direct memory access (DMA) operations, and high speed peripheral control, but are by no means limited to these three.

**Programmable Timers**

The iSBC 80/30 provides three independent, fully programmable 16-bit interval timers/event counters utilizing the Intel 8253 Programmable Interval Timer. Each counter is capable of operating in either BCD or binary modes. Two of these timers/counters are available to the systems designer to generate accurate time intervals under software control. Routing for the outputs and gate/trigger inputs of two of these counters is jumper selectable. The outputs may be independently routed to the 8255A Programmable Interrupt Controller, to the I/O line drivers associated with the 8255A Programmable Peripheral Interface, and to the 8041A/8741A Universal Programmable Interface, or may be routed as inputs to the 8255A and 8041A/8741A chips. The gate/trigger inputs may be routed to I/O terminators associated with the 8255A or as output connections from the 8255A. The third interval timer in the 8253 provides the programmable baud rate generator for the iSBC 80/30 RS232C USART serial port. In utilizing the iSBC 80/30, the systems designer simply configures, via software, each timer independently to meet system requirements. Whenever a given time delay or count is needed, software commands to the programmable timers/event counters select the desired function. Seven functions are available, as shown in Table 2. The contents of each counter may be read at any time during system operation with simple read operations for event counting applications, and special commands are included so that the contents of each counter can be read "on the fly".

### Table 2. Programmable Timer Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal count</td>
<td>When terminal count is reached, an interrupt request is generated. This function is extremely useful for generation of real-time clocks.</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>Output goes low upon receipt of an external trigger edge or software command and returns high when terminal count is reached. This function is retriggerable.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle, and the period from one low-going pulse to the next is N times the input clock period.</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>Output will remain high until one-half the count has been completed, and go low for the other half of the count.</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>Output remains high until software loads count (N). N counts after count is loaded, output goes low for one input clock period.</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>Output goes low for one clock period N counts after rising edge on counter trigger input. The counter is retriggerable.</td>
</tr>
<tr>
<td>Event counter</td>
<td>On a jumper selectable basis, the clock input becomes an input from the external system. CPU may read the number of events occurring after the counting &quot;window&quot; has been enabled or an interrupt may be generated after N events occur in the system.</td>
</tr>
</tbody>
</table>

**Interrupt Capability**

The iSBC 80/30 provides vectoring for 12 interrupt levels. Four of these levels are handled directly by the interrupt processing capability of the 8085A CPU and represent the four highest priority interrupts of the iSBC 80/30. Requests are routed to the 8085A interrupt inputs, TRAP, RST 7.5, RST 6.5, and RST 5.5 (in decreasing order of priority) and each input generates a unique memory address (TRAP: 24H; RST 7.5: 3CH; RST 6.5: 34H; and RST 5.5: 2CH). An 8085A jump instruction at each of these addresses then provides linkage to interrupt ser-
vice routines located independently anywhere in memory. All interrupt inputs with the exception of the trap interrupt may be masked via software. The trap interrupt should be used for conditions such as power-down sequences which require immediate attention by the 8085A CPU. The Intel 8259A Programmable Interrupt Controller (PIC) provides vectoring for the next eight interrupt levels. As shown in Table 3, a selection of four priority processing modes is available to the systems designer for use in designing request processing configurations to match system requirements. Operating mode and priority assignments may be reconfigured dynamically via software at any time during system operation. The PIC accepts interrupt requests from the programmable parallel and serial I/O interfaces, the programmable timers, the system bus, or directly from peripheral equipment. The PIC then determines which of the incoming requests is of the highest priority, determines whether this request is of higher priority than the level currently being serviced, and, if appropriate, issues an interrupt to the CPU. Any combination of interrupt levels may be masked, via software, by storing a single byte in the interrupt mask register of the PIC. The PIC generates a unique memory address for each interrupt level. These addresses are equally spaced at intervals of 4 or 8 (software selectable) bytes. This 32- or 64-byte block may be located to begin at any 32- or 64-byte boundary in the 65,536-byte memory space. A single 8085A jump instruction at each of these addresses then provides linkage to locate each interrupt service routine independently anywhere in memory.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully nested</td>
<td>Interrupt request line priorities fixed at 0 as highest, 7 as lowest.</td>
</tr>
<tr>
<td>Auto-rotating</td>
<td>Equal priority. Each level, after receiving service, becomes the lowest priority level until next interrupt occurs.</td>
</tr>
<tr>
<td>Specific priority</td>
<td>System software assigns lowest priority level. Priority of all other levels based in sequence numerically on this assignment.</td>
</tr>
<tr>
<td>Polled</td>
<td>System software examines priority-encoded system interrupt status via interrupt status register.</td>
</tr>
</tbody>
</table>

Interrupt Request Generation — Interrupt requests may originate from 18 sources. Two jumper selectable interrupt requests can be automatically generated by the programmable peripheral interface when a byte of information is ready to be transferred to the CPU (i.e., input buffer is full) or a byte of information has been transferred to a peripheral device (i.e., output buffer is empty). Two jumper selectable interrupt requests can be automatically generated by the USART when a character is ready to be transferred to the CPU (i.e., receive channel buffer is full), or a character is ready to be transmitted (i.e., transmit channel data buffer is empty). A jumper selectable request can be generated by each of the programmable timers and by the universal peripheral interface, eight additional interrupt request lines are available to the user for direct interface to user designated peripheral devices via the system bus, and two interrupt request lines may be jumper routed directly from peripherals via the parallel I/O driver/terminator section.

Power-Fail Control
Control logic is also included to accept a power-fail interrupt in conjunction with the AC-low signal from the ISBC 635 Power Supply or equivalent.

Expansion Capabilities
Memory and I/O capacity may be expanded and additional functions added by using Intel MULTIBUS compatible expansion boards. High speed integer and floating point arithmetic capabilities may be added by using the ISBC 310A High Speed Mathematics Unit. Memory may be expanded to 65,536 bytes by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capacity may be increased by adding digital I/O and analog I/O expansion boards. Mass storage capability may be achieved by adding single or double density diskette controllers as subsystems. Modular expandable backplanes and card cages are available to support multi-board systems.

Real-Time Software
Intel's IRMX 80 Real-Time Multi-Tasking Executive software, specifically designed for Intel ISBC 80 single board computers, provides the capability to monitor and control multiple asynchronous external events. The IRMX 80 executive, which synchronizes and controls the execution of multiple tasks, is provided as a linkable and relocatable module requiring only 2K bytes of memory space. Optional linkable and relocatable modules for teletypewriter and CRT control, diskette file system, high speed math unit, and analog subsystems are also available.

System Development Capability
The development cycle of ISBC 80/30-based products may be significantly reduced using the Intellec series microcomputer development systems. The resident macroassembler, text editor, and system monitor greatly simplify the design, development, and debug of ISBC 80/30 system software. An optional diskette operating system provides a relocating macroassembler, relocating loader and linkage editor, and a library manager. A unique in-circuit emulator (ICE-85) option provides the capability of developing and debugging software directly on the ISBC 80/30.

Programming Capability
PL/M-80 — Intel's high level programming language, PL/M, is also available as a resident Intellec microcomputer development system option. PL/M provides the capability to program in a natural, algorithmic language and eliminates the need to manage register usage or allocate memory. PL/M programs can be written in a much shorter time than assembly language programs for a given application.
FORTRAN-80 — For applications requiring computational and formatted I/O capabilities, the high level FORTRAN-80 programming language is also available as a resident option of the Intellic system. FORTRAN-80 meets and exceeds the ANS FORTRAN 77 subset language specification. The FORTRAN-80 compiler produces relocatable object code that may be easily linked with other FORTRAN-80, PL/M, or assembly language program modules. This gives the user wide flexibility in developing software by using the best software tool for a particular functional module within the user's application.

SPECIFICATIONS

Word Size
Instruction — 8, 16, or 24 bits
Data — 8 bits

Cycle Time
Basic Instruction Cycle — 1.45 µs
Note
Basic instruction cycle is defined as the fastest instruction (i.e., four clock cycles).

Memory Addressing
On-Board ROM/EPROM — 0-07FF (using 2708 or 2758 EPROMs); 0-FFF (using 2716 EPROMs); 0-1FF (using 2716 EPROMs); 0-1FFF (using 2732 EPROMs).
On-Board RAM — 16K bytes of dual port RAM starting on a 16K boundary. One or two 8K-byte segments may be reserved for CPU use only.

Memory Capacity
On-Board Read Only Memory — 8K bytes (sockets only)
On-Board RAM — 16K bytes
Off-Board Expansion — Up to 65,536 bytes in user specified combinations of RAM, ROM, and EPROM
Note
Read only memory may be added in 1K, 2K, or 4K-byte increments.

I/O Addressing
On-Board Programmable I/O (see Table 1)

<table>
<thead>
<tr>
<th>Port</th>
<th>8255A</th>
<th>8041A/8741A</th>
<th>USART</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Address</td>
<td>E8</td>
<td>E9</td>
<td>EA</td>
</tr>
</tbody>
</table>

I/O Capacity
Parallel — 42 programmable lines using one 8255A (24 I/O lines) and an optional 8041A/8741A (18 I/O lines)
Serial — 2 programmable lines using one 8251A and an optional 8041A/8741A programmed for serial operation
Note:
For additional information on the 8041A/8741A refer to the UPI-41 User's Manual (Publication 9800504).

BASIC-80 — A high level language interpreter with extended disk capabilities which operates under the iRMX 80 Real-Time Multi-tasking Executive and translates BASIC-80 source programs into an internally executable form. This language interpreter, provided as a set of linkable object modules, is ideally suited to the OEM who requires a pass thru programming language. The BASIC-80 programs may be created, stored and interpreted on the iSBC 80-based system. The BASIC-80 language has a rich complement of statements, functions, and commands to program applications requiring a full range of 1) string manipulation and disk I/O for data processing, 2) single and double precision floating point and array handling for numeric analysis, or 3) port I/O with mask operations controlled through bit-wise Boolean logical operators.

Serial Communications Characteristics
Synchronous — 5—8 bit characters; internal or external character synchronization; automatic sync insertion.
Asynchronous — 5—8 bit characters; break character generation; 1, 1½, or 2 stop bits; false start bit detection.

Baud Rates

<table>
<thead>
<tr>
<th>Frequency (kHz) (Software Selectable)</th>
<th>Synchronous</th>
<th>Asynchronous</th>
</tr>
</thead>
<tbody>
<tr>
<td>153.6</td>
<td>—</td>
<td>— 16 — 64</td>
</tr>
<tr>
<td>76.8</td>
<td>—</td>
<td>9600 2400</td>
</tr>
<tr>
<td>38.4</td>
<td>38400</td>
<td>4800 1200</td>
</tr>
<tr>
<td>19.2</td>
<td>19200</td>
<td>1200 300</td>
</tr>
<tr>
<td>9.6</td>
<td>9600</td>
<td>600 150</td>
</tr>
<tr>
<td>4.8</td>
<td>4800</td>
<td>300 75</td>
</tr>
<tr>
<td>2.4</td>
<td>2400</td>
<td>150 — —</td>
</tr>
<tr>
<td>1.76</td>
<td>1760</td>
<td>110 — —</td>
</tr>
</tbody>
</table>

Note
Frequency selected by I/O write of appropriate 16-bit frequency factor to baud rate register (8253 Timer 2).

Interrupts
Addresses for 8259A Registers (Hex notation, I/O address space)
DA Interrupt request register
DA In-service register
DB Mask register
DA Command register
DB Block address register
DA Status (polling register)
Note
Several registers have the same physical address; sequence of access and one data bit of control word determine which register will respond.

Interrupt Levels routed to 8085A CPU automatically vector the processor to unique memory locations:

<table>
<thead>
<tr>
<th>Interrupt Input</th>
<th>Memory Address</th>
<th>Priority</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAP</td>
<td>24</td>
<td>Highest</td>
<td>Non-maskable</td>
</tr>
<tr>
<td>RST 7.5</td>
<td>3C</td>
<td></td>
<td>Maskable</td>
</tr>
<tr>
<td>RST 6.5</td>
<td>34</td>
<td></td>
<td>Maskable</td>
</tr>
<tr>
<td>RST 5.5</td>
<td>2C</td>
<td>Lowest</td>
<td>Maskable</td>
</tr>
</tbody>
</table>
Timers
Register Addresses (Hex notation, I/O address space)
DF Control register
DC Timer 0
DD Timer 1
DE Timer 2

Note
Timer counts loaded as two sequential output operations to same address, as given.

Input Frequencies
Reference: 2.46 MHz ± 0.1% (0.041 μs period, nominal); 1.23 MHz ± 0.1% (0.81 μs period, nominal); or 153.60 kHz ± 0.1% (6.51 μs period nominal).

Note
Above frequencies are user selectable

Event Rate: 2.46 MHz max

Note
Maximum rate for external events in event counter function.

Output Frequencies/Timing Intervals

<table>
<thead>
<tr>
<th>Function</th>
<th>Single Timer/Counter</th>
<th>Dual Timer/Counter (Two Timers Cascaded)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Real-time Interrupt</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Rate generator</td>
<td>2.342 Hz</td>
<td>613.5 kHz</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>2.342 Hz</td>
<td>613.5 kHz</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
</tbody>
</table>

Interfaces
MULTIBUS — All signals TTL compatible
Parallel I/O — All signals TTL compatible
Interrupt Requests — All TTL compatible
Timer — All signals TTL compatible
Serial I/O — RS232C compatible, data set configuration

System Clock (8085A CPU)
2.76 MHz ± 0.1%

Auxiliary Power
An auxiliary power bus is provided to allow separate power to RAM for systems requiring battery backup of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

Memory Protect
An active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during system power-down sequences.

Line Drivers and Terminators
I/O Drivers — The following line drivers are all compatible with the I/O driver sockets on the iSBC 80/30.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7436</td>
<td>1.OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>1.OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>1.OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

Note
I = inverting; NI = non-inverting; OC = open collector.

Port 1 of the 8255A has 20 mA totem-pole bidirectional drivers and 1 kΩ terminators.

I/O Terminators — 220Ω/330Ω divider or 1 kΩ pullup

Bus Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-state</td>
<td>50</td>
</tr>
<tr>
<td>Address</td>
<td>Tri-state</td>
<td>50</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-state</td>
<td>32</td>
</tr>
</tbody>
</table>

Physical Characteristics
Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 18 oz. (509.6 gm)
### Electrical Characteristics

#### DC Power Requirements

<table>
<thead>
<tr>
<th>Configuration</th>
<th>$V_{CC} = +5V \pm 5%$(max)</th>
<th>$V_{DD} = +12V \pm 5%$(max)</th>
<th>$V_{BB} = -5V \pm 5%$(max)</th>
<th>$V_{AA} = -12V \pm 5%$(max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without EPROM$^1$</td>
<td>$I_{CC} = 3.5A$</td>
<td>$I_{DD} = 220mA$</td>
<td>$I_{BB} = -$</td>
<td>$I_{AA} = 50mA$</td>
</tr>
<tr>
<td>With 8041/8741$^2$</td>
<td>3.6A</td>
<td>220mA</td>
<td>-$</td>
<td>50mA</td>
</tr>
<tr>
<td>RAM only$^3$</td>
<td>350mA</td>
<td>20mA</td>
<td>2.5mA</td>
<td>-$</td>
</tr>
<tr>
<td>With ISBC 530$^4$</td>
<td>3.5A</td>
<td>320mA</td>
<td>-$</td>
<td>150mA</td>
</tr>
<tr>
<td>With 2K EPROM$^5$ (using 8708)</td>
<td>4.4A</td>
<td>350mA</td>
<td>95mA</td>
<td>40mA</td>
</tr>
<tr>
<td>With 2K EPROM$^5$ (using 2758)</td>
<td>4.6A</td>
<td>220mA</td>
<td>-$</td>
<td>50mA</td>
</tr>
<tr>
<td>With 4K EPROM$^5$ (using 2716)</td>
<td>4.6A</td>
<td>220mA</td>
<td>-$</td>
<td>50mA</td>
</tr>
<tr>
<td>With 8K EPROM$^5$ (using 2332)</td>
<td>4.6A</td>
<td>220mA</td>
<td>-$</td>
<td>50mA</td>
</tr>
</tbody>
</table>

#### Notes
1. Does not include power required for optional EPROM/ROM, 8041A/8741A I/O drivers, and I/O terminators.
2. Does not include power required for optional EPROM/ROM, I/O drivers and I/O terminators.
3. RAM chips powered via auxiliary power bus.
4. Does not include power required for optional EPROM/ROM, 8041A/8741A I/O drivers, and I/O terminators. Power for ISBC 530 is supplied through the serial port connector.
5. Includes power required for two EPROM/ROM chips, 8041A/8741A and 220D/330D input terminators installed for 34 I/O lines; all terminator inputs low.

### Environmental Characteristics

**Operating Temperature** — $0°C$ to $55°C$

### Reference Manual

**9800611B** — ISBC 80/30 Single Board Computer Hardware Reference Manual (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.
iSBC 86/05™
SINGLE BOARD COMPUTER

- iAPX 86/10 (8086-2) Microprocessor with 5 or 8 MHz CPU clock
- Fully software compatible with iSBC 86/12A Single Board Computer
- Optional iAPX 86/20 Numeric Data Processor with iSBC 337 MULTIMODULE Processor
- 8K bytes of static RAM; expandable on-board to 16K bytes
- Sockets for up to 64K bytes of JEDEC 24/28-pin standard memory devices; expandable on-board to 128K bytes
- Two iSBX™ bus connectors
- 24 programmable parallel I/O lines
- Programmable synchronous/asynchronous RS232C compatible serial interface with software selectable baud rates
- Two programmable 16-bit BCD or binary timers/event counters
- 9 Levels of vectored interrupt control, expandable to 65 levels
- MULTIBUS interface for multimaster configurations and system expansion
- Supported by a complete family of single board computers, memory, digital and analog I/O, peripheral controllers, packaging and software

The iSBC 86/05 Single Board Computer is a member of Intel's complete line of OEM microcomputer systems which take full advantage of Intel's technology to provide economical, self-contained, computer-based solutions for OEM applications. The iSBC 86/05 board is a complete computer system on a single 6.75 x 12.00-in. printed circuit card. The CPU, system clock, read/write memory, nonvolatile read only memory, I/O ports and drivers, serial communications interface, priority interrupt logic and programmable timers, all reside on the board. The large control storage capacity makes the iSBC 86/05 board ideally suited for control-oriented applications such as process control, instrumentation, industrial automation, and many others.
FUNCTIONAL DESCRIPTION

Central Processing Unit

The central processor for the iSBC 86/05 board is Intel's iAPX 86/10 (8086-2) CPU. A clock rate of 8 MHz is supported with a jumper selectable option of 5 MHz. The CPU architecture includes four 16-bit byte addressable data registers, two 16-bit memory base pointer registers and two 16-bit index registers, all accessed by a total of 24 operand addressing modes for comprehensive memory addressing and for support of the data structures required for today's structured, high level languages as well as assembly language.

Instruction Set

The 8086 instruction repertoire includes variable length instruction format (including double operand instructions), 8-bit and 16-bit signed and unsigned arithmetic operators for binary, BCD and unpacked ASCII data, and iterative word and byte string manipulation functions.

For enhanced numerics processing capability, the iSBC 337 MULTIMODULE Numeric Data Processor extends the iAPX 86/10 architecture and data set. Over 60 numeric instructions offer arithmetic, trigonometric, transcendental, logarithmic and exponential instructions. Supported data types include 16, 32, and 64-bit integer, and 32 and 64-bit floating point, 18-digit packed BCD and 80-bit temporary.

Architectural Features

A 6-byte instruction queue provides pre-fetching of sequential instructions and can reduce the 750 nsec minimum instruction cycle to 250 nsec for queued instructions. The stack-oriented architecture readily supports modular programming by facilitating fast, simple, inter-module communication, and other programming constructs needed for asynchronous real-time systems. The memory expansion capabilities offer a 1 megabyte addressing range. The dynamic relocation scheme allows ease in segmentation of pure procedure and data for efficient memory utilization. Four segment registers (code, stack, data, extra) contain program loaded offset values which are used to map 16-bit addresses to 20-bit addresses. Each register maps 64K bytes at a time and activation of a specific register is controlled explicitly by program control and is also selected implicitly by specific functions and instructions. All Intel languages support the extended memory capability, relieving the programmer of managing the megabyte memory space, yet allowing explicit control when necessary.

Figure 1. iSBC 86/05 Block Diagram
Memory Configuration

The iSBC 86/05 microcomputer contains 8K bytes of high-speed static RAM on-board. In addition, the on-board RAM may be expanded to 16K bytes with the iSBC 302 MULTIMODULE RAM option which mounts on the iSBC 86/05 board. All on-board RAM is accessed by the 8086-2 CPU with no wait states, yielding a memory cycle time of 500 nsec.

In addition to the on-board RAM, the iSBC 86/05 board has four 28-pin sockets, configured to accept JEDEC 24/28-pin standard memory devices. Up to 64K bytes of EPROM are supported in 16K-byte increments with Intel 27128 EPROMs. The iSBC 86/05 board is also compatible with the 2716, 2732, and 2764 EPROMs offering expansion to 8, 16 and 32K bytes, respectively.

With the addition of the iSBC 341 MULTIMODULE EPROM option, the on-board capacity for these devices is doubled, providing up to 128K bytes of EPROM capacity on-board.

Parallel I/O Interface

The iSBC 86/05 Single Board Computer contains 24 programmable parallel I/O lines implemented using the Intel 8255A Programmable Peripheral Interface. The system software is used to configure the I/O lines in any combination of unidirectional input/output and bidirectional ports indicated in Table 1. In order to take advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators, allowing the selection of the appropriate combination of optional line drivers and terminators with the required drive/termination characteristics. The 24 programmable I/O lines and signal ground lines are brought out to a 50-pin edge connector.

Serial I/O

A programmable communications interface using the Intel 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) is contained on the iSBC 86/05 board. A software selectable baud rate generator provides the USART with all common communication frequencies. The mode of operation (i.e., synchronous or asynchronous), data format, control character format, parity, and baud rate are all under program control. The 8251A provides full duplex, double buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the USART. The RS232C compatible interface on each board, in conjunction with the USART, provides a direct interface to RS232C compatible terminals, cassettes, and asynchronous and synchronous modems. The RS232C command lines, serial data lines and signal ground line are brought out to a 26-pin edge connector.

Programmable Timers

The iSBC 86/05 board provides three independent, fully programmable 16-bit interval timers/event counters utilizing the Intel 8253 Programmable

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unidirectional</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latched</td>
<td>Latched &amp; Strobed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Output</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latched</td>
<td>Latched &amp; Strobed</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X¹</td>
</tr>
</tbody>
</table>

NOTE:
1. Part of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
Interval Timer. Each counter is capable of operating in either BCD or binary modes. Two of these timers/counters are available to the systems designer to generate accurate time intervals under software control. Routing for the outputs and gate/trigger inputs of two of these counters is jumper selectable. The outputs may be independently routed to the 8259A Programmable Interrupt Controller and to the I/O terminators associated with the 8255A to allow external devices or an 8255A port to gate the timer or to count external events. The third interval timer in the 8253 provides the programmable baud rate generator for the iSBC 86/05 board RS232C USART serial port. The system software configures each timer independently to select the desired function. Seven functions are available as shown in Table 2. The contents of each counter may be read at any time during system operation.

Table 2. Programmable Timer Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal count</td>
<td>When terminal count is reached, an interrupt request is generated. This function is extremely useful for generation of real-time clocks.</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>Output goes low upon receipt of an external trigger edge or software command and returns high when terminal count is reached. This function is retriggerable.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle, and the period from one low going pulse to the next is N times the input clock period.</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>Output will remain high until one half the count has been completed, and go low for the other half of the count.</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>Output remains high until software loads count (N). N counts after count is loaded, output goes low for one input clock period.</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>Output goes low for one clock period N counts after rising edge counter trigger input. The counter is retriggerable.</td>
</tr>
<tr>
<td>Event counter</td>
<td>On a jumper selectable basis, the clock input becomes an input from the external system. CPU may read the number of events occurring after the counter “window” has been enabled or an interrupt may be generated after N events occur in the system.</td>
</tr>
</tbody>
</table>

iSBX MULTIMODULE On-Board Expansion

Two 8/16-bit iSBX MULTIMODULE connectors are provided on the iSBC 86/05 microcomputer. Through these connectors, additional on-board I/O functions may be added. iSBX MULTIMODULES optimally support functions provided by VLSI peripheral components such as additional parallel and serial I/O, analog I/O, small mass storage device controllers (e.g., cassettes and floppy disks), and other custom interfaces to meet specific needs. By mounting directly on the single board computer, less interface logic, less power, simpler packaging, higher performance, and lower cost result when compared to other alternatives such as MULTIBUS form factor compatible boards. The iSBX connectors on the iSBC 86/05 provide all signals necessary to interface to the local on-board bus, including 16 data lines for maximum data transfer rates. iSBX MULTIMODULES are also designed for use on the iSBC 86/05 board. An iSBX bus interface specification and iSBX connectors are available from Intel.

MULTIBUS™ SYSTEM BUS AND MULTIMASTER CAPABILITIES

Overview

The MULTIBUS system bus is Intel's industry standard microcomputer bus structure. Both 8 and 16-bit single board computers are supported on the MULTIBUS structure with 24 address and 16 data lines. In its simplest application, the MULTIBUS system bus allows expansion of functions already contained on a single board computer (e.g., memory and digital I/O). However, the MULTIBUS structure also allows very powerful distributed processing configurations with multiple processors and intelligent slave I/O, and peripheral boards capable of solving the most demanding microcomputer applications. The MULTIBUS system bus is supported with a broad array of board level products, LSI interface components, detailed published specifications and application notes.

Expansion Capabilities

Memory and I/O capacity may be expanded and additional functions added using Intel MULTIBUS
compatible expansion boards. Memory may be expanded by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capacity may be added with digital I/O and analog I/O expansion boards. Mass storage capability may be achieved by adding single or double density diskette controllers, or hard disk controllers. Modular expandable backplanes and cardcages are available to support multiboard systems.

Multimaster Capabilities

For those applications requiring additional processing capacity and the benefits of multiprocessing (i.e., several CPUs and/or controllers logically sharing system tasks through communication of the system bus), the iSBC 86/05 board provides full MULTIBUS arbitration control logic. This control logic allows up to three iSBC 86/05 boards or other bus masters, including iSBC 80 family MULTIBUS compatible 8-bit single board computers to share the system bus using a serial (daisy chain) priority scheme and allows up to 16 masters to share the MULTIBUS system bus with an external parallel priority decoder. In addition to the multiprocessing configurations made possible with multimaster capability, it also provides a very efficient mechanism for all forms of DMA (Direct Memory Access) transfers.

Interrupt Capability

The iSBC 86/05 board provides 9 vectored interrupt levels. The highest level is the NMI (Non-Maskable Interrupt) line which is directly tied to the 8086 CPU. This interrupt is typically used for signaling catastrophic events (e.g., power failure). The Intel 8259A Programmable Interrupt Controller (PIC) provides control and vectoring for the next eight interrupt levels. As shown in Table 3, a selection of four priority processing modes is available for use in designing request processing configurations to match system requirements for efficient interrupt servicing with minimal latencies. Operating mode and priority assignments may be reconfigured dynamically via software at any time during system operation. The PIC accepts interrupt requests from all on-board I/O resources and from the MULTIBUS system bus. The PIC then resolves requests according to the selected mode and, if appropriate, issues an interrupt to the CPU. Any combination of interrupt levels may be masked via software, by storing a single byte in the interrupt mask register of the PIC. In systems requiring additional interrupt levels, slave 8259A PICs may be interfaced via the MULTIBUS system bus, to generate additional vector addresses, yielding a total of 65 unique interrupt levels.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully nested</td>
<td>Interrupt request line priorities fixed at 0 as highest, 7 as lowest.</td>
</tr>
<tr>
<td>Auto-rotating</td>
<td>Equal priority. Each level, after receiving service, becomes the lowest priority level until next interrupt occurs.</td>
</tr>
<tr>
<td>Specific priority</td>
<td>System software assigns lowest priority level. Priority of all other levels based in sequence numerically on this assignment.</td>
</tr>
<tr>
<td>Polled</td>
<td>System software examines priority-encoded system interrupt status via interrupt status register.</td>
</tr>
</tbody>
</table>

Interrupt Request Generation

Interrupt requests to be serviced by the iSBC 86/05 board may originate from 24 sources. Table 4 includes a list of devices and functions supported by interrupts. All interrupt signals are brought to the interrupt jumper matrix where any combination of interrupt sources may be strapped to the desired interrupt request level on the 8259A PIC or the NMI input to the CPU directly.

Power-Fail Control and Auxiliary Power

Control logic is also included to accept a power-fail interrupt in conjunction with the AC-low signal from the iSBC 635 and iSBC 640 Power Supply or equivalent, to initiate an orderly shut down of the system in the event of a power failure. Additionally, an active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during system power-down sequences. An auxiliary power bus is also provided to allow separate power to RAM for systems requiring battery back-up of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

System Development Capabilities

The development cycle of iSBC 86/05 products can be significantly reduced and simplified by
using the Intellec Series Microcomputer Development Systems. The Assembler, Locating Linker, Library Manager, Text Editor and System Monitor are all supported by the ISIS-II disk-based operating system. To facilitate conversion of 8080A/8085A assembly language programs to run on the iSBC 86/05 board, CONV-86 is available under the ISIS-II operating system.

IN-CIRCUIT EMULATOR

The ICE-86 In-Circuit Emulator provides the necessary link between the software development environment provided by the Intellec system and the "target" iSBC 86/05 execution system. In addition to providing the mechanism for loading executable code and data into the iSBC 86/05 board, the ICE-86 In-Circuit Emulator provides a sophisticated command set to assist in debugging software and final integration of the user hardware and software.

PL/M-86

Intel's system's implementation language, PL/M-86, is also available as an Intellec Microcomputer Development System option. PL/M-86 provides the capability to program in algorithmic language and eliminates the need to manage register usage or allocate memory while still allowing explicit control of the system's resources when needed.

Run-Time Support

Intel also offers two run-time support packages; iRMX 88 Realtime Multitasking Executive and the iRMX 86 Operating System. iRMX 86 is a simple, highly configurable and efficient foundation for small, high performance applications. Its multitasking structure establishes a solid foundation for modular system design and provides task scheduling and management, intertask communication and synchronization, and interrupt servicing for a variety of peripheral devices. Other configurable options include terminal handlers, disk file system, debuggers and other utilities. iRMX 86 is a high functional operating system with a very rich set of features and options based on an object-oriented architecture. In addition to being modular and configurable, functions beyond the nucleus include a sophisticated file management and I/O system, and powerful human interface. Both packages are easily customized and extended by the user to match unique requirements.

<table>
<thead>
<tr>
<th>Device</th>
<th>Function</th>
<th>Number of Interrupts</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIBUS interface</td>
<td>Requests from MULTIBUS resident peripherals or other CPU boards</td>
<td>8; may be expanded to 64 with slave 8259A PICs on MULTIBUS boards</td>
</tr>
<tr>
<td>8255A Programmable Peripheral Interface</td>
<td>Signals input buffer full or output buffer empty; also BUS INTR OUT general purpose interrupt from driver/terminator sockets</td>
<td>3</td>
</tr>
<tr>
<td>8251A USART</td>
<td>Transmit buffer empty and receive buffer full</td>
<td>2</td>
</tr>
<tr>
<td>8253 Timers</td>
<td>Timer 0, 1 outputs; function determined by timer mode</td>
<td>2</td>
</tr>
<tr>
<td>iSBX connectors</td>
<td>Function determined by iSBX MULTIMODULE board</td>
<td>4</td>
</tr>
<tr>
<td>Bus fail safe timer</td>
<td>Indicates addressed MULTIBUS resident device has not responded to command within 6 msec</td>
<td>1</td>
</tr>
<tr>
<td>Power fail interrupt</td>
<td>Indicates AC power is not within tolerance</td>
<td>1</td>
</tr>
<tr>
<td>Power line clock</td>
<td>Source of 120 Hz signal from power supply</td>
<td>1</td>
</tr>
<tr>
<td>External interrupt</td>
<td>General purpose interrupt from auxiliary (P2) connector on backplane</td>
<td>1</td>
</tr>
<tr>
<td>iSBX 337 MULTIMODULE Numeric Data Processor</td>
<td>Indicates error or exception condition</td>
<td>1</td>
</tr>
</tbody>
</table>
SPECIFICATIONS

Word Size
INSTRUCTION — 8, 16, 24, or 32 bits
DATA — 8, 16 bits

System Clock
5.00 MHz or 8.00 MHz ± 0.1% (jumper selectable)

Cycle Time

BASIC INSTRUCTION CYCLE
At 8 MHz — 750 nsec
 — 250 nsec (assumes instruction in the queue)
At 5 MHz — 1.2 μsec
 — 400 nsec (assumes instruction in the queue)

NOTES:
Basic instruction cycle is defined as the fastest instruction time (i.e., two clock cycles).

Memory Cycle Time
RAM — 500 nsec (no wait states)
EPROM — Jumper selectable from 500 nsec to 875 nsec

Memory Capacity/Addressing

ON-BOARD EPROM

<table>
<thead>
<tr>
<th>Device</th>
<th>Total Capacity</th>
<th>Address Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2716</td>
<td>8K bytes</td>
<td>F0000-FFFFFH</td>
</tr>
<tr>
<td>2732</td>
<td>16K bytes</td>
<td>F0000-FFFFFH</td>
</tr>
<tr>
<td>2764</td>
<td>32K bytes</td>
<td>F8000-FFFFFH</td>
</tr>
<tr>
<td>27128</td>
<td>64K bytes</td>
<td>F0000-FFFFFH</td>
</tr>
</tbody>
</table>

WITH ISBC 341 MULTIMODULE EPROM

<table>
<thead>
<tr>
<th>Device</th>
<th>Total Capacity</th>
<th>Address Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2716</td>
<td>16K bytes</td>
<td>F0000-FFFFFH</td>
</tr>
<tr>
<td>2732</td>
<td>32K bytes</td>
<td>F8000-FFFFFH</td>
</tr>
<tr>
<td>2764</td>
<td>64K bytes</td>
<td>F0000-FFFFFH</td>
</tr>
<tr>
<td>27128</td>
<td>128K bytes</td>
<td>E0000-FFFFFH</td>
</tr>
</tbody>
</table>

NOTES:
ISBC 86/05 EPROM sockets support JEDEC 24/28-pin standard EPROMs and RAMs; ISBC 341 sockets also support E²PROMs.

ON-BOARD RAM
8K bytes — 0-1FFFH

WITH ISBC 302 MULTIMODULE RAM
16K bytes — 0-3FFFH

I/O Capacity
PARALLEL — 24 programmable lines using one 8255A.
SERIAL — 1 programmable line using one 8251A
ISBX MULTIMODULE — 2 ISBX MULTIMODULE boards

Serial Communications Characteristics

SYNCHRONOUS — 5-8 bit characters; internal or external character synchronization; automatic sync insertion

ASYNCHRONOUS — 5-8 bit characters; break character generation; 1, 1½, or 2 stop bits; false start bit detection

BAUD RATES

<table>
<thead>
<tr>
<th>Frequency (kHz) (Software Selectable)</th>
<th>Baud Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Synchronous</td>
</tr>
<tr>
<td>153.6</td>
<td>—</td>
</tr>
<tr>
<td>76.8</td>
<td>—</td>
</tr>
<tr>
<td>38.4</td>
<td>38400</td>
</tr>
<tr>
<td>19.2</td>
<td>19200</td>
</tr>
<tr>
<td>9.6</td>
<td>9600</td>
</tr>
<tr>
<td>4.8</td>
<td>4800</td>
</tr>
<tr>
<td>2.4</td>
<td>2400</td>
</tr>
<tr>
<td>1.76</td>
<td>1760</td>
</tr>
</tbody>
</table>

NOTES:
Frequency selected by I/O write of appropriate 16-bit frequency factor to baud rate register (8253 Timer 2).

Timers

INPUT FREQUENCIES
Reference: 2.46 MHz ± 0.1% (0.041 μsec period, nominal); or 153.60 kHz ± 0.1% (6.51 μsec period, nominal)

NOTES:
Above frequencies are user selectable.

Event Rate: 2.46 MHz max

OUTPUT FREQUENCIES/TIMING INTERVALS

<table>
<thead>
<tr>
<th>Function</th>
<th>Single Timer/Counter</th>
<th>Dual Timer/Counter (Two Timers Cascaded)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Real-time Interrupt</td>
<td>1.63μs</td>
<td>427.1ms</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>1.63μs</td>
<td>427.1ms</td>
</tr>
<tr>
<td>Rate generator</td>
<td>2.342Hz</td>
<td>613.5kHz</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>2.342Hz</td>
<td>613.5kHz</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>1.63μs</td>
<td>427.1ms</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>1.63μs</td>
<td>427.1ms</td>
</tr>
<tr>
<td>Event counter</td>
<td>—</td>
<td>2.46MHz</td>
</tr>
</tbody>
</table>
Interfaces
MULTIBUS — All signals TTL compatible
iSBX BUS — All signals TTL compatible
PARALLEL I/O — All signals TTL compatible
SERIAL I/O — RS232C compatible, configurable as a data set or data terminal
TIMER — All signals TTL compatible
INTERRUPT REQUESTS — All TTL compatible

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Double-Sided Pins (qty)</th>
<th>Centers (in.)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIBUS™ System</td>
<td>86</td>
<td>0.156</td>
<td>Viking 3KH43/9AMK12 Wire Wrap</td>
</tr>
<tr>
<td>iSBX™ Bus</td>
<td>36</td>
<td>0.1</td>
<td>iSBX 960-5</td>
</tr>
<tr>
<td>8-Bit Data</td>
<td>36</td>
<td>0.1</td>
<td>iSBX 961-5</td>
</tr>
<tr>
<td>16-Bit Data</td>
<td>44</td>
<td>0.1</td>
<td>3M 3415-000 Flat or TI H312125 Pins</td>
</tr>
<tr>
<td>Parallel I/O (2)</td>
<td>50</td>
<td>0.1</td>
<td>3M 3462-0001 Flat or AMP 88106-1 Flat</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>26</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Line Drivers and Terminators
I/O DRIVERS — The following line drivers are all compatible with the I/O driver sockets on the iSBC 86/05 board

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I,OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>Ni</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>Ni,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>Ni</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

NOTES:
I = inverting; Ni = non-inverting; OC = open collector.
Port 1 of the 8255A has 20 mA totem-pole bidirectional drivers and 1 kΩ terminators
I/O TERMINATORS — 220Ω/330Ω divider or 1 kΩ pullup

220Ω/330Ω (iSBC 901 OPTION)

1 kΩ (iSBC 902 OPTION)

MULTIBUS Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-State</td>
<td>50</td>
</tr>
<tr>
<td>Address</td>
<td>Tri-State</td>
<td>50</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-State</td>
<td>32</td>
</tr>
<tr>
<td>Bus Control</td>
<td>Open Collector</td>
<td>20</td>
</tr>
</tbody>
</table>

Physical Characteristics
WIDTH — 12.00 in. (30.48 cm)
HEIGHT — 6.75 in. (17.15 cm)
DEPTH — 0.70 in. (1.78 cm)
WEIGHT — 14 oz (388 gm)

Electrical Characteristics

DC POWER REQUIREMENTS

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Current Requirements (All Voltages ± 5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+ 5V</td>
</tr>
<tr>
<td>Without EPROM</td>
<td>4.7A</td>
</tr>
<tr>
<td>RAM only¹</td>
<td>120 mA</td>
</tr>
<tr>
<td>With 8K EPROM³</td>
<td>5.0A</td>
</tr>
<tr>
<td>(using 2716)</td>
<td></td>
</tr>
<tr>
<td>With 16K EPROM³</td>
<td>4.9A</td>
</tr>
<tr>
<td>(using 2732)</td>
<td></td>
</tr>
<tr>
<td>With 32K EPROM³</td>
<td>4.9A</td>
</tr>
<tr>
<td>(using 2764)</td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
1. Does not include power for optional ROM/EPROM, I/O drivers, and I/O terminators.
2. RAM chips powered via auxiliary power bus in power-down mode.
3. Includes power required for 4 ROM/EPROM chips, and I/O terminators installed for 16 I/O lines; all terminator inputs low.

Environmental Characteristics
OPERATING TEMPERATURE — 0°C to 55°C
RELATIVE HUMIDITY — to 90% (without condensation)

Reference Manual
143153-001 — iSBC 86/05 Hardware Reference Manual (NOT SUPPLIED)
Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION
Part Number       | Description
SBC 86/05         | 16-bit Single Board Computer with 8K bytes RAM
iSBC™ 86/12A or (pSBC 86/12A*)
SINGLE BOARD COMPUTER

- 8086 16-bit HMOS microprocessor central processor unit
- 32K bytes of dual-port read/write memory expandable on-board to 64K bytes with on-board refresh
- Sockets for up to 16K bytes of read only memory expandable on-board to 32K bytes
- System memory expandable to 1 megabyte
- 24 programmable parallel I/O lines with sockets for interchangeable line drivers and terminators
- Programmable synchronous/asynchronous RS232C compatible serial interface with software selectable baud rates
- Two programmable 16-bit BCD or binary timers/event counters
- 9 levels of vectored interrupt control, expandable to 65 levels
- Auxiliary power bus and power fail interrupt control logic for read/write memory battery backup
- MULTIBUS® interface for multimaster configurations and system expansion
- Compatible with iSBC 337 MULTI- MODULE™ Numeric Data Processor
- Compatible with iSBC 80 family single board computers, memory, digital and analog I/O, and peripheral controller boards

The iSBC 86/12A Single Board Computer is a member of Intel's complete line of OEM microcomputer systems which take full advantage of Intel's LSI technology to provide economical self-contained computer based solutions for OEM applications. The iSBC 86/12A board is a complete computer system on a single 6.75 x 12.00-inch printed circuit card. The CPU, system clock, read/write memory, nonvolatile read only memory, I/O ports and drivers, serial communications interface, priority interrupt logic and programmable timers, all reside on the board. Full MULTIBUS interface logic is included to offer compatibility with the Intel OEM Microcomputer Systems family of Single Board Computers, expansion memory options, digital and analog I/O expansion boards and peripheral controllers.

*Same product, manufactured by Intel Puerto Rico, Inc.

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September 1981
9803115A.01
FUNCTIONAL DESCRIPTION

Central Processing Unit
The central processor for the iSBC 86/12A board is Intel's 8086, a powerful 16-bit HMOS device. The 225 sq. mil chip contains 29,000 transistors and has a clock rate of 5MHz. The architecture includes four (4) 16-bit byte addressable data registers, two (2) 16-bit memory base pointer registers and two (2) 16-bit index registers, all accessed by a total of 24 operand addressing modes for complex data handling and very flexible memory addressing.

Instruction Set — The 8086 instruction repertoire includes variable length instruction format (including double operand instructions), 8-bit and 16-bit signed and unsigned arithmetic operators for binary, BCD and unpacked ASCII data, and iterative word and byte string manipulation functions. In addition, the iSBC 337 MULTIMODULE Numeric Data Processor may be installed to add over 60 numeric instructions and hardware support for multiple precision integer and floating point data types.

Architectural Features — A 6-byte instruction queue provides pre-fetching of sequential instructions and can reduce the 1.2μsec minimum instruction cycle to 400 nsec for queued instructions. The stack oriented architecture facilitates nested subroutines and co-routines, reentrant code and powerful interrupt handling. The memory expansion capabilities offer a 1 megabyte addressing range. The dynamic relocation scheme allows ease in segmentation of pure procedure and data for efficient memory utilization. Four segment registers (code, stack, data, extra) contain program loaded offset values which are used to map 16-bit addresses to 20-bit addresses. Each register maps 64K-bytes at a time and activation of a specific register is controlled explicitly by program control and is also selected implicitly by specific functions and instructions.

Bus Structure
The iSBC 86/12A microcomputer has three buses: an internal bus for communicating with on-board memory and I/O options, the MULTIBUS system bus for referencing additional memory and I/O options, and the dual-port bus which allows access to RAM from the on-board CPU and the MULTIBUS system bus. Local (on-board) accesses do not require MULTIBUS communication, making the system bus available for use by other MULTIBUS masters (i.e. DMA devices and other single board computers transferring to additional system memory). This feature allows true parallel processing in a multiprocessor environment. In addition, the MULTIBUS interface can be used for system expansion through the use of other 8- and 16-bit iSBC computers, memory and I/O expansion boards.

---

Figure 1. ISBC 86/12A Single Board Computer Block Diagram
RAM Capabilities
The iSBC 86/12A microcomputer contains 32K bytes of dynamic read/write memory using 16K-bit 2717 RAMs. In addition, the on-board RAM complement may be expanded to 64K bytes with the iSBC 300 32K-byte MULTIMODULE RAM option. Power for the on-board RAM and refresh circuitry may be optionally provided on an auxiliary power bus, and memory protect logic is included for RAM battery backup requirements. The iSBC 86/12A board contains a dual-port controller which allows access to the on-board RAM (32K bytes or 64K bytes when the iSBC 300 module is included with the iSBC 86/12A board) from the iSBC 86/12A CPU and from any other MULTIBUS master via the system bus. The dual-port controller allows 8- and 16-bit accesses from the MULTIBUS system bus, and the on-board CPU transfers data to RAM over a 16-bit data path. Priorities have been established such that memory refresh is guaranteed by the on-board refresh logic and that the on-board CPU has priority over MULTIBUS system bus requests for access to RAM. The dual-port controller includes independent addressing logic for RAM access from the on-board CPU and from the MULTIBUS system bus. The on-board CPU will always access RAM starting at location 00000H. Address jumpers allow on-board RAM to be located starting on any 8-byte boundary within a 1 megabyte address range for accesses from the MULTIBUS system bus. In conjunction with this feature, the iSBC 86/12A microcomputer has the ability to protect on-board memory from MULTIBUS access to any contiguous 8K-byte segments (or 16K-byte segments with iSBC 300 module). These features allow the multiprocessor systems to establish local memory for each processor and shared system (MULTIBUS) memory configurations where the total system memory size (including local on-board memory) can exceed 1 megabyte without addressing conflicts.

EPROM Capabilities
Four sockets are provided for up to 16K bytes of non-volatile read only memory on the iSBC 86/12A board. EPROM may be added in 2K-byte increments up to a maximum of 4K bytes by using Intel® 2758 electrically programmable ROMs (EPROMs); in 4K-byte increments up to 8K bytes by using Intel 2716 EPROMs; or in 8K-byte increments up to 16K bytes using Intel 2732 EPROMs. On-board EPROM is accessed via 16-bit data paths. On-board EPROM capacity may be expanded to 32K bytes with the addition of the iSBC 340 16K-byte MULTIMODULE EPROM option. It provides an additional four sockets for Intel 2732 EPROMs. With user modification of the iSBC 86/12A’s on-board memory and MULTIBUS address decode, Intel 2758 and 2716 EPROMs may be optionally supported. System memory size is easily expanded by the addition of MULTIBUS system bus compatible memory boards available in the iSBC product family.

Parallel I/O Interface
The iSBC 86/12A single board computer contains 24 programmable parallel I/O lines implemented using the Intel 8255A Programmable Peripheral Interface. The system software is used to configure the I/O lines in any combination of unidirectional input/output and bidirectional ports indicated in Table 1. Therefore, the I/O interface may be customized to meet specific peripheral requirements. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators. Hence, the flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. The 24 programmable I/O lines and signal ground lines are brought out to a 50-pin edge connector that mates with flat, woven, or round cable.

Serial I/O
A programmable communications interface using the Intel 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) is contained on the iSBC 86/12A board. A software selectable baud rate generator provides the USART with all common communication

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
<th>Bidirectional</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unidirectional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input</td>
<td>Output</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latched</td>
<td>Latched &amp;</td>
<td>Latched &amp;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Strobed</td>
<td>Strobed</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Note:
1. Port of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
frequencies. The USART can be programmed by the system software to select the desired asynchronous or synchronous serial data transmission technique (including IBM Bi-Sync). The mode of operation (i.e., synchronous or asynchronous), data format, control character format, parity, and baud rate are all under program control. The 8251A provides full duplex, double buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the USART. The RS232C compatible interface on each board, in conjunction with the USART, provides a direct interface to RS232C compatible terminals, cassettes, and asynchronous and synchronous modems. The RS232C command lines, serial data lines, and signal ground line are brought out to a 26 pin edge connector that mates with asynchronous and synchronous modems. The Teletypewriter RS232C compatible flat interface for those systems requiring a board, in conjunction with the control. transmit and receive interface to simply transfers for the accommodation of devices with various tiplexing logic time during system operation with to meet system requirements. Whenever a given time transfer rates up to 5 megawords/sec. A

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal count</td>
<td>When terminal count is reached, an interrupt request is generated.</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>Output goes low upon receipt of an external trigger edge or software command and returns high when terminal count is reached. This function is retriggerable.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle, and the period from one low going pulse to the next is N times the input clock period.</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>Output will remain high until one-half the count has been completed, and go low for the other half of the count.</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>Output remains high until software loads count (N). N counts after count is loaded, output goes low for one input clock period.</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>Output goes low for one clock period N counts after rising edge counter trigger input. The counter is retriggerable.</td>
</tr>
<tr>
<td>Event counter</td>
<td>On a jumper selectable basis, the clock input becomes an input from the external system. CPU may read the number of events occurring after the counting &quot;window&quot; has been enabled or an interrupt may be generated after N events occur in the system.</td>
</tr>
</tbody>
</table>

**Multimaster Capabilities** — The iSBC™ 86/12A Board is a full computer on a single board with resources capable of supporting a great variety of OEM system requirements. For those applications requiring additional processing capacity and the benefits of multiprocessing (i.e., several CPUs and/or controllers logically sharing system tasks through communication over the system bus), the iSBC 86/12A board provides full MULTIBUS arbitration control logic. This control logic allows up to three iSBC 86/12A boards or other bus masters, including iSBC 80 family MULTIBUS compatible 8-bit single board computers, to share the system bus in serial (daisy chain) priority fashion and up to 16 masters to share the MULTIBUS system bus with the addition of an external priority network. The MULTIBUS arbitration logic operates synchronously with a MULTIBUS clock (provided by the iSBC 86/12A board or optionally provided directly from the MULTIBUS) while data is transferred via a handshake between the master and slave modules. This allows different speed controllers to share resources on the same bus, and transfers via the bus proceed asynchronously. Thus, transfer speed is dependent on transmitting and
receiving devices only. This design prevents slow master modules from being handicapped in their attempts to gain control of the bus, but does not restrict the speed at which faster modules can transfer data via the same bus. The most obvious applications for the master-slave capabilities of the bus are multiprocessor configurations, high speed peripheral control, but are by no means limited to these three.

Interrupt Capability
The iSBC 86/12A board provides 9 vectored interrupt levels. The highest level is the NMI (Non-maskable Interrupt) line which is directly tied to the 8086 CPU. This interrupt cannot be inhibited by software and is typically used for signalling catastrophic events (i.e., power failure). On servicing this interrupt, program control will be implicitly transferred through location 0008H. The Intel 8259A Programmable Interrupt Controller (PIC) provides vectoring for the next eight interrupt levels. As shown in Table 3, a selection of four priority processing modes is available to the systems designer for use in designing request processing configurations to match system requirements. Operating mode and priority assignments may be reconfigured dynamically via software at any time during system operation. The PIC accepts interrupt requests from the programmable parallel and serial I/O interfaces, the programmable timers, the system bus, or directly from peripheral equipment. The PIC then determines which of the incoming requests is of the highest priority, determines whether this request is of higher priority than the level currently being serviced, and, if appropriate, issues an interrupt to the CPU. Any combination of interrupt levels may be masked, via software, by storing a single byte in the interrupt mask register of the PIC. The PIC generates a unique memory address for each interrupt level. These addresses are equally spaced at 4-byte intervals. This 32-byte block may begin at any 32-byte boundary in the lowest 1K-bytes of memory, and contains unique instruction pointers and code segment offset values (for expanded memory operation) for each interrupt level. After acknowledging an interrupt and obtaining a device identifier byte from the 8259A PIC, the CPU will store its status flags on the stack and execute an indirect CALL instruction through the vector location (derived from the device identifier) to the interrupt service routine. In systems requiring additional interrupt levels, slave 8259A PIC’s may be interfaced via the MULTIBUS system bus, to generate additional vector addresses, yielding a total of 65 unique interrupt levels.

Interrupt Request Generation — Interrupt requests may originate from 18 sources. Two jumper selectable interrupt requests can be automatically generated by the programmable peripheral interface when a byte of information is ready to be transferred to the CPU (i.e., input buffer is full) or a byte of information has been transferred to a peripheral device (i.e., output buffer is empty). Two jumper selectable interrupt requests can be automatically generated by the USART when a character is ready to be transferred to the CPU (i.e., receive channel buffer is full, or a character is ready to be transmitted (i.e., transmit channel data buffer is empty). A jumper selectable request can be generated by each of the programmable timers. An additional interrupt request line may be jumpered directly from the parallel I/O driver terminator section. Eight prioritized interrupt request lines allow the iSBC 86/12A board to recognize and service interrupts originating from peripheral boards interfaced via the MULTIBUS system bus. The MULTIBUS fail safe timer of the 337 processor and the exception and error output signal also can be selected as interrupt sources.

Power-Fail Control
Control logic is also included to accept a power-fail interrupt in conjunction with the AC-low signal from the iSBC 655 and iSBC 640 Power Supply or equivalent.

Expansion Capabilities
Memory and I/O capacity may be expanded and additional functions added using Intel MULTIBUS compatible expansion boards. Memory may be expanded by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capacity may be increased by adding digital I/O and analog I/O expansion boards. Mass storage capability may be achieved by adding single or double density diskette controllers, or hard disk controllers. Modular expandable backplanes and cardcages are available to support multiboard systems.

Note: Certain system restrictions may be incurred by the inclusion of some of the iSBC 80 family options in an iSBC 86/12A system. Consult the Intel OEM Microcomputer System Configuration Guide for specific data.

Table 3. Programmable Interrupt Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully nested</td>
<td>Interrupt request line priorities fixed at 0 as highest, 7 as lowest.</td>
</tr>
<tr>
<td>Auto-rotating</td>
<td>Equal priority. Each level, after receiving service, becomes the lowest priority level until next interrupt occurs.</td>
</tr>
<tr>
<td>Specific priority</td>
<td>System software assigns lowest priority level. Priority of all other levels based in sequence numerically on this assignment.</td>
</tr>
<tr>
<td>Poll</td>
<td>System software examines priority-encoded system interrupt status via interrupt status register.</td>
</tr>
</tbody>
</table>

*Note: The first 32 vector locations are reserved by Intel for dedicated vectors. Users who wish to maintain compatibility with present and future Intel products should not use these locations for user-defined vector addresses.
System Development Capabilities

The development cycle of ISBC 86/12A products can be significantly reduced by using the Intellic™ series microcomputer development system. The Assembler, High Level Languages, Locating Linker, Library Manager, Text Editor and System Monitor are all supported by the ISIS-II disk-based operating system.

In-Circuit Emulator — ICE™-86 in-circuit emulator provides the necessary link between the software development environment provided by the Intellic system and the "target" ISBC 86/12A execution system. In addition to providing the mechanism for loading executable code and data into the ISBC 86/12A board, ICE™-86 in-circuit emulator provides a sophisticated command set to assist in debugging software and final integration of the user hardware and software. ICE™-86 in-circuit emulator maximizes the use of available development resources by allowing Intellic resident resources (e.g., memory and peripherals) to be accessed by software running on the target ISBC 86/12A system. In addition, software can be executed without an ISBC 86/12A execution vehicle, in 2K bytes of RAM resident in the ICE™-86 system itself. Symbolic references to instruction and data locations can be made through ICE™-86 in-circuit emulator to allow the user to reference memory locations with assigned names.

PL/M-86 — Intel's high level programming language, PL/M-86, is also available as an Intellic Microcomputer Development System option. PL/M-86 provides the capability to program in a natural, algorithmic language and eliminates the need to manage register usage or allocate memory. PL/M-86 programs can be written in a much shorter time than assembly language programs for a given application. PL/M-86 includes byte and word, integer, pointer and floating point (32-bit) data types and also includes conditional compilation and macro features.

SPECIFICATIONS

Word Size
Instruction — 8, 16, 24, or 32 bits
Data — 8, 16 bits

Cycle Time
Basic Instruction Cycle — 1.2 µsec
— 400 nsec (assumes instruction in the queue)

Note:
Basic instruction cycle is defined as the fastest instruction time (i.e., two clock cycles)

Memory Capacity
On-Board Read Only Memory — 16K bytes (sockets only); expandable to 32K bytes with ISBC 340 16K-byte MULTIMODULE EPROM option.
On-Board RAM — 32K bytes; expandable to 64K bytes with ISBC 300 32K-byte MULTIMODULE RAM option.
Off-Board Expansion — Up to 1 megabyte in user specified combinations of RAM and EPROM.

Note:
Read only memory may be added in 2K, 4K, or 8K-byte increments.

Memory Addressing
On-Board EPROM — FF000—FFFFF in (using 2758 EPROMs); FF000—FFFFF in (using 2716 EPROMs); FC000—FFFFF in (using 2732 EPROMS); F8000—FFFFF in (with ISBC 340 EPROM option and four additional 2732 EPROMs).
On-Board RAM — 32K bytes of dual port RAM. Optionally expandable to 64K bytes with ISBC 300 RAM option.
CPU Access — 32K bytes: 00000—07FFFF; 64K bytes: 00000—0FFFFF.

I/O Capacity
Parallel — 24 programmable lines using one 8255A.
Serial — 1 programmable line using one 8251A.

I/O Addressing
On-Board Programmable I/O

<table>
<thead>
<tr>
<th>Port</th>
<th>8255A</th>
<th>USART</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Address</td>
<td>CB</td>
<td>CA</td>
</tr>
</tbody>
</table>

Serial Communications Characteristics

Synchronous — 5—8 bit characters; internal or external character synchronization; automatic sync insertion.
Asynchronous — 5—8 bit characters; break character generation; 1, 1½, or 2 stop bits; false start bit detection.

Baud Rates

<table>
<thead>
<tr>
<th>Frequency (kHz) (Software Selectable)</th>
<th>Baud Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Synchronous</td>
</tr>
<tr>
<td>153.6</td>
<td>—</td>
</tr>
<tr>
<td>76.8</td>
<td>4800</td>
</tr>
<tr>
<td>38.4</td>
<td>2400</td>
</tr>
<tr>
<td>19.2</td>
<td>1200</td>
</tr>
<tr>
<td>9.6</td>
<td>600</td>
</tr>
<tr>
<td>4.8</td>
<td>4800</td>
</tr>
<tr>
<td>2.4</td>
<td>2400</td>
</tr>
<tr>
<td>1.76</td>
<td>1760</td>
</tr>
</tbody>
</table>

Note:
Frequency selected by I/O write of appropriate 16-bit frequency factor to baud rate register (8253 Timer 2).
Interrupts
Addresses for 8259A Registers (Hex notation I/O address space)
C0 or C4  Write: Initialization Command Word 1 (ICW1) and Operation Control Words 2 and 3 (OCW2 and OCW3)
Read: Status and Poll Registers
C2 or C6  Write: ICW2, ICW3, ICW4, OCW1 (Mask Register)
Read: OCW1 (Mask Register)

Note:
Several registers have the same physical address; sequence of access and one data bit of control word determine which register will respond.

Interrupt Levels — 8086 CPU includes a non-maskable interrupt (NMI) and a maskable interrupt (INTR). NMI interrupt is provided for catastrophic events such as power failure. NMI vector address is 00008. INTR interrupt is driven by on-board 8259A PIC, which provides 8-bit identifier of interrupting device to CPU. CPU multiplies identifier by four to derive vector address. Jumpers select interrupts from 18 sources without necessity of external hardware. PIC may be programmed to accommodate edge-sensitive or level-sensitive inputs.

Timers
Register Addresses (Hex notation, I/O address space)
D0  Timer 0
D2  Timer 1
D4  Timer 2
D6  Control register

Note:
Timer frequencies are loaded as two sequential output operations to same address as given.

Input Frequencies
Reference: 2.46 MHz ± 0.1% (0.041 μs period, nominal); 1.23 MHz ± 0.1% (0.81 μs period, nominal); or 153.60 kHz ± 0.1% (6.51 μs period nominal).

Note:
Above frequencies are user selectable.

Event Rate: 2.46 MHz max

Output Frequencies/Timing Intervals

<table>
<thead>
<tr>
<th>Function</th>
<th>Single Timer/Counter</th>
<th>Dual Timer/Counter (Two Timers Cascaded)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Real-time interrupt</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Rate generator</td>
<td>2.342 Hz</td>
<td>613.5 kHz</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>2.342 Hz</td>
<td>613.5 kHz</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Event counter</td>
<td>—</td>
<td>2.46 MHz</td>
</tr>
</tbody>
</table>

Interfaces
MULTIBUS — All signals TTL compatible
Parallel I/O — All signals TTL compatible
Interrupt Requests — All TTL compatible
Timer — All signals TTL compatible
Serial I/O — RS232C compatible, data set configuration

System Clock (8086 CPU)
5.00 MHz ± 0.1%

Auxiliary Power
An auxiliary power bus is provided to allow separate power to RAM for systems requiring battery backup of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (n)</th>
<th>Centers (m)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>88</td>
<td>0.156</td>
<td>VIKING 3KH43/9AMK12</td>
</tr>
<tr>
<td>Parallel I/O</td>
<td>50</td>
<td>0.1</td>
<td>3M 3415-000</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>26</td>
<td>0.1</td>
<td>3M 3462-000</td>
</tr>
</tbody>
</table>

Memory Protect
An active low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during system power down sequences.

Line Drivers and Terminators
I/O Drivers — The following line drivers are all compatible with the I/O driver sockets on the iSBC 86/12A board

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I,OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

Note:
I = inverting; NI = non-inverting; OC = open collector.

Port 1 of the 8255A has 20 mA totem-pole bidirectional drivers and 1 kΩ terminators.

I/O Terminators — 220Ω/330Ω divider or 1 kΩ pullup

220Ω/330Ω (ISBC 901 OPTION)

1 kΩ (ISBC 902 OPTION)
Bus Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-state</td>
<td>50</td>
</tr>
<tr>
<td>Address</td>
<td>Tri-state</td>
<td>50</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-state</td>
<td>32</td>
</tr>
</tbody>
</table>

Physical Characteristics

Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.70 in. (1.78 cm)
Weight — 19 oz. (539 gm)

Environmental Characteristics

Operating Temperature — 0°C to 55°C
Relative Humidity — to 90% (without condensation)

Reference Manual

9803074-01 — ISBC 86/12A Single Board Computer Hardware Reference Manual (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

Electrical Characteristics

DC Power Requirements

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Current Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_{CC} = +5V \pm 5%$ (max)</td>
</tr>
<tr>
<td>Without EPROM$^1$</td>
<td>5.2A</td>
</tr>
<tr>
<td>RAM Only$^3$</td>
<td>390 mA</td>
</tr>
<tr>
<td>With ISBC 530$^4$</td>
<td>5.2A</td>
</tr>
<tr>
<td>With 4K EPROM$^5$ (using 2758)</td>
<td>5.5A</td>
</tr>
<tr>
<td>With 8K EPROM$^5$ (using 2716)</td>
<td>5.5A</td>
</tr>
<tr>
<td>With 16K EPROM$^5$ (using 2732)</td>
<td>5.4A</td>
</tr>
</tbody>
</table>

Notes:
1. Does not include power for optional EPROM, I/O drivers, and I/O terminators.
2. Does not include power required for optional EPROM, I/O drivers, and I/O terminators.
3. RAM chips powered via auxiliary power bus.
4. Does not include power for optional EPROM, I/O drivers, and I/O terminators. Power for ISBC 530 is supplied via serial port connector.
5. Includes power required for four EPROM chips, and I/O terminators installed for 16 I/O lines; all terminator inputs low.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 86/12A</td>
<td>Single Board Computer with 32K bytes RAM</td>
</tr>
</tbody>
</table>
iSBC™ 86/14 and iSBC™ 86/30
SINGLE BOARD COMPUTERS

- iAPX 86/10 (8086-2) Microprocessor with 5 or 8 MHz CPU clock
- Fully software compatible with iSBC™ 86/12A Single Board Computer
- Optional iAPX 86/20 Numeric Data Processor with iSBC™ 337 MULTIMODULE™ processor
- 32K/128K bytes of dual-port read/write memory expandable on-board to 256K bytes with on-board refresh
- Sockets for up to 64K bytes of JEDEC 24/28-pin standard memory devices
- Two iSBX™ bus connectors
- 24 programmable parallel I/O lines
- Programmable synchronous/asynchronous RS232C compatible serial interface with software selectable baud rates
- Two programmable 16-bit BCD or binary timers/event counters
- 9 Levels of vectored interrupt control, expandable to 65 levels
- MULTIBUS® interface for multimaster configurations and system expansion
- Supported by a complete family of single board computers, memory, digital and analog I/O, peripheral controllers, packaging and software

The iSBC 86/14 and iSBC 86/30 Single Board Computers are members of Intel's complete line of OEM microcomputer systems which take full advantage of Intel's technology to provide economical, self-contained, computer-based solutions for OEM applications. Each board is a complete computer system on a single 6.75 x 12.00-in. printed circuit card distinguished by RAM memory content with 32K bytes and 128K bytes provided on the iSBC 86/14 and iSBC 86/30 board, respectively. The CPU, system clock, read/write memory, nonvolatile read only memory, I/O ports and drivers, serial communications interface, priority interrupt logic and programmable timers, all reside on the boards.

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FUNCTIONAL DESCRIPTION

Central Processing Unit

The central processor for the iSBC 86/XX(1) boards is Intel's iAPX 86/10 (8086-2) CPU. A clock rate of 8 MHz is supported with a jumper selectable option of 5 MHz. The CPU architecture includes four 16-bit byte addressable data registers, two 16-bit memory base pointer registers and two 16-bit index registers, all accessed by a total of 24 operand addressing modes for comprehensive memory addressing and for support of the data structures required for today's structured, high level languages as well as assembly language.

Instruction Set

The 8086 instruction repertoire includes variable length instruction format (including double operand instructions), 8-bit and 16-bit signed and unsigned arithmetic operators for binary, BCD and unpacked ASCII data, and iterative word and byte string manipulation functions.

For enhanced numerics processing capability, the iSBC 337 MULTIMODULE Numeric Data Processor extends the iAPX 86/10 architecture and data set. Over 60 numeric instructions offer arithmetic, trigonometric, transcendental, logarithmic and exponential instructions. Supported data types include 16, 32, and 64-bit integer, and 32 and 64-bit floating point, 18-digit packed BCD and 80-bit temporary.

Architectural Features

A 6-byte instruction queue provides pre-fetching of sequential instructions and can reduce the 750 nsec minimum instruction cycle to 250 nsec for queued instructions. The stack-oriented architecture readily supports modular programming by facilitating fast, simple, inter-module communication, and other programming constructs needed for asynchronous real-time systems. The memory expansion capabilities offer a 1 megabyte addressing range. The dynamic relocation scheme allows ease in segmentation of pure procedure and data for efficient memory utilization. Four segment registers (code, stack, data, extra) contain program loaded offset values which are used to map 16-bit addresses to 20-bit addresses. Each register maps 64K bytes at a time and activation of a specific register is controlled explicitly by program control and is also selected implicitly by specific functions and instructions.

RAM Capabilities

The iSBC 86/14 and iSBC 86/30 microcomputers contain 32K bytes and 128K bytes of dual-port dynamic RAM, respectively. In addition, on-board

---

(1) iSBC 86/XX designates both the iSBC 86/14 and iSBC 86/30 CPU boards.

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Figure 1. iSBC™ 86/XX Block Diagram
iSBC™ 86/14 and iSBC™ 86/30

RAM may be doubled on each microcomputer by optionally adding RAM MULTIMODULE boards. The on-board RAM may be expanded to 256K bytes with the iSBC 304 MULTIMODULE Board mounted onto the iSBC 86/30 board. Likewise, the iSBC 86/14 microcomputer may be expanded to 64K bytes with the iSBC 300A MULTIMODULE option. The dual-port controller allows access to the on-board RAM (including RAM MULTIMODULE options) from the iSBC 86/XX boards and from any other MULTIBUS master via the system bus. Segments of on-board RAM may be configured as a private resource, protected from MULTIBUS system access. The amount of memory allocated as a private resource may be configured in increments of 25% of the total on-board memory ranging from 0% to 100% (optional RAM MULTIMODULE boards double the increment size). These features allow the multiprocessor systems to establish local memory for each processor and shared system memory configurations where the total system memory size (including local on-board memory) can exceed one megabyte without addressing conflicts.

EPROM Capabilities

Four 28-pin sockets are provided for the use of Intel 2716s, 2732s, 2764s, 27128s, and their respective ROMs. When using 27128s, the on-board EPROM capacity is 64K bytes. Other JEDEC standard pinout devices are also supported, including byte-wide static RAMs.

Parallel I/O Interface

The iSBC 86/XX Single Board Computers contain 24 programmable parallel I/O lines implemented using the Intel 8255A Programmable Peripheral Interface. The system software is used to configure the I/O lines in any combination of unidirectional input/output and bidirectional ports indicated in Table 1. In order to take advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators, allowing the selection of the appropriate combination of optional line drivers and terminators with the required drive/termination characteristics. The 24 programmable I/O lines and signal ground lines are brought out to a 50-pin edge connector.

Serial I/O

A programmable communications interface using the Intel 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) is contained on the iSBC 86/XX boards. A software selectable baud rate generator provides the USART with all common communication frequencies. The mode of operation (i.e., synchronous or asynchronous), data format, control character format, parity, and baud rate are all under program control. The 8251A provides full duplex, double buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the USART. The RS232C command lines, serial data lines and signal ground line are brought out to a 26-pin edge connector.

Programmable Timers

The iSBC 86/XX boards provide three independent, fully programmable 16-bit interval timers/event counters utilizing the Intel 8253 Programmable Interval Timer. Each counter is capable of operating in either BCD or binary modes. Two of these timers/counters are available to the systems designer to generate accurate time intervals under software control. Routing for the outputs and gate/trigger inputs of two of these counters is jumper selectable. The outputs may be indepen-

Table 1. Input/Output Port Modes of Operation

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unidirectional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latched</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

NOTE:
1. Part of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
boards optimally support functions provided by VLSI peripheral components such as additional parallel and serial I/O, analog I/O, small mass storage device controllers (e.g., cassettes and floppy disks), and other custom interfaces to meet specific needs. By mounting directly on the single board computer, less interface logic, less power, simpler packaging, higher performance, and lower cost result when compared to other alternatives such as MULTIBUS form factor compatible boards. The iSBX connectors on the iSBC 86/XX boards provide all signals necessary to interface to the local on-board bus, including 16 data lines for maximum data transfer rates. iSBX MULTIMODULE boards designed with 8-bit data paths and using the 8-bit iSBX connector are also supported on the iSBC 86/XX microcomputers. A broad range of iSBX MULTIMODULE options are available in this family from Intel. Custom iSBX modules may also be designed for use on the iSBC 86/XX boards. An iSBX bus interface specification and iSBX connectors are available from Intel.

MULTIBUS® SYSTEM BUS AND MULTIMASTER CAPABILITIES

Overview

The MULTIBUS system bus is Intel's industry standard microcomputer bus structure. Both 8 and 16-bit single board computers are supported on the MULTIBUS structure with 24 address and 16 data lines. In its simplest application, the MULTIBUS system bus allows expansion of functions already contained on a single board computer (e.g., memory and digital I/O). However, the MULTIBUS structure also allows very powerful distributed processing configurations with multiple processors and intelligent slave I/O, and peripheral boards capable of solving the most demanding microcomputer applications. The MULTIBUS system bus is supported with a broad array of board level products, LSI interface components, detailed published specifications and application notes.

Expansion Capabilities

Memory and I/O capacity may be expanded and additional functions added using Intel MULTIBUS compatible expansion boards. Memory may be expanded by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capacity may be added with digital I/O and analog I/O expansion boards. Mass storage capability may be achieved by adding single or double density diskette controllers, or

Table 2. Programmable Timer Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal count</td>
<td>When terminal count is reached, an interrupt request is generated. This</td>
</tr>
<tr>
<td></td>
<td>function is extremely useful for generation of real-time clocks.</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>Output goes low upon receipt of an external trigger edge or software</td>
</tr>
<tr>
<td></td>
<td>command and returns high when terminal count is reached. This function is</td>
</tr>
<tr>
<td></td>
<td>retriggerable.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle,</td>
</tr>
<tr>
<td></td>
<td>and the period from one low going pulse to the next is N times the input</td>
</tr>
<tr>
<td></td>
<td>clock period.</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>Output will remain high until one-half the count has been completed, and</td>
</tr>
<tr>
<td></td>
<td>go low for the other half of the count.</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>Output remains high until software loads count (N). N counts after count</td>
</tr>
<tr>
<td></td>
<td>is loaded, output goes low for one input clock period.</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>Output goes low for one clock period N counts after rising edge counter</td>
</tr>
<tr>
<td></td>
<td>trigger input. The counter is retriggerable.</td>
</tr>
<tr>
<td>Event counter</td>
<td>On a jumper selectable basis, the clock input becomes an input from the</td>
</tr>
<tr>
<td></td>
<td>external system. CPU may read the number of events occurring after the</td>
</tr>
<tr>
<td></td>
<td>counter “window” has been enabled or an interrupt may be generated after</td>
</tr>
<tr>
<td></td>
<td>N events occur in the system.</td>
</tr>
</tbody>
</table>

iSBX™ MULTIMODULE™ On-Board Expansion

Two 8/16-bit iSBX MULTIMODULE connectors are provided on the iSBC 86/XX microcomputers. Through these connectors, additional on-board I/O functions may be added. iSBX MULTIMODULE
hard disk controllers. Modular expandable backplanes and cardcages are available to support multiboard systems.

Multimaster Capabilities

For those applications requiring additional processing capacity and the benefits of multiprocessing (i.e., several CPUs and/or controllers logically sharing system tasks through communication of the system bus), the iSBC 86/XX boards provide full MULTIBUS arbitration control logic. This control logic allows up to three iSBC 86/XX boards or other bus masters, including iSBC 80 family MULTIBUS compatible 8-bit single board computers to share the system bus using a serial (daisy chain) priority scheme and allows up to 16 masters to share the MULTIBUS system bus with an external parallel priority decoder. In addition to the multiprocessing configurations made possible with multimaster capability, it also provides a very efficient mechanism for all forms of DMA (Direct Memory Access) transfers.

Interrupt Capability

The iSBC 86/XX boards provide 9 vectored interrupt levels. The highest level is the NMI (Non-Maskable Interrupt) line which is directly tied to the 8086 CPU. This interrupt is typically used for signaling catastrophic events (e.g., power failure). The Intel 8259A Programmable Interrupt Controller (PIC) provides control and vectoring for the next eight interrupt levels. As shown in Table 3, a selection of four priority processing modes is available for use in designing request processing configurations to match system requirements for efficient interrupt servicing with minimal latencies. Operating mode and priority assignments may be reconfigured dynamically via software at any time during system operation. The PIC accepts interrupt requests from all on-board I/O resources and from the MULTIBUS system bus. The PIC then resolves requests according to the selected mode and, if appropriate, issues an interrupt to the CPU. Any combination of interrupt levels may be masked via software, by storing a single byte in the interrupt mask register of the PIC. In systems requiring additional interrupt levels, slave 8259A PICs may be interfaced via the MULTIBUS system bus, to generate additional vector addresses, yielding a total of 65 unique interrupt levels.

Interrupt Request Generation

Interrupt requests to be serviced by the iSBC 86/XX boards may originate from 28 sources. Table 4 includes a list of devices and functions supported by interrupts. All interrupt signals are brought to the interrupt jumper matrix where any combination of interrupt sources may be strapped to the desired interrupt request level on the 8259A PIC or the NMI input to the CPU directly.

Power-Fail Control and Auxiliary Power

Control logic is also included to accept a power-fail interrupt in conjunction with the AC-low signal from the iSBC 635 and iSBC 640 Power Supply or equivalent, to initiate an orderly shut down of the system in the event of a power failure. Additionally, an active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during system power-down sequences. An auxiliary power bus is also provided to allow separate power to RAM for systems requiring battery back-up of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

System Development Capabilities

The development cycle of iSBC 86/XX products can be significantly reduced and simplified by using either the System 86/330 or the Intellec Series Microcomputer Development Systems. The Assembler, Locating Linker, Library Manager, Text Editor and System Monitor are all supported by the ISIS-II disk-based operating system. To facilitate conversion of 8080A/8085A assembly language programs to run on the iSBC 86/XX boards, CONV-86 is available under the ISIS-II operating system.
IN-CIRCUIT EMULATOR

The Intellec ICE-86 In-Circuit Emulator provides the necessary link between the software development environment provided by the Intellec system and the "target" iSBC 86/XX execution system. In addition to providing the mechanism for loading executable code and data into the iSBC 86/XX boards, the ICE-86 In-Circuit Emulator provides a sophisticated command set to assist in debugging software and final integration of the user hardware and software.

PLM-86

Intel's system's implementation language, PLM-86, is standard in the System 86/330 and is also available as an Intellec Microcomputer Development System option. PLM-86 provides the capability to program in algorithmic language and eliminates the need to manage register usage or allocate memory while still allowing explicit control of the system's resources when needed. FORTRAN 86 and PASCAL 86 are also available on Intellec or 86/330 systems.

Run-Time Support

Intel also offers two run-time support packages; iRMX 88 Realtime Multitasking Executive and the iRMX 86 Operating System. The iRMX 88 executive is a simple, highly configurable and efficient foundation for small, high performance applications. Its multitasking structure establishes a solid foundation for modular system design and provides task scheduling and management, intertask communication and synchronization, and interrupt servicing for a variety of peripheral devices. Other configurable options include terminal handlers, disk file system, debuggers and other utilities. The iRMX 86 Operating System is a high functional operating system with a very rich set of features and options based on an object-oriented architecture. In addition to being modular and configurable, functions beyond the nucleus include a sophisticated file management and I/O system, and powerful human interface. Both packages are easily customized and extended by the user to match unique requirements.

Table 4. Interrupt Request Sources

<table>
<thead>
<tr>
<th>Device</th>
<th>Function</th>
<th>Number of Interrupts</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIBUS® interface</td>
<td>Requests from MULTIBUS® resident peripherals or other CPU boards</td>
<td>8; may be expanded to 64 with slave 8259A PICs on MULTIBUS® boards</td>
</tr>
<tr>
<td>8255A Programmable Peripheral Interface</td>
<td>Signals input buffer full or output buffer empty; also BUS INTR OUT general purpose interrupt from driver/terminator sockets</td>
<td>3</td>
</tr>
<tr>
<td>8251A USART</td>
<td>Transmit buffer empty and receive buffer full</td>
<td>2</td>
</tr>
<tr>
<td>8253 Timers</td>
<td>Timer 0, 1 outputs; function determined by timer mode</td>
<td>2</td>
</tr>
<tr>
<td>iSBX™ connectors</td>
<td>Function determined by iSBX™ MULTIMODULE™ board</td>
<td>4 (2 per iSBX™ connector)</td>
</tr>
<tr>
<td>Bus fail safe timer</td>
<td>Indicates addressed MULTIBUS® resident device has not responded to command within 6 msec</td>
<td>1</td>
</tr>
<tr>
<td>Power fail interrupt</td>
<td>Indicates AC power is not within tolerance</td>
<td>1</td>
</tr>
<tr>
<td>Power line clock</td>
<td>Source of 120 Hz signal from power supply</td>
<td>1</td>
</tr>
<tr>
<td>External interrupt</td>
<td>General purpose interrupt from auxiliary (P2) connector on backplane</td>
<td>1</td>
</tr>
<tr>
<td>iSBCTM 337 MULTIMODULE™ Numeric Data Processor</td>
<td>Indicates error or exception condition</td>
<td>1</td>
</tr>
<tr>
<td>Parity error</td>
<td>Indicates on-board RAM parity error from iSBC™ 303 parity MULTIMODULE™ board (iSBC™ 86/14 option)</td>
<td>1</td>
</tr>
<tr>
<td>Edge-level conversion</td>
<td>Converts edge triggered interrupt request to level interrupt</td>
<td>1</td>
</tr>
<tr>
<td>OR-gate matrix</td>
<td>Outputs of OR-gates on-board for multiple interrupts</td>
<td>2</td>
</tr>
</tbody>
</table>
SPECIFICATIONS

Word Size
INSTRUCTION — 8, 16, 24, or 32 bits
DATA — 8, 16 bits

System Clock
5.00 MHz or 8.00 MHz ± 0.1% (jumper selectable)

Cycle Time
BASIC INSTRUCTION CYCLE
8 MHz — 750 ns
— 250 ns (assumes instruction in the queue)
5 MHz — 1.2 µsec
— 400 ns (assumes instruction in the queue)

NOTE: Basic instruction cycle is defined as the fastest instruction time (i.e., two clock cycles).

Memory Cycle Time
RAM — 750 ns
EPROM — Jumper selectable from 500 ns to 875 ns

Memory Capacity/Addressing

ON-BOARD EPROM
Device   Total Capacity Address Range
2716     8K bytes FE000-FFFFFH
2732     16K bytes FC000-FFFFFH
2764     32K bytes F8000-FFFFFH
27128    64K bytes F0000-FFFFFH

NOTE: iSBC 86/XX EPROM sockets support JEDEC 24/28-pin standard EPROMs and RAMs.

ON-BOARD RAM
Board    Total Capacity Address Range
iSBC 86/14 32K bytes 0-07FFFH
iSBC 86/30 128K bytes 0-1FFFFH

WITH MULTIMODULE™ RAM
Board    Total Capacity Address Range
iSBC 300A 64K bytes 0-0FFFFH
(with iSBC 86/14)
iSBC 304 256K bytes 0-3FFFFH
(with iSBC 86/30)

I/O Capacity
PARALLEL — 24 programmable lines using one 8255A.
SERIAL — 1 programmable line using one 8251A
iSBX™ MULTIMODULE™ — 2 iSBX boards

Serial Communications Characteristics
SYNCHRONOUS — 5–8 bit characters; internal or external character synchronization; automatic sync insertion

ASYNCHRONOUS — 5–8 bit characters; break character generation; 1, 1½, or 2 stop bits; false start bit detection

BAUD RATES

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Baud Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Software Selectable)</td>
<td>Synchronous</td>
</tr>
<tr>
<td>153.6</td>
<td>—</td>
</tr>
<tr>
<td>76.8</td>
<td>—</td>
</tr>
<tr>
<td>38.4</td>
<td>38400</td>
</tr>
<tr>
<td>19.2</td>
<td>19200</td>
</tr>
<tr>
<td>9.6</td>
<td>9600</td>
</tr>
<tr>
<td>4.8</td>
<td>4800</td>
</tr>
<tr>
<td>2.4</td>
<td>2400</td>
</tr>
<tr>
<td>1.76</td>
<td>1760</td>
</tr>
</tbody>
</table>

NOTE: Frequency selected by I/O write of appropriate 16-bit frequency factor to baud rate register (8253 Timer 2).

Timers

INPUT FREQUENCIES
Reference: 2.46 MHz ± 0.1% (0.041 µsec period, nominal); or 153.60 kHz ± 0.1% (6.51 µsec period, nominal)

NOTE: Above frequencies are user selectable.

Event Rate: 2.46 MHz max

OUTPUT FREQUENCIES/TIMING INTERVALS

<table>
<thead>
<tr>
<th>Function</th>
<th>Single Timer/Counter</th>
<th>Dual Timer/Counter (Cascaded)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Real-time</td>
<td>1.63 µs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Interrupt</td>
<td>1.63 µs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>2.342 Hz</td>
<td>613.5 kHz</td>
</tr>
<tr>
<td>Rate generator</td>
<td>2.342 Hz</td>
<td>613.5 kHz</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>2.342 Hz</td>
<td>613.5 kHz</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>1.63 µs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>1.63 µs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Event counter</td>
<td>—</td>
<td>2.46 MHz</td>
</tr>
</tbody>
</table>

Interfaces

MULTIBUS® — All signals TTL compatible
iSBX™ BUS — All signals TTL compatible
PARALLEL I/O — All signals TTL compatible
SERIAL I/O — RS232C compatible, configurable as a data set or data terminal
**iSBC™ 86/14 and iSBC™ 86/30**

**TIMER** — All signals TTL compatible

**INTERRUPT REQUESTS** — All TTL compatible

### Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Double-Sided Pins</th>
<th>Centers (in.)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIBUS® System</td>
<td>86</td>
<td>0.156</td>
<td>Viking 3KH43/9AMK12 Wire Wrap</td>
</tr>
<tr>
<td>iSBX™ Bus 8-Bit Data</td>
<td>36</td>
<td>0.1</td>
<td>iSBX 960-5</td>
</tr>
<tr>
<td>Parallel I/O (2)</td>
<td>50</td>
<td>0.1</td>
<td>3M 3415-000 Flat or TI H312125 Pins</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>26</td>
<td>0.1</td>
<td>3M 3462-0001 Flat or AMP 88106-1 Flat</td>
</tr>
</tbody>
</table>

### Line Drivers and Terminators

**I/O DRIVERS** — The following line drivers are all compatible with the I/O driver sockets on the iSBC 86/05 board

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I,OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

**NOTE:** I = inverting; NI = non-inverting; OC = open collector.

Port 1 of the 8255A has 20 mA totem-pole bidirectional drivers and 1 kΩ terminators

**I/O TERMINATORS** — 220Ω/330Ω divider or 1 kΩ pullup

**220Ω/330Ω (iSBC™ 901 OPTION)**

**1 kΩ (iSBC™ 902 OPTION)**

### MULTIBUS® Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-State</td>
<td>32</td>
</tr>
<tr>
<td>Address</td>
<td>Tri-State</td>
<td>32</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-State</td>
<td>32</td>
</tr>
<tr>
<td>Bus Control</td>
<td>Open Collector</td>
<td>20</td>
</tr>
</tbody>
</table>

### Physical Characteristics

**WIDTH** — 12.00 in. (30.48 cm)

**HEIGHT** — 6.75 in. (17.15 cm)

**DEPTH** — 0.70 in. (1.78 cm)

**WEIGHT** — 14 oz (388 gm)

### Environmental Characteristics

**OPERATING TEMPERATURE** — 0°C to 55°C

**RELATIVE HUMIDITY** — to 90% (without condensation)

### Electrical Characteristics

#### DC POWER REQUIREMENTS

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Current Requirements (All Voltages ±5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+5V</td>
</tr>
<tr>
<td>Without EPROM₁</td>
<td>5.1A</td>
</tr>
<tr>
<td>RAM only²</td>
<td>600 mA</td>
</tr>
<tr>
<td>With 8K EPROM³ (using 2716)</td>
<td>5.4A</td>
</tr>
<tr>
<td>With 16K EPROM³ (using 2732)</td>
<td>5.5A</td>
</tr>
<tr>
<td>With 32K EPROM³ (using 2764)</td>
<td>5.6A</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Does not include power for optional ROM/EPROM, I/O drivers, and I/O terminators.
2. RAM chips powered via auxiliary power bus in power-down mode.
3. Includes power required for 4 ROM/EPROM chips, and I/O terminators installed for 16 I/O lines; all terminator inputs low.

### Environmental Characteristics

**OPERATING TEMPERATURE** — 0°C to 55°C

**RELATIVE HUMIDITY** — to 90% (without condensation)

### Reference Manual

144044-001 — iSBC 86/14 and iSBC 86/30 Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

### ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 86/14</td>
<td>Single Board Computer</td>
</tr>
<tr>
<td>SBC 86/30</td>
<td>Single Board Computer</td>
</tr>
</tbody>
</table>
iSBC™ 88/25
SINGLE BOARD COMPUTER

- 8-bit 8088 Microprocessor operating at 5 MHz
- One megabyte addressing range
- Two iSBX™ bus connectors
- Optional Numeric Data Processor with iSBC 337 MULTIMODULE™ Processor
- 4K bytes of static RAM; expandable on-board to 16K bytes
- Sockets for up to 64K bytes of JEDEC 24/28-pin standard memory devices; expandable on-board to 128K bytes
- Programmable synchronous/asynchronous RS232C compatible serial interface with software selectable baud rates
- 24 programmable parallel I/O lines
- Two programmable 16-bit BCD or binary timers/event counters
- 9 Levels of vectored interrupt control, expandable to 65 levels
- MULTIBUS® interface for multimaster configurations and system expansion
- Supported by a complete family of single board computers, memory, digital and analog I/O, peripheral controllers, packaging and software

The iSBC 88/25 Single Board Computer is a member of Intel's complete line of OEM microcomputer systems which take full advantage of Intel's technology to provide economical, self-contained, computer-based solutions for OEM applications. The iSBC 88/25 board is a complete computer system on a single 6.75 x 12.00-in. printed circuit card. The CPU, system clock, read/write memory, nonvolatile read only memory, I/O ports and drivers, serial communications interface, priority interrupt logic and programmable timers, all reside on the board. The large control storage capacity makes the iSBC 88/25 board ideally suited for control-oriented applications such as process control, instrumentation, industrial automation, and many others.
FUNCTIONAL DESCRIPTION

Central Processing Unit
The central processor for the iSBC 88/25 board is Intel's 8088 CPU operating at 5 MHz. The CPU architecture includes four 16-bit byte addressable data registers, two 16-bit memory base pointer registers and two 16-bit index registers, all accessed by a total of 24 operand addressing modes for comprehensive memory addressing and for support of the data structures required for today's structured, high level languages, as well as assembly language.

Instruction Set
The 8088 instruction repertoire includes variable length instruction format (including double operand instructions), 8-bit and 16-bit signed and unsigned arithmetic operators for binary, BCD and unpacked ASCII data, and iterative word and byte string manipulation functions.

For enhanced numerics processing capability, the iSBC 337 MULTIMODULE Numeric Data Processor extends the architecture and data set. Over 60 numeric instructions offer arithmetic, trigonometric, transcendental, logarithmic and exponential instructions. Supported data types include 16, 32, and 64-bit integer, and 32 and 64-bit floating point, 18-digit packed BCD and 80-bit temporary.

Architectural Features
A 4-byte instruction queue provides pre-fetching of sequential instructions and can reduce the 750 nsec minimum instruction cycle to 250 nsec for queued instructions. The stack-oriented architecture readily supports modular programming by facilitating fast, simple, inter-module communication, and other programming constructs needed for asynchronous real-time systems. The memory expansion capabilities offer a 1 megabyte addressing range. The dynamic relocation scheme allows ease in segmentation of pure procedure and data for efficient memory utilization. Four segment registers (code, stack, data, extra) contain program loaded offset values which are used to map 16-bit addresses to 20-bit addresses. Each register maps 64K bytes at a time and activation of a specific register is controlled explicitly by program control and is also selected implicitly by specific functions and instructions. All Intel® languages support the extended memory capability, relieving the programmer of managing the megabyte memory space, yet allowing explicit control when necessary.

Figure 1. iSBC 88/25 Block Diagram
Memory Configuration

The iSBC 88/25 microcomputer contains 4K bytes of high-speed static RAM on-board. In addition, the on-board RAM may be expanded to 12K bytes via the iSBC 302 8K byte RAM module which mounts on the iSBC 88/25 board and then to 16K bytes by adding two 4Kx4 RAM devices in sockets on the iSBC 302 module. All on-board RAM is accessed by the 8088 CPU with no wait states, yielding a memory cycle time of 800 nsec.

In addition to the on-board RAM, the iSBC 88/25 board has four 28-pin sockets, configured to accept JEDEC 24/28-pin standard memory devices. Up to 64K bytes of EPROM are supported in 16K-byte increments with Intel 27128 EPROMs. The iSBC 88/25 board is also compatible with the 2716, 2732, and 2764 EPROMs allowing a capacity of 8K, 16K, and 32K bytes, respectively. Other JEDEC standard pinout devices are also supported, including byte-wide static and integrated RAMs.

With the addition of the iSBC 341 MULTIMODULE EPROM option, the on-board capacity for these devices is doubled, providing up to 128K bytes of EPROM capacity on-board.

Parallel I/O Interface

The iSBC 88/25 Single Board Computer contains 24 programmable parallel I/O lines implemented using the Intel 8255A Programmable Peripheral Interface. The system software is used to configure the I/O lines in any combination of unidirectional input/output and bidirectional ports indicated in Table 1. In order to take advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators, allowing the selection of the appropriate combination of optional line drivers and terminators with the required drive/termination characteristics. The 24 programmable I/O lines and signal ground lines are brought out to a 50-pin edge connector.

Serial I/O

A programmable communications interface using the Intel 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) is contained on the iSBC 88/25 board. A software selectable baud rate generator provides the USART with all common communication frequencies. The mode of operation (i.e., synchronous or asynchronous), data format, control character format, parity, and baud rate are all under program control. The 8251A provides full duplex, double buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the USART. The RS232C compatible interface on each board, in conjunction with the USART, provides a direct interface to RS232C compatible terminals, cassette, and asynchronous and synchronous modems. The RS232C command lines, serial data lines and signal ground line are brought out to a 26-pin edge connector.

Programmable Timers

The iSBC 88/25 board provides three independent, fully programmable 16-bit interval timers/event counters utilizing the Intel 8253 Programmable

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unidirectional</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input</td>
<td>Output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latched</td>
<td>Latched &amp; Strobed</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

NOTE:
1. Part of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
Interval Timer. Each counter is capable of operating in either BCD or binary modes. Two of these timers/counters are available to the systems designer to generate accurate time intervals under software control. Routing for the outputs and gate/trigger inputs of two of these counters is jumper selectable. The outputs may be independently routed to the 8259A Programmable Interrupt Controller and to the I/O terminators associated with the 8255A to allow external devices or an 8255A port to gate the timer or to count external events. The third interval timer in the 8253 provides the programmable baud rate generator for the iSBC 88/25 board RS232C USART serial port. The system software configures each timer independently to select the desired function. Seven functions are available as shown in Table 2. The contents of each counter may be read at any time during system operation.

Table 2. Programmable Timer Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal count</td>
<td>When terminal count is reached, an interrupt request is generated. This function is extremely useful for generation of real-time clocks.</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>Output goes low upon receipt of an external trigger edge or software command and returns high when terminal count is reached. This function is retriggerable.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle, and the period from one low going pulse to the next is N times the input clock period.</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>Output will remain high until one-half the count has been completed, and go low for the other half of the count.</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>Output remains high until software loads count (N). N counts after count is loaded, output goes low for one input clock period.</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>Output goes low for one clock period N counts after rising edge counter trigger input. The counter is retriggerable.</td>
</tr>
<tr>
<td>Event counter</td>
<td>On a jumper selectable basis, the clock input becomes an input from the external system. CPU may read the number of events occurring after the counter “window” has been enabled or an interrupt may be generated after N events occur in the system.</td>
</tr>
</tbody>
</table>

iSBX MULTIMODULE On-Board Expansion

Two 8-bit iSBX MULTIMODULE connectors are provided on the iSBC 88/25 microcomputer. Through these connectors, additional on-board I/O functions may be added. iSBX MULTIMODULES optimally support functions provided by VLSI peripheral components such as additional parallel and serial I/O, analog I/O, small mass storage device controllers (e.g., cassettes and floppy disks), and other custom interfaces to meet specific needs. By mounting directly on the single board computer, less interface logic, less power, simpler packaging, higher performance, and lower cost result when compared to other alternatives such as MULTIBUS form factor compatible boards. The iSBC connectors on the iSBC 88/25 provide all signals necessary to interface to the local on-board bus. A broad range of iSBX MULTIMODULE options are available in this family from Intel. Custom iSBX modules may also be designed for use on the iSBC 88/25 board. An iSBC bus interface specification and iSBC connectors are available from Intel.

MULTIBUS SYSTEM BUS AND MULTIMASTER CAPABILITIES

Overview

The MULTIBUS system bus is Intel's industry standard microcomputer bus structure. Both 8 and 16-bit single board computers are supported on the MULTIBUS structure with 24 address and 16 data lines. In its simplest application, the MULTIBUS system bus allows expansion of functions already contained on a single board computer (e.g., memory and digital I/O). However, the MULTIBUS structure also allows very powerful distributed processing configurations with multiple processors and intelligent slave I/O, and peripheral boards capable of solving the most demanding microcomputer applications. The MULTIBUS system bus is supported with a broad array of board level products, LSI interface components, detailed published specifications and application notes.

Expansion Capabilities

Memory and I/O capacity may be expanded and additional functions added using Intel MULTIBUS compatible expansion boards. Memory may be expanded by adding user specified combinations
of RAM boards, EPROM boards, or combination boards. Input/output capacity may be added with digital I/O and analog I/O expansion boards. Mass storage capability may be achieved by adding single or double density diskette controllers, or hard disk controllers. Modular expandable backplanes and cardcages are available to support multiboard systems.

**Multimaster Capabilities**

For those applications requiring additional processing capacity and the benefits of multiprocessing (i.e., several CPUs and/or controllers logically sharing system tasks through communication of the system bus), the iSBC 88/25 board provides full MULTIBUS arbitration control logic. This control logic allows up to three iSBC 88/25 boards or other bus masters, including iSBC 80 and iSBC 86 family MULTIBUS compatible single board computers to share the system bus using a serial (daisy chain) priority scheme and allows up to 16 masters to share the MULTIBUS system bus with an external parallel priority decoder. In addition to the multiprocessing configurations made possible with multimaster capability, it also provides a very efficient mechanism for all forms of DMA (Direct Memory Access) transfers.

**Interrupt Capability**

The iSBC 88/25 board provides 9 vectored interrupt levels. The highest level is the NMI (Non-Maskable Interrupt) line which is directly tied to the 8088 CPU. This interrupt is typically used for signaling catastrophic events (e.g., power failure). The Intel 8259A Programmable Interrupt Controller (PIC) provides control and vectoring for the next eight interrupt levels. As shown in Table 3, a selection of four priority processing modes is available for use in designing request processing configurations to match system requirements for efficient interrupt servicing with minimal latencies. Operating mode and priority assignments may be reconfigured dynamically via software at any time during system operation. The PIC accepts interrupt requests from all on-board I/O resources and from the MULTIBUS system bus. The PIC then resolves requests according to the selected mode and, if appropriate, issues an interrupt to the CPU. Any combination of interrupt levels may be masked via software, by storing a single byte in the interrupt mask register of the PIC. In systems requiring additional interrupt levels, slave 8259A PICs may be interfaced via the MULTIBUS system bus, to generate additional vector addresses, yielding a total of 65 unique interrupt levels.

**Table 3. Programmable Interrupt Modes**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully nested</td>
<td>Interrupt request line priorities fixed at 0 as highest, 7 as lowest.</td>
</tr>
<tr>
<td>Auto-rotating</td>
<td>Equal priority. Each level, after receiving service, becomes the lowest priority level until next interrupt occurs.</td>
</tr>
<tr>
<td>Specific priority</td>
<td>System software assigns lowest priority level. Priority of all other levels based in sequence numerically on this assignment.</td>
</tr>
<tr>
<td>Polled</td>
<td>System software examines priority-encoded system interrupt status via interrupt status register.</td>
</tr>
</tbody>
</table>

**Interrupt Request Generation**

Interrupt requests to be serviced by the iSBC 88/25 board may originate from 24 sources. Table 4 includes a list of devices and functions supported by interrupts. All interrupt signals are brought to the interrupt jumper matrix where any combination of interrupt sources may be strapped to the desired interrupt request level on the 8259A PIC or the NMI input to the CPU directly.

**Power-Fail Control and Auxiliary Power**

Control logic is also included to accept a power-fail interrupt in conjunction with the AC-low signal from the iSBC 635 and iSBC 640 Power Supply or equivalent, to initiate an orderly shut down of the system in the event of a power failure. Additionally, an active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during system power-down sequences. An auxiliary power bus is also provided to allow separate power to RAM for systems requiring battery back-up of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

**System Development Capabilities**

The development cycle of iSBC 88/25 products can be significantly reduced and simplified by
using the Intellec Series Microcomputer Development Systems. The Assembler, Locating Linker, Library Manager, Text Editor and System Monitor are all supported by the ISIS-II disk-based operating system. To facilitate conversion of 8080A/8085A assembly language programs to run on the iSBC 88/25 board, CONV-86 is available under the ISIS-II operating system.

IN-CIRCUIT EMULATOR

The ICE-88 In-Circuit Emulator provides the necessary link between the software development environment provided by the Intellec system and the "target" iSBC 88/25 execution system. In addition to providing the mechanism for loading executable code and data into the iSBC 88/25 board, the ICE-88 In-Circuit Emulator provides a sophisticated command set to assist in debugging software and final integration of the user hardware and software.

PL/M-86

Intel's system's implementation language, PL/M-86, is also available as an Intellec Microcomputer Development System option. PL/M-86 provides the capability to program in algorithmic language and eliminates the need to manage register usage or allocate memory while still allowing explicit control of the system's resources when needed.

Run-Time Support

Intel also offers two run-time support packages; iRMX 88 Realtime Multitasking Executive and the iRMX 86 Operating System. iRMX 88 is a simple, highly configurable and efficient foundation for small, high performance applications. Its multitasking structure establishes a solid foundation for modular system design and provides task scheduling and management, intertask communication and synchronization, and interrupt servicing for a variety of peripheral devices. Other configurable options include terminal handlers, disk file system, debuggers and other utilities. iRMX 86 is a high functional operating system with a very rich set of features and options based on an object-oriented architecture. In addition to being modular and configurable, functions beyond the nucleus include a sophisticated file management and I/O system, and powerful human interface. Both packages are easily customized and extended by the user to match unique requirements.

<table>
<thead>
<tr>
<th>Device</th>
<th>Function</th>
<th>Number of Interrupts</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIBUS interface</td>
<td>Requests from MULTIBUS resident peripherals or other CPU boards</td>
<td>8; may be expanded to 64 with slave 8259A PIC's on MULTIBUS boards</td>
</tr>
<tr>
<td>8255A Programmable Peripheral Interface</td>
<td>Signals input buffer full or output buffer empty; also BUS INTR OUT general purpose interrupt from driver/terminator sockets</td>
<td>3</td>
</tr>
<tr>
<td>8251A USART</td>
<td>Transmit buffer empty and receive buffer full</td>
<td>2</td>
</tr>
<tr>
<td>8253 Timers</td>
<td>Timer 0, 1 outputs; function determined by timer mode</td>
<td>2</td>
</tr>
<tr>
<td>ISBX connectors</td>
<td>Function determined by ISBX MULTIMODULE board</td>
<td>4</td>
</tr>
<tr>
<td>(2 per ISBX connector)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus fail safe timer</td>
<td>Indicates addressed MULTIBUS resident device has not responded to command within 6 msec</td>
<td>1</td>
</tr>
<tr>
<td>Power fail interrupt</td>
<td>Indicates AC power is not within tolerance</td>
<td>1</td>
</tr>
<tr>
<td>Power line clock</td>
<td>Source of 120 Hz signal from power supply</td>
<td>1</td>
</tr>
<tr>
<td>External interrupt</td>
<td>General purpose interrupt from parallel port J1 connector</td>
<td>1</td>
</tr>
<tr>
<td>iSBC 337 MULTIMODULE Numeric Data Processor</td>
<td>Indicates error or exception condition</td>
<td>1</td>
</tr>
</tbody>
</table>
SPECIFICATIONS

Word Size
INSTRUCTION — 8, 16, 24, or 32 bits
DATA — 8 bits

System Clock
5.00 MHz or 4.17 MHz ± 0.1% (jumper selectable)
NOTE: 4.17 MHz required with the optional iSBC 337 module.

Cycle Time
BASIC INSTRUCTION CYCLE
At 5 MHz — 1.2 μsec
— 400 nsec (assumes instruction in the queue)
NOTES: Basic instruction cycle is defined as the fastest instruction time (i.e., two clock cycles).

Memory Cycle Time
RAM — 800 nsec (no wait states)
EPROM — Jumper selectable from 800 nsec to 1400 nsec

Memory Capacity/Addressing
ON-BOARD EPROM

<table>
<thead>
<tr>
<th>Device</th>
<th>Total Capacity</th>
<th>Address Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2716</td>
<td>8K bytes</td>
<td>FE000–FFFFFH</td>
</tr>
<tr>
<td>2732</td>
<td>16K bytes</td>
<td>FC000–FFFFFH</td>
</tr>
<tr>
<td>2764</td>
<td>32K bytes</td>
<td>F8000–FFFFFH</td>
</tr>
<tr>
<td>27128</td>
<td>64K bytes</td>
<td>F0000–FFFFFH</td>
</tr>
</tbody>
</table>

WITH iSBC 341 MULTIMODULE EPROM

<table>
<thead>
<tr>
<th>Device</th>
<th>Total Capacity</th>
<th>Address Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2716</td>
<td>16K bytes</td>
<td>FC000–FFFFFH</td>
</tr>
<tr>
<td>2732</td>
<td>32K bytes</td>
<td>F8000–FFFFFH</td>
</tr>
<tr>
<td>2764</td>
<td>64K bytes</td>
<td>F0000–FFFFFH</td>
</tr>
<tr>
<td>27128</td>
<td>128K bytes</td>
<td>E0000–FFFFFH</td>
</tr>
</tbody>
</table>

NOTES: iSBC 88/25 EPROM sockets support JEDEC 24/28-pin standard EPROMs and RAMs (2 sockets); iSBC 341 sockets also support E²PROMs.

ON-BOARD RAM
4K bytes — 0–0FFFH

WITH iSBC 302 MULTIMODULE RAM
12K bytes — 0–2FFFH

WITH iSBC 302 MULTIMODULE BOARD AND TWO 4K x 4 RAM CHIPS
16K bytes — 0–3FFFH

I/O Capacity
PARALLEL — 24 programmable lines using one 8255A
SERIAL — 1 programmable line using one 8251A
iSBX MULTIMODULE — 2 iSBX MULTIMODULE boards

Serial Communications Characteristics
SYNCHRONOUS — 5–8 bit characters; internal or external character synchronization; automatic sync insertion
ASYNCHRONOUS — 5–8 bit characters; break character generation; 1, 1 ½, or 2 stop bits; false start bit detection

BAUD RATES

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Baud Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Software Selectable)</td>
<td>Synchronous</td>
</tr>
<tr>
<td>153.6</td>
<td>—</td>
</tr>
<tr>
<td>76.8</td>
<td>—</td>
</tr>
<tr>
<td>38.4</td>
<td>38400</td>
</tr>
<tr>
<td>19.2</td>
<td>19200</td>
</tr>
<tr>
<td>9.6</td>
<td>9600</td>
</tr>
<tr>
<td>4.8</td>
<td>4800</td>
</tr>
<tr>
<td>2.4</td>
<td>2400</td>
</tr>
<tr>
<td>1.76</td>
<td>1760</td>
</tr>
</tbody>
</table>

NOTES: Frequency selected by I/O write of appropriate 16-bit frequency factor to baud rate register (8253 Timer 2).

Timers

INPUT FREQUENCIES
Reference: 2.458 MHz ± 0.1% (406.9 nsec period, nominal); or 1.229 MHz ± 0.1% (813.8 nsec period, nominal); or 153.6 kHz ± 0.1% (6.510 μsec period, nominal)

NOTES: Above frequencies are user selectable.

Event Rate: 2.46 MHz max

OUTPUT FREQUENCIES/TIMING INTERVALS

<table>
<thead>
<tr>
<th>Function</th>
<th>Single Timer/Counter</th>
<th>Dual Timer/Counter (Two Timers Cascaded)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Real-time</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Interrupt</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>2.342 Hz</td>
<td>613.5 kHz</td>
</tr>
<tr>
<td>Rate generator</td>
<td>2.342 Hz</td>
<td>613.5 kHz</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>1.63 μs</td>
<td>427.1 ms</td>
</tr>
<tr>
<td>Event counter</td>
<td>—</td>
<td>2.46 MHz</td>
</tr>
</tbody>
</table>
Interfaces

MULTIBUS — All signals TTL compatible
iSBX BUS — All signals TTL compatible
PARALLEL I/O — All signals TTL compatible
SERIAL I/O — RS232C compatible, configurable as a data set or data terminal
TIMER — All signals TTL compatible
INTERRUPT REQUESTS — All TTL compatible

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Double-Sided Pins (qty)</th>
<th>Centers (in.)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIBUS System</td>
<td>86</td>
<td>0.156</td>
<td>Viking 3KH43/9AMK12 Wire Wrap</td>
</tr>
<tr>
<td>iSBX Bus 8-Bit Data</td>
<td>36</td>
<td>0.1</td>
<td>iSBX 960-5</td>
</tr>
<tr>
<td>Parallel I/O (2)</td>
<td>50</td>
<td>0.1</td>
<td>3M 3415-000 Flat or TI H312125 Pins</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>26</td>
<td>0.1</td>
<td>3M 3462-0001 Flat or AMP88106-1 Flat</td>
</tr>
</tbody>
</table>

Line Drivers and Terminators

I/O DRIVERS — The following line drivers are all compatible with the I/O driver sockets on the iSBC 88/25 board

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I,OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

NOTES:
I = inverting; NI = non-inverting; OC = open collector.
Port 1 of the 8255A has 32 mA totem-pole bidirectional drivers and 10 kΩ terminators

I/O TERMINATORS — 220Ω/330Ω divider or 1 kΩ pullup
220Ω/330Ω (iSBC 901 OPTION)
1 kΩ (iSBC 902 OPTION)

MULTIBUS Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-State</td>
<td>32</td>
</tr>
<tr>
<td>Address</td>
<td>Tri-State</td>
<td>24</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-State</td>
<td>32</td>
</tr>
<tr>
<td>Bus Control</td>
<td>Open Collector</td>
<td>20</td>
</tr>
</tbody>
</table>

Physical Characteristics

WIDTH — 12.00 in. (30.48 cm)
HEIGHT — 6.75 in. (17.15 cm)
DEPTH — 0.70 in. (1.78 cm)
WEIGHT — 14 oz (388 gm)

Electrical Characteristics

DC POWER REQUIREMENTS

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Current Requirements (All Voltages ± 5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+ 5V</td>
</tr>
<tr>
<td>Without EPROM1</td>
<td>3.8A</td>
</tr>
<tr>
<td>RAM only2</td>
<td>104 mA</td>
</tr>
<tr>
<td>With 8K EPROM3 (using 2716)</td>
<td>4.3A</td>
</tr>
<tr>
<td>With 16K EPROM3 (using 2732)</td>
<td>4.4A</td>
</tr>
<tr>
<td>With 32K EPROM3 (using 2764)</td>
<td>4.4A</td>
</tr>
</tbody>
</table>

NOTES:
1. Does not include power for optional ROM/EPROM, I/O drivers, and I/O terminators.
2. RAM chips powered via auxiliary power bus in power-down mode. Does not include power for optional RAM.
3. Includes power required for 4 ROM/EPROM chips, and I/O terminators installed for 16 I/O lines; all terminator inputs low.

Environmental Characteristics

OPERATING TEMPERATURE — 0°C to 55°C
RELATIVE HUMIDITY — to 90% (without condensation)

Reference Manual

143825-001 — iSBC 88/25 Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 88/25</td>
<td>8-bit Single Board Computer with 4K bytes RAM</td>
</tr>
</tbody>
</table>
iSBC 88/40
MEASUREMENT AND CONTROL COMPUTER

- High performance 5 MHz iAPX 88/10 8-bit HMOS processor
- 12-bit, 20 kHz analog-to-digital converter with programmable gain control
- 16 differential/32 single-ended analog input channels
- Three iSBX MULTIMODULE connectors for analog, digital, and other I/O expansion
- 4K bytes static RAM, expandable via iSBC 301 MULTIMODULE RAM to 8K bytes (1K byte dual-ported)
- Four ERROM/E2PROM sockets for up to 32K bytes, expandable to 64K bytes with iSBC 341 expansion MULTIMODULE
- On-board 21-volt power supply for E2PROM modification under program control
- MULTIBUS Intelligent Slave or Multimaster

The Intel iSBC 88/40 Measurement and Control Computer is a member of Intel's large family of Single Board Computers that takes full advantage of Intel's VLSI technology to provide an economical self-contained computer based solution for applications in the areas of process control and data acquisition. The on-board iAPX 88/10 processor with its powerful instruction set allows users of the iSBC 88/40 board to update process loops as much as 5-10 times faster than previously possible with other 8-bit microprocessors. For example, the high performance iSBC 88/40 can concurrently process and update 16 control loops in less than 200 milliseconds using a traditional PID (Proportional-Integral-Derivative) control algorithm. The iSBC 88/40 board consists of a 16 differential/32 single ended channel analog multiplexer with input protected circuits, A/D converter, programmable central processing unit, dual port and private RAM, read only memory sockets, interrupt logic, 24 channels of parallel I/O, three programmable timers and MULTIBUS control logic on a single 6.75 by 12.00-inch printed circuit card. The iSBC 88/40 board is capable of functioning by itself in a stand-alone system or as a multimaster or intelligent slave in a large MULTIBUS system.
FUNCTIONAL DESCRIPTION

Three Modes of Operation

The iSBC 88/40 Measurement and Control Computer (MACC) is capable of operating in one of three modes: stand-alone controller, bus multimaster or intelligent slave. A block diagram of the iSBC 88/40 Measurement and Control Computer is shown in Figure 1.

Stand-Alone Controller

The iSBC 88/40 Measurement and Control Computer may function as a stand-alone single board controller with CPU, memory and I/O elements on a single board. The on-board 4K bytes of RAM and up to 32K bytes of read only memory, as well as the analog-to-digital converter and programmable parallel I/O lines allow significant control and monitoring capabilities from a single board.

Bus Multimaster

In this mode of operation the iSBC 88/40 board may interface and control a wide variety of iSBC memory and I/O boards or even with additional iSBC 88/40 boards or other single board computer masters or intelligent slaves.

Intelligent Slave

The iSBC 88/40 board can perform as an intelligent slave to any Intel 8 or 16-bit MULTIBUS master CPU by not only offloading the master of the analog data collection, but it can also do a significant amount of pre-processing and decision making on its own. The distribution of processing tasks to intelligent slaves frees the system master to do other system functions. The dual port RAM with flag bytes for signalling allows the iSBC 88/40 board to process and store data without MULTIBUS memory or bus contention.

Central Processing Unit

The central processor unit for the iSBC 88/40 board is a powerful 8-bit HMOS iAPX 88/10 microprocessor. The 22.5 sq. mil. chip contains approximately 29,000 transistors and has a clock rate of 8 MHz. The architecture includes four (4) addressable data registers and two (2) 16-bit memory base pointer registers and two (2) 16-bit index registers, all accessed by a total of 24 operand addressing modes for complex data handling and very flexible memory addressing.

Figure 1. iSBC 88/40 Measurement and Control Computer Block Diagram
INSTRUCTION SET — The iAPX 88/10 instruction repertoire includes variable length instruction format (including double operand instructions), 8-bit and 16-bit signed and unsigned arithmetic operators for binary, BCD and unpacked ASCII data, and iterative word and byte string manipulation functions. The instruction set of the iAPX 88/10 is a superset of the 8080A/8085A family and with available software tools, programs written for the 8080A/8085A can be easily converted and run on the iAPX 88/10 processor. Programs can also be run that are implemented on the iAPX 88/10 with little or no modification.

ARCHITECTURAL FEATURES — A 4-byte instruction queue provides pre-fetching of sequential instructions and can reduce the 750 nsec minimum instruction cycle to 250 nsec for queued instructions. The stack oriented architecture facilitates nested subroutines and co-routines, reentrant code and powerful interrupt handling. The memory expansion capabilities offer a 1 megabyte addressing range. The dynamic relocation scheme allows ease in segmentation of pure procedure instructions and data for efficient memory utilization. Four segment registers (code, stack, data, extra) contain program loaded offset values which are used to map 16-bit addresses to 20-bit addresses. Each register maps 64K bytes at a time and activation of a specific register is controlled explicitly by program control and is also selected implicitly by specific functions and instructions.

Bus Structure
The iSBC 88/40 single board computer has three buses: 1) an internal bus for communicating with on-board memory, analog-to-digital converter, iSBX MULTIMODULES and I/O options; 2) the MULTIBUS system bus for referencing additional memory and I/O options, and 3) the dual-port bus which allows access to RAM from the on-board CPU and the MULTIBUS system bus. Local (on-board) accesses do not require MULTIBUS communication, making the system bus available for use by other MULTIBUS masters (i.e. DMA devices and other single board computers transferring to additional system memory). This feature allows true parallel processing in a multiprocessor environment. In addition, the MULTIBUS interface can be used for system expansion through the use of other 8- and 16-bit iSBC computers, memory and I/O expansion boards.

RAM Capabilities
DUAL-PORT RAM — The dual-port RAM of the iSBC 88/40 board consists of 1K bytes of static RAM, implemented with Intel 2114A chips. The on-board base address of this RAM is 00C00 (3K) normally; it is relocated to 01C00 (7K) when the iSBC 301 MULTIMODULE RAM is added to the protected RAM. The MULTIBUS port base address of the dual-port RAM can be jumpered to any 1K byte boundary in the 1M byte address space. The dual-port RAM can be accessed in a byte-wide fashion from the MULTIBUS system bus. When accessed from the MULTIBUS system bus, the dual-port RAM decode logic will generate INH1/ (Inhibit RAM) to allow dual-port RAM to overlay other system RAM. The dual-port control logic is designed to favor an on-board RAM access. If the dual-port is not currently performing a memory cycle for the MULTIBUS system port, only one wait state will be required. The on-board port may require more than one wait state if the dual-port RAM was busy when the on-board cycle was requested. The LOCK prefix facility of the iAPX 88/10 assembly language will disallow system bus accesses to the dual-port RAM. In addition, the on-board port to the dual-port RAM can be locked by other compatible MULTIBUS masters, which allow true symmetric semaphore operation. When the board is functioning in the master mode, the LOCK prefix will additionally disable other masters from obtaining the system bus.

PRIVATE RAM — In addition to the 1K byte dual-port RAM, there is a 3K byte section of private static RAM not accessible from the system bus. This RAM has a base address of 00000, and consists of three Intel 8185 RAM chips which are interfaced to the multiplexed address/data bus of the iAPX 88/10 microprocessor. Expansion of this private RAM from 3K to 7K bytes can be accomplished by the addition of an iSBC 301 MULTIMODULE RAM (4K bytes). When the 301 is added, protected RAM extends from 0 to 7K, and the base address of the dual-port RAM is relocated from 3K (00C00) to 7K (01C00). All protected RAM accesses require one wait state. The private RAM resides on the local on-board bus, which eliminates contention problems between on-board accesses to private RAM and system bus accesses to dual-port RAM. The private RAM can be battery backed (up to 16K bytes).

Additional RAM can be added by utilizing JEDEC-compatible static or pseudo-static RAMs in the available EPROM sockets.

Parallel I/O Interface
The iSBC 88/40 single board computer contains 24 programmable parallel I/O lines implemented using the Intel 8255A Programmable Peripheral In-
interface. The system software is used to configure the I/O lines in any combination of unidirectional input/output and bidirectional ports indicated in Table 1. There the I/O interface may be customized to meet specific peripheral requirements. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators. Port 2 can also accept TTL compatible peripheral drives, such as 75461/462, 75471/472, etc. These are open collector, high voltage drivers (up to 55 volts) which can sink 300 mA. Hence, the flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. The 24 programmable I/O lines and signal ground lines are brought out to a 50-pin edge connector that mates with flat, woven, or round cable. This edge connector is also compatible with the Intel iCS 920 Digital I/O and iCS 930 AC Signal Conditioning/Termination Panels, for field wiring, optical isolation and high power (up to 3 amp) power drive.

**EPROM Capabilities**

Four (4) 28-pin sockets are provided for the use of Intel 2716s, 2732s, 2764s, future JEDEC-compatible 128K and 256K bit EPROMs and their respective ROMs. When using 2764s the on-board EPROM capacity is 32K bytes. Read only memory expansion is available through the use of the ISBC 341 EPROM/ROM memory expansion MULTIMODULE. When the ISBC 341 is used an additional four (4) EPROM sockets are made available, for a total ISBC 88/40 board capacity of 64K bytes EPROM with Intel 2764s.

**EEPROM Capabilities**

The four 28-pin sockets can also accommodate Intel 2816 EEPROMs, for dynamic storage of control loop setpoints, conversion parameters, or other data (or programs) that change periodically but must be kept in nonvolatile storage. To give the user dynamic control of this nonvolatile memory, the ISBC 88/40 board also contains an on-board DC to DC converter which under program control will furnish the voltage necessary for modifying the contents of Intel 2816/2815 EEPROMs.

**Timing Logic**

The ISBC 88/40 board provides an 8253-5 Programmable Interval Timer, which contains three independent, programmable 16-bit timers/event counters. All three of these counters are available to generate time intervals or event counts under software control. The outputs of the three counters may be independently routed to the interrupt matrix. The inputs and outputs of timers 0 and 1 can be connected to parallel I/O lines on the J1 connector, where they replace 8255A port C lines. The third counter is also used for timing EEPROM write operations.

**Interrupt Capability**

The ISBC 88/40 board provides 9 vectored interrupt levels. The highest level is the NMI (Non-maskable Interrupt) line which is directly tied to the iAPX 88/10 CPU. This interrupt cannot be inhibited by software and is typically used for signalling catastrophic events (i.e., power failure). On servicing this interrupt, program control will be implicitly transferred through location 00008H. The Intel 8259A Programmable Interrupt Controller (PIC) provides vectoring for the next eight interrupt levels. As shown in Table 2, a selection

---

**Table 1. Input/Output Port Modes of Operation**

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
<th>Unidirectional</th>
<th>Bidirectional</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Input</td>
<td>Output</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Latched</td>
<td>Latched &amp; Strobed</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**

1. Part of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
of four priority processing modes is available to
the designer to match system requirements. Oper­
at­ing mode and priority assignments may be re­
configured dynamically via software at any time
during system operation. The PIC accepts inter­
rupt requests from the programmable parallel
and/or iSBX interfaces, the programmable timers,
the system bus, or directly from peripheral equip­
ment. The PIC then determines which of the in­
coming requests is of the highest priority, deter­
mines whether this request is of higher priority
than the level currently being serviced, and, if ap­
propriate, issues an interrupt to the CPU. Any
combination of interrupt levels may be masked,
via software, by storing a single byte in the inter­
rupt mask register of the PIC. The PIC generates a
unique memory address for each interrupt level.
These addresses are equally spaced at 4-byte in­
tervals. This 32-byte block may begin at any
32-byte boundary in the lowest 1K bytes of mem­
ory*, and contains unique instruction pointers
and code segment offset values (for expanded
memory operation) for each interrupt level. After
acknowledging an interrupt and obtaining a de­
vice identifier byte from the 8259A PIC, the CPU
will store its status flags on the stack and execute
an indirect CALL instruction through the vector
location (derived from the device identifier) to the
interrupt service routine.

*NOTE: The first 32 vector locations are reserved by Intel for
dedicated vectors. Users who wish to maintain compatibility
with present and future Intel products should not use these
locations for user-defined vector addresses.

Table 2. Programmable Interrupt Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully nested</td>
<td>Interrupt request line priorities fixed at 0 as highest, 7 as lowest.</td>
</tr>
<tr>
<td>Auto-rotating</td>
<td>Equal priority. Each level, after receiving service, becomes the lowest priority level until next interrupt occurs.</td>
</tr>
<tr>
<td>Specific priority</td>
<td>System software assigns lowest priority level. Priority of all other levels based in sequence numerically on this assignment.</td>
</tr>
<tr>
<td>Polled</td>
<td>System software examines priority-encoded system interrupt status via interrupt status register.</td>
</tr>
</tbody>
</table>

interrupt request generation — Interrupt requests may originate from 26 sources. Two
jumper selectable interrupt requests can be auto­
matically generated by the programmable peripheral interface when a byte of information is ready
to be transferred to the CPU (i.e., input buffer is
full) or a byte of information has been transferred
to a peripheral device (i.e., output buffer is empty).
A jumper selectable request can be generated by
each of the programmable timers. An additional
interrupt request line may be jumpered directly
from the parallel I/O driver terminator section.
Eight prioritized interrupt request lines allow the
iSBC 88/40 board to recognize and service inter­
rupts originating from peripheral boards inter­
faced via the MULTIBUS system bus. The fail safe
timer can be selected as an interrupt source. Also,
inter­rupts are provided from the iSBX connectors
(6), end-of-conversion, PFIN and from the power
line clock.

Power-Fail Control
Control logic is also included to accept a power­
fail interrupt in conjunction with the AC-low signal
from the iSBC 635, iSBC 640, and iCS 645 Power
Supply or equivalent.

iSBC MULTIMODULE Expansion Capabilities
Three iSBC MULTIMODULE connectors are pro­
vided on the iSBC 88/40 board. Up to three (3)
single wide MULTIMODULE or one (1) double wide
and one (1) single wide iSBC MULTIMODULE can be
added to the iSBC 88/40 board. A wide variety
of peripheral controllers, analog and digital expan­
sion options are available. For more information
on specific iSBC MULTIMODULES consult the
Intel OEM Microcomputer System Configuration
Guide.

Processing Expansion Capabilities
The addition of a iSBC 337 Multimodule Numeric
Data Processor offers high performance integer
and floating point math functions to users of the
iSBC 88/40 board. The iSBC 337 incorporates the
Intel 8087 and because of the MULTIMODULE
implementation, it allows on-board expansion
directly on the iSBC 88/40 board, eliminating the
need for additional boards for floating point
requirements.

MULTIBUS Expansion
Memory and I/O capacity may be expanded further
and additional functions added using Intel MULTI­
BUS compatible expansion boards. Memory may
be expanded by adding user specified combina­
tions of RAM boards, EPROM boards, or memory
combination boards. Input/output capacity may be
increased by adding digital I/O and analog I/O
MULTIBUS expansion boards. Mass storage capa­
bility may be achieved by adding single or double
density diskette controllers, or hard disk con­
trollers either through the use of expansion boards and ISBX MULTIMODULES. Modular expandable backplanes and cardcages are available to support multiboard systems.

NOTE: Certain system restrictions may be incurred by the inclusion of some of the ISBC 80 family options in an ISBC 88/40 system. Consult the Intel OEM Microcomputer System Configuration Guide for specific data.

Analog Input Section

The analog section of the ISBC 88/40 board receives all control signals through the local bus to initiate channel selection, gain selection, sample and hold operation, and analog-to-digital conversion. See Figure 2.

INPUT CAPACITY — 32 separate analog signals may be randomly or sequentially sampled in single-ended mode with the 32 input multiplexers and a common ground. For noisy environments, differential input mode can be configured to achieve 16 separate differential signal inputs, or 32 pseudo differential inputs.

RESOLUTION — The analog section provides 12-bit resolution with a successive approximation analog-to-digital converter. For bipolar operation (−5 to +5 or −10 to +10 volts) it provides 11 bits plus sign.

SPEED — The A-to-D converter conversion speed is 50 μS (20 kHz samples per second). Combined with the programming interface, maximum throughput via the local bus and into memory will be 55 microseconds per sample, or 18 kHz samples per second, for a single channel, a random channel, or a sequential channel scan at a gain of 1, 5 ms at a gain of 5, 250 ms at a gain of 50, and 20 ms at a gain of 250. A-to-D conversion is initiated via a programmed command from the iAPX 88/10 central processor. Interrupt on end-of-conversion is a standard feature to ease programming and timing constraints.

ACCURACY — High quality components are used to achieve 12 bits resolution and accuracy of 0.035% full scale range ± 1/2 LSB. Offset is adjustable under program control to obtain a nominal ± 0.024% FSR ± 1/2 LSB accuracy at any fixed temperature between 0°C and 60°C (gain = 1). See specifications for other gain accuracies.

GAIN — To allow sampling of millivolt level signals such as strain gauges and thermocouples, gain is made configurable via user program commands up to 250 x (20 millivolts full scale input range). User can select gain ranges of 1 (5V), 5 (1V), 50 (100 mV), 250 (20 mV) to match his application.

OPERATIONAL DESCRIPTION — The ISBC 88/40 single board computer addresses the analog-to-digital converter by executing IN or OUT instructions to the port address. Analog-to-digital conversions can be programmed in either of two modes: 1) start conversion and poll for end-of-conversion (EOC), or 2) start conversion and wait for interrupt at end of conversion. When the conversion is complete as signaled by one of the above techniques, INput instructions read two bytes (low and high bytes) containing the 12-bit data word as shown on the following page.
**Output Command** — Select input channel and start conversion.

<table>
<thead>
<tr>
<th>BIT POSITION</th>
<th>GAIN CONNECTOR</th>
<th>CHANNEL SELECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT CHANNEL</td>
<td>G1 G2 J C3 C2 C1 C0</td>
<td></td>
</tr>
</tbody>
</table>

**Input Data** — Read converted data (low byte) or Read converted data (high byte).

<table>
<thead>
<tr>
<th>BIT POSITION</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW/STATUS BYTE</td>
<td>D3 D2 D1 D0 EOC</td>
</tr>
<tr>
<td>DATA HIGH BYTE</td>
<td>D11 D10 D9 D8 D7 D6 D5 D4</td>
</tr>
</tbody>
</table>

**Offset Correction** — At higher gains (x 50, x 250) the voltage offset tempco in the A/D circuitry can sometimes cause unacceptable inaccuracies. To correct for this offset, one channel can be dedicated to be used as a reference standard. This channel can be read from the program to determine the amount of offset. The reading from this channel will then be subtracted from all other channel readings, in effect eliminating the offset tempco.

**System Software Development**
The development cycle of the iSBC 88/40 board may be significantly reduced using an Intel Intellic Microcomputer Development System with the optional iAPX 88/iAPX 86 Software Development package.

The iAPX 88/iAPX 86 Software Development package includes Intel’s high-level programming language, PL/M 86. PL/M 86 provides the capability to program in a natural, algorithmic language and eliminates the need to manage register usage or allocate memory. PL/M 86 programs can be written in a much shorter time than assembly language programs for a given application.

**SPECIFICATIONS**

**Word Size**
Instruction — 8, 16, or 32 bits
Data — 8 bits

**Instruction Cycle Time**
417 nanoseconds for fastest executable instruction (assumes instruction is in the queue). 1.04 microseconds for fastest executable instruction (assumes instruction is not in the queue).

**Memory Capacity**

**On-board ROM/EPROM/E²PROM**
Up to 32K bytes; user installed in 2K, 4K or 8K byte increments or up to 64K if iSBC 341 MULTI-MODULE EPROM option installed. Up to 8K bytes of E²PROM using Intel 2816s may be user-installed in increments of 2, 4 or 8K bytes.

**On-board RAM**
4K bytes or 8K bytes if the iSBC 301 MULTIMODULE RAM is installed. Integrity maintained during power failure with user-furnished batteries. 1K bytes are dual-ported.

**Off-board Expansion**
Up to 1 megabyte of user-specified combination of RAM, ROM, and EPROM.

**Memory Addressing**

**On-board ROM/EPROM**
- FE000–FFFFF (using 2716 EPROMs)
- FC000–FFFFF (using 2732 EPROMs)
- F8000–FFFFF (using 2764 EPROMs)

**On-board ROM/EPROM (With iSBC 341 MULTI-MODULE EPROM option installed)**
- FC000–FFFFF (using 2716 EPROMs)
- F8000–FFFFF (using 2732 EPROMs)
- F0000–FFFFF (using 2764 EPROMs)

**On-board RAM (CPU Access)**
- 00000–00FFF
- 00000–01FFF (if iSBC 301 MULTIMODULE RAM option installed)

**On-board RAM**
Jumpers allow 1K bytes of RAM to act as slave RAM for access by another bus master. Addressing may be set within any 1K boundary in the 1-megabyte system address space.

**Slave RAM Access**
Average; 350 nanoseconds

**Interval Timer**

**Output Frequencies**

<table>
<thead>
<tr>
<th>Function</th>
<th>Single Timer Min.</th>
<th>Single Timer Max.</th>
<th>Dual Timers (Two Timers Cascaded) Min.</th>
<th>Dual Timers (Two Timers Cascaded) Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-Time</td>
<td>0.977 µs</td>
<td>64 ms</td>
<td>69.9 minutes</td>
<td>maximum</td>
</tr>
<tr>
<td>Interrupt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interval</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate Generator</td>
<td>15.625 Hz</td>
<td>1024 kHz</td>
<td>0.00024 Hz</td>
<td>minimum</td>
</tr>
<tr>
<td>(Frequency)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**iAPX 88/10 CPU Clock**
4.8 MHz ± 0.1%
**I/O Addressing**

All communications to parallel I/O ports, iSBX bus, A/D port, timers, and interrupt controller are via read and write commands from the on-board iAPX 88/10 CPU.

**Interface Compatibility**

Parallel I/O — 24 programmable lines (8 lines per port); one port includes a bidirectional bus driver. IC sockets are included for user installation of line drivers and/or I/O terminators and/or peripheral drivers as required for interface ports.

iSBX Bus Connectors — Three iSBX bus connectors are provided. These connectors accept 8-bit iSBX MULTIMODULE boards. One set of the three iSBX MULTIMODULE connectors will accept a double wide iSBX MULTIMODULE board.

**Interrupts**

iAPX 88/10 CPU includes a non-maskable interrupt (NMI). NMI interrupt is provided for catastrophic events such as power failure. The on-board 8259A PIC provides 8-bit identifier of interrupting device to CPU. CPU multiplies identifier by four to derive vector address. Jumpers select interrupts from 26 sources without necessity of external hardware. PIC may be programmed to accommodate edge-sensitive or level-sensitive inputs.

**Analog Input**

16 differential (bipolar operation) or 32 single-ended (unipolar operation).

Full Scale Voltage Range — ± 5 to +5 volts (bipolar), 0 to +5 volts (unipolar).

Gain — Program selectable for gain of 1, 5, 50, or 250.

Resolution — 12 bits (11 bits plus sign for ±5, ±10 volts).

Accuracy — Including noise and dynamic errors

<table>
<thead>
<tr>
<th>Gain</th>
<th>25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>± 0.05% FSR*</td>
</tr>
<tr>
<td>5</td>
<td>± 0.075% FSR*</td>
</tr>
<tr>
<td>50</td>
<td>± 0.085% FSR*</td>
</tr>
<tr>
<td>250</td>
<td>± 0.12% FSR*</td>
</tr>
</tbody>
</table>

*NOTE: FSR = Full Scale Range ± 1/2 LSB. Figures are in percent of full scale reading. At any fixed temperature between 0°C and 60°C, the accuracy is adjustable to ±0.05% of full scale.

Gain TC (at gain = 1) — 30 PPM (typical), 56 PPM (max) per degree centigrade, 40 PPM at other gains.

Offset TC —

<table>
<thead>
<tr>
<th>Gain (in % of FSR/°C)</th>
<th>Offset TC (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0018%</td>
</tr>
<tr>
<td>5</td>
<td>0.0036%</td>
</tr>
<tr>
<td>50</td>
<td>0.024%</td>
</tr>
<tr>
<td>250</td>
<td>0.12%</td>
</tr>
</tbody>
</table>

Sample and Hold-sample Time — 15 μs

Aperature-hold Aperature Time — 120 ns

Input Overvoltage Protection — 30 volts

Input Impedance — 20 megohms (min.)

Conversion Speed — 50 μS (max.) at gain = 1

Common Mode Rejection Ratio — 60 dB (min.)

**Physical Characteristics**

Width — 30.48 cm (12.00 in.)

Length — 17.15 cm (6.75 in.)

Height — 1.78 cm (0.7 in.)

2.82 cm (1.13 in.) with iSBX Memory Expansion, MULTIMODULES, iSBX Numeric Data Processor or iSBX MULTI-MODULES.

**Electrical Requirements**

Power Requirements (Maximum) —

<table>
<thead>
<tr>
<th>Configuration</th>
<th>+5V</th>
<th>+5V Aux</th>
<th>+12V</th>
<th>–12V</th>
</tr>
</thead>
<tbody>
<tr>
<td>iSBX 88/40</td>
<td>4</td>
<td>5.5</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>Max</td>
<td>Max</td>
<td>Max</td>
</tr>
</tbody>
</table>

**NOTES:**

1. The current requirement includes one worst case (active-standby) EPROM current.

2. If +5V Aux is supplied by the iSBX 88/40 board, the total +5V current is the sum of the +5V and the +5V Aux.

**Environmental Requirements**

Operating Temperature — 0° to 55°C (32°C to 131°F) with 200 lfm air flow

Relative Humidity — to 90% without condensation

**Equipment Supplied**

The following are supplied with the iSBX 88/40 board:

a. Schematic diagram

b. Assembly drawing

**Reference Manuals**


Manuals may be ordered from an Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 88/40</td>
<td>Measurement and Control Computer</td>
</tr>
</tbody>
</table>
The iSBC 310A High Speed Mathematics Unit is a member of Intel’s complete family of OEM computers and expansion modules. The iSBC 310A acts as an intelligent slave processor to one or more iSBC computer masters as it performs its high speed arithmetic functions. It plugs into a standard iSBC 604/614 cardcage to interface directly into any iSBC 80 single board computer. Designed to increase the computational throughput of all computers in the iSBC 80 family, the iSBC 310A utilizes Intel’s high speed Series 3000 Bipolar Microprocessor. The iSBC 310A performs arithmetic functions an order of magnitude faster than is possible with software routines. Standard operations include floating point add, subtract, multiply, divide, square, and square root; fixed point integer multiply, divide, and extended divide; and conversions between fixed and floating point representations, as well as test, compare, and argument exchange.
FUNCTIONAL DESCRIPTION

iSBC 80 single board computers communicate with the iSBC 310A using I/O and memory read/write commands. To pass arguments from the iSBC 80 to the iSBC 310A, a memory write command is used for each byte to be loaded into the iSBC 310A's working registers. An operation command is then given to the iSBC 310A by using an output instruction to pass the appropriate opcode. The mathematics unit will then perform the function independently from the single board computer; therefore, any iSBC 80 can continue to operate while the iSBC 310A is performing its arithmetic operations. Upon completion of its designated operation, the high speed mathematics unit notifies the iSBC 80 via an interrupt or by setting a status bit. The resultant data can then be read by the iSBC 80 via a memory read command to the proper memory address.

Arithmetic Functions

The iSBC 310A provides a full complement of arithmetic functions which operate on 16- and 32-bit unsigned fixed point integers, 32-bit signed fixed point integers, and 32-bit single precision floating point numbers. These functions are detailed in Table 1. The results of comparison operations are described in the operation results section.

Status Byte

The iSBC 310A may be operated in either an interrupt driven or polled mode. Three status indications are available:

Busy — The iSBC 310A is currently processing an arithmetic command, and cannot respond to further requests.

Complete — The iSBC 310A has completed an operation without an error. This line may be connected to an interrupt level via an on-board jumper.

Error — The iSBC 310A has completed an operation which results in an error condition. This line may be connected to an interrupt level via an on-board jumper.

Result Byte

After completion of an operation, a result byte may be read. This byte indicates the error conditions where applicable (see Specifications), and the results of a compare or test operation.

---

Figure 1. iSBC 310A Block Diagram Showing Functional Components
### Table 1. ISBC 310A Arithmetic Functions

<table>
<thead>
<tr>
<th>Operation</th>
<th>OpCode</th>
<th>Max Time (^1) (μs)</th>
<th>Notes (^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed point multiply (MUL)</td>
<td>0</td>
<td>19</td>
<td>(M_1 = m_1 \cdot m_1)</td>
</tr>
<tr>
<td>Fixed point divide (DIV)</td>
<td>1</td>
<td>28</td>
<td>(m_1 = m_1/M_2, \ m_2 = \text{remainder})</td>
</tr>
<tr>
<td>Extended fixed point divide (EDIV)</td>
<td>E</td>
<td>94</td>
<td>(M_1 = M_1/m_2, \ M_2 = \text{remainder})</td>
</tr>
<tr>
<td>Floating point multiply (FMUL)</td>
<td>2</td>
<td>91</td>
<td>(X_1 = X_1 \cdot X_2)</td>
</tr>
<tr>
<td>Floating point divide (FDIV)</td>
<td>3</td>
<td>102</td>
<td>(X_1 = X_1/X_2)</td>
</tr>
<tr>
<td>Floating point add (FADD)</td>
<td>4</td>
<td>56</td>
<td>(X_1 = X_1 + X_2)</td>
</tr>
<tr>
<td>Floating point subtract (FSUB)</td>
<td>5</td>
<td>56</td>
<td>(X_1 = X_1 - X_2)</td>
</tr>
<tr>
<td>Square (FSQ)</td>
<td>6</td>
<td>91</td>
<td>(X_1 = X_1^2)</td>
</tr>
<tr>
<td>Square root (FSQRT)</td>
<td>7</td>
<td>199</td>
<td>(X_1 = \sqrt{X_1})</td>
</tr>
<tr>
<td>Fixed-to-float-conversion (FLOAT)</td>
<td>8</td>
<td>89</td>
<td>(X_1 = N_1)</td>
</tr>
<tr>
<td>Float-to-fixed-conversion (FIX)</td>
<td>9</td>
<td>81</td>
<td>(N_1 = X_1)</td>
</tr>
<tr>
<td>Compare (FCOMP)</td>
<td>A</td>
<td>5</td>
<td>Compare (X_1) and (X_2)</td>
</tr>
<tr>
<td>Test (FTST)</td>
<td>B</td>
<td>5</td>
<td>Compare (X_1) and 0.0</td>
</tr>
<tr>
<td>Exchange (EXCH)</td>
<td>F</td>
<td>4</td>
<td>Exchange arguments (fixed or floating)</td>
</tr>
</tbody>
</table>

#### Notes
1. Does not include register setup time
2. \(m\) - 16-bit unsigned fixed point integers; \(M\) - 32-bit unsigned fixed point integer; \(N\) - 32-bit two’s complement signed fixed integer; \(X\) - 32-bit single precision floating point number

---

### SPECIFICATIONS

#### Arithmetic Functions

See Table 1

#### Formats

**Single Precision Floating Point (32 Bits)**

<table>
<thead>
<tr>
<th>Memory Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Address (M)</td>
</tr>
<tr>
<td>(M + 1)</td>
</tr>
<tr>
<td>(M + 2)</td>
</tr>
<tr>
<td>(M + 3)</td>
</tr>
</tbody>
</table>

where: \(S = \text{sign bit}\)

\(0 = \text{positive}\)
\(1 = \text{negative}\)

\(E_2 - E_0 = \text{biased exponent (8 bits) (bias = 7F_{16})}\)

\(F_{22} - F_0 = \text{fraction (23 bits)}\)

**Fixed Point Integer (16-Bit)**

<table>
<thead>
<tr>
<th>Memory Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Address (M)</td>
</tr>
<tr>
<td>(M + 1)</td>
</tr>
</tbody>
</table>

where:  
\(F_{15} - F_0 = 16\)-bit integer

---

**Extended Precision Integer**

<table>
<thead>
<tr>
<th>Memory Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Address (M)</td>
</tr>
<tr>
<td>(M + 1)</td>
</tr>
<tr>
<td>(M + 2)</td>
</tr>
<tr>
<td>(M + 3)</td>
</tr>
</tbody>
</table>

where: \(S = \text{sign bit}\)

\(F_{30} - F_0 = \text{two’s complement integer}\)

**Result Byte**

Contains the following information:

<table>
<thead>
<tr>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>=</td>
<td>&gt;</td>
<td>&lt;</td>
<td>R</td>
<td>R</td>
<td>ERR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

where: \(R\) is reserved for future use

\(=\) is equal (for FCOMP and FTST)

\(>\) is greater than (for FCOMP and FTST)

\(<\) is less than (for FCOMP and FTST)

and: ERR is a 3-bit error code that specifies one of the following error conditions:

| 000 | No error |
| 001 | Divide by zero |
| 010 | Square root of negative number |
| 011 | Overflow |
| 100 | Underflow |
| 101 | First argument valid |
| 110 | Second argument valid |
| 111 | Reserved |
**Status Byte**
Contains the following information:

<table>
<thead>
<tr>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>E</td>
<td>C</td>
<td>B</td>
</tr>
</tbody>
</table>

where:
- **R** is reserved for future use
- **B** is busy
- **C** is operation complete without error
- **E** is operation complete with error

**Addressing**

**I/O Addressing** — Used to pass operation codes, memory address boundaries, and result and status bytes between host processor and iSBC 310A.

<table>
<thead>
<tr>
<th>Port Address</th>
<th>Output</th>
<th>Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base (P)</td>
<td>OP CODE</td>
<td>R</td>
</tr>
<tr>
<td>P+1</td>
<td>MEM LOW</td>
<td>Result byte</td>
</tr>
<tr>
<td>P+2</td>
<td>MEM HIGH</td>
<td>R</td>
</tr>
<tr>
<td>P+3</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>P+4</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>P+5</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>P+6</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>P+7</td>
<td>R</td>
<td>Status byte</td>
</tr>
</tbody>
</table>

where:
- **P** = I/O base address of X0 or X8 (where X = any hex digit)
- **R** = reserved for iSBC 310A usage
- **OP CODE** = mathematic commands (see Table 1)
- **MEM LOW** = programmable base address (see Memory Addressing)
- **MEM HIGH** = memory addressing

**Memory Addressing** — Sixteen memory locations are used; the first eight are used for argument/result storage; the second eight are reserved for future use. Memory addresses are assigned from the host processor via an I/O output instruction (see I/O Addressing). MEM LOW (the lower address byte) must be X0 (where X is any hex digit). MEM HIGH (the upper address byte) may be any value.

**Interrupts**

Interrupts are generated on operation complete and operation error. Either one or both interrupts may be connected to any of the 8 interrupt levels on the iSBC 80 bus via jumper selection.

**Bus Interface**
All signals are TTL compatible.

**Bus Connector**
- **Bus Connector** — 86-pin, double-sided PC edge connector with 0.156-in. contact centers.
- **Mating Connector** — Viking 3KH43/9AMK12

**Physical Characteristics**
- **Width** — 12.00 in (30.48 cm)
- **Height** — 6.75 in. (17.15 cm)
- **Depth** — 0.50 in. (1.27 cm)
- **Weight** — 12 oz (340.5 gm)

**Electrical Characteristics**

**DC Power Requirements**

<table>
<thead>
<tr>
<th>VCC</th>
<th>Icc</th>
</tr>
</thead>
<tbody>
<tr>
<td>5V ± 5%</td>
<td>6.7A max; 4.9A typ</td>
</tr>
</tbody>
</table>

**Environmental Characteristics**

**Operating Temperature** — 0°C to 55°C

**Equipment Supplied**
- High speed mathematics units
- Standard preprogrammed ROMs (installed)
- Schematics
- Assembly drawing

**Reference Manual**
- **9800410A** — iSBC 310A Hardware Reference Manual (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

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**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 310A</td>
<td>High Speed Mathematics Unit</td>
</tr>
</tbody>
</table>
iSBX 331
FIXED/FLOATING POINT MATH
MULTIMODULE BOARD

- iSBX bus compatible high speed
  fixed/floating point math expansion
- 4 MHz operation
- Fixed point single and double precision
  (16/32-bit)
- Floating point double precision (32-bit)
- Binary data formats
- Add, subtract, multiply and divide
- Trigonometric and inverse trigonometric
  functions
- Square root, log, and exponential
  functions
- Float-to-fixed and fixed-to-float
  conversions
- End of operation interrupt
- Software reset control
- Low power requirements
- iSBX bus on-board expansion elimi-
  nates MULTIBUS system bus latency
  and increases system throughput

The Intel® iSBX 331 Fixed/Floating Point Math MULTIMODULE Board is a member of Intel’s new line of iSBX bus compatible MULTIMODULE products. The iSBX MULTIMODULE board plugs directly into any iSBX bus compatible host board offering low cost incremental on-board expansion. As a result, any iSBX bus compatible host board may be expanded to perform high speed math computations, affording up to a 40 x improvement in speed compared to software math. The iSBX 331 module performs single/double (16/32-bit) precision fixed point plus double (32-bit) precision floating point arithmetic operations. In addition, the module performs transcendental, data manipulation, and fixed to float/float to fixed point conversion operations. The command operations run entirely independent of the host board permitting efficient concurrent processing. The iSBX board is closely coupled to the host board through the iSBX bus, and as such, offers maximum on-board performance and frees MULTIBUS system traffic for other system resources. Incremental power dissipation is minimal requiring only 2.73 watts.
FUNCTIONAL DESCRIPTION

The iSBX 331 module uses the Intel 8231 Arithmetic Processing Unit (APU) to accomplish high speed (4 MHz) math operation. The system software may communicate with the iSBX 331 module across the iSBX bus using I/O read/write commands. All transfers, including operand, result, status, and command information, take place over an 8-bit bidirectional data bus. Operands are pushed onto an internal stack and commands are issued to perform operations on the data. Results are then available from the stack. A status byte may be read to monitor execution completion and the nature of the result (zero, sign, or errors). In addition, control logic is included on the iSBX 331 module to facilitate single instruction software reset control.

Command Functions

The iSBX 331 module commands fall into three categories: double precision floating point, single precision fixed point, and double precision fixed point (see Table 1). There are four arithmetic operations that can be performed in either fixed or floating point numbers: add, subtract, multiply, and divide. These operations require two operands. The 8231 assumes these operands are located in the internal stack as Top of Stack (TOS) and Next on Stack (NOS). The result will always be returned to TOS. There are four types of transcendental operations that can be performed in floating point numbers: trigonometric functions, logarithms, exponentials, and square roots. The results of these operations will be returned to TOS. There are four types of data manipulation operations that can be performed in either fixed or floating point numbers: sign change of TOS, exchange of TOS and NOS and copying or popping operands onto or off of TOS. Fixed to floating point conversion can be performed on floating point instructions and floating point to fixed point conversion can be performed on fixed point instructions.

The execution times of the commands are shown in Table 2.

Interrupt Requests

There is one interrupt line from the APU that may generate an interrupt request to the host: END (MINTRI). The END interrupt line is active upon command completion. The END signal is cleared by a reset or status register read.

Installation

The iSBX 331 module plugs directly into the female iSBX connector on the host board. The module is then secured at one additional point with nylon hardware to insure the mechanical security of the assembly (see Figures 1 and 2).
### Table 1. Command Summary

#### Double Precision Floating Point Instructions (32-Bit)

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Description</th>
<th>Hex Code</th>
<th>Stack Contents After Execution&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Status Flags Affected&lt;sup&gt;(2)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACOS</td>
<td>Inverse Cosine of A</td>
<td>0 6</td>
<td>R U U U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>ASIN</td>
<td>Inverse Sine of A</td>
<td>0 5</td>
<td>R U U U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>ATAN</td>
<td>Inverse Tangent of A</td>
<td>0 7</td>
<td>R B U U</td>
<td>S, Z</td>
</tr>
<tr>
<td>CHSF</td>
<td>Sign Change of A</td>
<td>1 5</td>
<td>R B C D</td>
<td>S, Z</td>
</tr>
<tr>
<td>COS</td>
<td>Cosine of A (radians)</td>
<td>0 3</td>
<td>R B U U</td>
<td>S, Z</td>
</tr>
<tr>
<td>EXP</td>
<td>$e^A$ Function</td>
<td>0 A</td>
<td>R B U U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>FADD</td>
<td>Add A and B</td>
<td>1 0</td>
<td>R C D U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>FDIV</td>
<td>Divide B by A</td>
<td>1 3</td>
<td>R C D U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>FLTD</td>
<td>32-Bit Fixed to Floating Point Conversion</td>
<td>1 C</td>
<td>R B C U</td>
<td>S, Z</td>
</tr>
<tr>
<td>FLTS</td>
<td>16-Bit Fixed to Floating Point Conversion</td>
<td>1 D</td>
<td>R B C U</td>
<td>S, Z</td>
</tr>
<tr>
<td>FMUL</td>
<td>Multiply A and B</td>
<td>1 2</td>
<td>R C D U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>FSUB</td>
<td>Subtract A from B</td>
<td>1 1</td>
<td>R C D U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>LOG</td>
<td>Common Logarithm (base 10) of A</td>
<td>0 8</td>
<td>R B U U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>LN</td>
<td>Natural Logarithm of A</td>
<td>0 9</td>
<td>R B U U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>POPF</td>
<td>Stack Pop</td>
<td>1 8</td>
<td>B C D A</td>
<td>S, Z</td>
</tr>
<tr>
<td>PTOF</td>
<td>Stack Push</td>
<td>1 7</td>
<td>A A B C</td>
<td>S, Z</td>
</tr>
<tr>
<td>PUPI</td>
<td>Push $\pi$ onto Stack</td>
<td>1 A</td>
<td>R A B C</td>
<td>S, Z</td>
</tr>
<tr>
<td>PWR</td>
<td>$B^A$ Power Function</td>
<td>0 B</td>
<td>R C U U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>SIN</td>
<td>Sine of A (radians)</td>
<td>0 2</td>
<td>R B U U</td>
<td>S, Z</td>
</tr>
<tr>
<td>SQRT</td>
<td>Square Root of A</td>
<td>0 1</td>
<td>R B C U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>TAN</td>
<td>Tangent of A (radians)</td>
<td>0 4</td>
<td>R B U U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>XCHF</td>
<td>Exchange A and B</td>
<td>1 9</td>
<td>B A C D</td>
<td>S, Z</td>
</tr>
</tbody>
</table>

#### Double Precision Fixed Point Instructions (32-Bit)

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Description</th>
<th>Hex Code</th>
<th>Stack Contents After Execution&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Status Flags Affected&lt;sup&gt;(2)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHSD</td>
<td>Sign Change of A</td>
<td>3 4</td>
<td>R B C D</td>
<td>S, Z, O</td>
</tr>
<tr>
<td>DADD</td>
<td>Add A and B</td>
<td>2 2</td>
<td>R C D A</td>
<td>S, Z, C, E</td>
</tr>
<tr>
<td>DDIV</td>
<td>Divide B by A</td>
<td>2 2</td>
<td>R C D U</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>DMUL</td>
<td>Multiply A and B (R = lower 32 bits)</td>
<td>2 2</td>
<td>R C D U</td>
<td>S, Z, O</td>
</tr>
<tr>
<td>DMUU</td>
<td>Multiply A and B (R = upper 32 bits)</td>
<td>3 6</td>
<td>R C D U</td>
<td>S, Z, O</td>
</tr>
<tr>
<td>DSUB</td>
<td>Subtract A from B</td>
<td>2 2</td>
<td>R C D A</td>
<td>S, Z, C, O</td>
</tr>
<tr>
<td>FIXD</td>
<td>Floating to Fixed Point Conversion</td>
<td>1 E</td>
<td>R B C U</td>
<td>S, Z, O</td>
</tr>
<tr>
<td>POPD</td>
<td>Stack Pop</td>
<td>3 2</td>
<td>B C D A</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>PTOD</td>
<td>Stack Push</td>
<td>3 7</td>
<td>A A B C</td>
<td>S, Z</td>
</tr>
<tr>
<td>XCHD</td>
<td>Exchange A and B</td>
<td>3 3</td>
<td>B A C D</td>
<td>S, Z</td>
</tr>
</tbody>
</table>
### Table 1. Command Summary (continued)

**Single Precision Fixed Point Instructions (16-Bit)**

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Description</th>
<th>Hex Code</th>
<th>Stack Contents After Execution</th>
<th>Status Flags Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHSS</td>
<td>Change Sign of AU</td>
<td>7 4</td>
<td>R A_L B_L C_L D_L</td>
<td>S, Z, O</td>
</tr>
<tr>
<td>FIXS</td>
<td>Floating to Fixed Point Conversion</td>
<td>1 F</td>
<td>R B_L C_L U U</td>
<td>S, Z, O</td>
</tr>
<tr>
<td>POPS</td>
<td>Stack Pop</td>
<td>7 8</td>
<td>A_L B_L C_L D_L</td>
<td>S, Z</td>
</tr>
<tr>
<td>PTOS</td>
<td>Stack Push</td>
<td>7 7</td>
<td>A_U A_L B_L C_L D_L</td>
<td>S, Z</td>
</tr>
<tr>
<td>SADD</td>
<td>Add AU and AL</td>
<td>6 C</td>
<td>R B_L C_L D_L</td>
<td>S, Z, C, E</td>
</tr>
<tr>
<td>SDIV</td>
<td>Divide AL by AU</td>
<td>6 E</td>
<td>R B_L C_L D_L</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>SMUL</td>
<td>Multiply AU by AL (R = lower 16 bits)</td>
<td>6 E</td>
<td>R B_L C_L D_L</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>SMUU</td>
<td>Multiply AU by AL (R = upper 16 bits)</td>
<td>7 6</td>
<td>R B_L C_L D_L</td>
<td>S, Z, E</td>
</tr>
<tr>
<td>SSUB</td>
<td>Subtract AU from AL</td>
<td>6 D</td>
<td>R B_L C_L D_L</td>
<td>S, Z, C, E</td>
</tr>
<tr>
<td>XCHS</td>
<td>Exchange AU and AL</td>
<td>7 9</td>
<td>A_U A_L B_L C_L D_L</td>
<td>S, Z</td>
</tr>
<tr>
<td>NOP</td>
<td>No Operation</td>
<td>0 0</td>
<td>A_U A_L B_L C_L D_L</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. The stack initially is composed of four 32-bit numbers (A, B, C, D). A is equivalent to Top Of Stack (TOS) and B is Next On Stack (NOS). Upon completion of a command the stack is composed of: the result (R); undefined (U); or the initial contents (A, B, C, or D).
2. The stack initially is composed of eight 16-bit numbers (AU, AL, BU, BL, CU, CL, DU, DL). AU is the TOS and AL is NOS. Upon completion of a command the stack is composed of: the result (R); undefined (U); or the initial contents (AU, AL, BU, BL, ...).
3. Nomenclature: Sign (S); Zero (Z); Overflow (O); Carry (C); Error Code Field (E).

### Table 2. Command Execution Times

<table>
<thead>
<tr>
<th>Command Mnemonic</th>
<th>(\mu\text{Seconds})</th>
<th>Command Mnemonic</th>
<th>(\mu\text{Seconds})</th>
</tr>
</thead>
<tbody>
<tr>
<td>SADD</td>
<td>4.25</td>
<td>ASIN</td>
<td>1917</td>
</tr>
<tr>
<td>SSUB</td>
<td>7.5</td>
<td>ACOS</td>
<td>1933.5</td>
</tr>
<tr>
<td>SMUL</td>
<td>21-23.5</td>
<td>ATAN</td>
<td>1501.5</td>
</tr>
<tr>
<td>SMUU</td>
<td>20-24.5</td>
<td>LOG</td>
<td>1118.5-1783</td>
</tr>
<tr>
<td>SDIV</td>
<td>21-23.5</td>
<td>EXP</td>
<td>1074.5-1739</td>
</tr>
<tr>
<td>DADD</td>
<td>5.25</td>
<td>LN</td>
<td>948.5-1219.5</td>
</tr>
<tr>
<td>DSUB</td>
<td>9.5</td>
<td>PWR</td>
<td>2072.5-3008</td>
</tr>
<tr>
<td>DMUL</td>
<td>48.5-52.5</td>
<td>NOP</td>
<td>1</td>
</tr>
<tr>
<td>DMUU</td>
<td>45.5-54.5</td>
<td>CHSS</td>
<td>5.75</td>
</tr>
<tr>
<td>DDIV</td>
<td>52</td>
<td>CHSD</td>
<td>6.75</td>
</tr>
<tr>
<td>FIXS</td>
<td>23-54</td>
<td>CHSF</td>
<td>4.5</td>
</tr>
<tr>
<td>FIXD</td>
<td>25-36.5</td>
<td>PTOS</td>
<td>4</td>
</tr>
<tr>
<td>FLTS</td>
<td>24.5-46.5</td>
<td>PTOD</td>
<td>5</td>
</tr>
<tr>
<td>FLTD</td>
<td>24.5-94.5</td>
<td>PTOF</td>
<td>5</td>
</tr>
<tr>
<td>FADD</td>
<td>13.5-92</td>
<td>POPS</td>
<td>2.5</td>
</tr>
<tr>
<td>FSUB</td>
<td>17.5-92.5</td>
<td>POPD</td>
<td>3</td>
</tr>
<tr>
<td>FMUL</td>
<td>36.5-42</td>
<td>POPF</td>
<td>3</td>
</tr>
<tr>
<td>FDIV</td>
<td>38.5-46</td>
<td>XCHS</td>
<td>4.5</td>
</tr>
<tr>
<td>SQRT</td>
<td>200</td>
<td>XCHD</td>
<td>6.5</td>
</tr>
<tr>
<td>SIN</td>
<td>1116</td>
<td>XCHF</td>
<td>6.5</td>
</tr>
<tr>
<td>COS</td>
<td>1029.5</td>
<td>PUPI</td>
<td>4</td>
</tr>
<tr>
<td>TAN</td>
<td>1438.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Assumes 4 MHz operation.
SPECIFICATIONS

Word Size
Data—8 bits.

On-Board Clock Rate
4.0 MHz ± 0.1%.

I/O Addressing

<table>
<thead>
<tr>
<th>Function</th>
<th>Type of Operation</th>
<th>iSBX Connector Port Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Transfer</td>
<td>Read or Write</td>
<td>X0, X2, X4, or X6</td>
</tr>
<tr>
<td>Command Transfer</td>
<td>Write</td>
<td>X1, X3, X5, or X7</td>
</tr>
<tr>
<td>Status Transfer</td>
<td>Read</td>
<td>X1, X3, X5, or X7</td>
</tr>
<tr>
<td>Reset</td>
<td>Write</td>
<td>X8 through XF</td>
</tr>
</tbody>
</table>

NOTE:
The port addresses are determined on the host ISBC microcomputer. Refer to the Hardware Reference Manual for your host ISBC microcomputer to determine the first digit (X) of the connector port addresses.

Arithmetic Functions
See Table 1.

Data Formats

Single Precision Fixed Point (16 bits)

Bit 15: S = Sign of the operand. Positive values are represented by a sign bit of zero (S = 0). Negative values are represented by the two’s complement of the corresponding positive value with a sign bit equal to 1 (S = 1).

Double Precision Fixed Point (32 bits)

Bit 31: S = Sign of operand. Positive values are represented by a sign of zero (S = 0). Negative values are represented by the two’s complement of the corresponding positive value with a sign bit equal to 1 (S = 1).

Bits 0–30: Values in the range from −2,147,483,648 to +2,147,483,647.

Double Precision Floating Point (32 bits)

Bit 31: MS = Sign of the mantissa. 1 represents negative and 0 represents positive.

Bits 24–30: ES = the exponent expressed as a two’s complement 7-bit value having a range of −64 to +63.

Bits 0–23: The mantissa is expressed as a 24-bit (fractional) value. The 8231 APU requires that floating point data be represented by a fractional mantissa value between 0.5 and 1 multiplied by 2 raised to an appropriate power (exponent). This is expressed as follows:

\[ \text{Value} = \text{mantissa} \times 2^{\text{exponent}} \]
Device Status

Device status is provided by means of an internal status register whose format is shown below:

<table>
<thead>
<tr>
<th>BUSY</th>
<th>SIGN</th>
<th>ZERO</th>
<th>ERROR CODE</th>
<th>CARRY</th>
</tr>
</thead>
</table>

BUSY: Indicates that 8231 is currently executing a command (1 = Busy)
SIGN: Indicates that the value on the top of stack is negative (1 = Negative)
ZERO: Indicates that the value on the top of stack is zero (1 = Value is zero)
ERROR CODE: This field contains an indication of the validity of the result of the last operation. The error codes are:
- 0000 — No error
- 1000 — Divide by zero
- 0100 — Square root or log of negative number
- 1100 — Argument of inverse sine, cosine, or 
 e too large
- XX10— Underflow
- XX01— Overflow
CARRY: Previous operation resulted in carry or borrow from most significant bit. (1 = Carry/Borrow, 0 = No Carry/No Borrow.)

If the BUSY bit in the status register is a one, the other status bits are not defined; if zero, indicating not busy, the operation is complete and the other status bits are defined as given above.

Access Time

Read—1900 ns (max.);
Write—1900 ns (max.)

NOTE:
Actual transfer speed is dependent upon the cycle time of the host microcomputer. The listed times assume no operation in progress. If an operation is executing when an access is attempted, the command execution time must be added to the above times for all accesses except status read.

Interrupts

One interrupt request may originate from the APU indicating command completion (END).

Interface

iSBX Bus—All signals TTL compatible

Physical Characteristics

Width—6.35 cm (2.50 in.)
Length—9.40 cm (3.70 in.)
Height*—2.04 cm (0.80 in.) iSBX 331 Board
—2.86 cm (1.13 in.) iSBX 331 Board + Host Board

Weight—51 gm (1.79 oz)

*See Figure 2.

Electrical Characteristics

DC Power Requirements
\[ V_{CC} = +5V \pm 5\% \quad I_{CC} = 365 \text{ mA max.} \]
\[ V_{DD} = +12V \pm 5\% \quad I_{DD} = 75 \text{ mA max.} \]

Environmental

Operating Temperature—0°C to 55°C
Free moving air across the base board and iSBX board.

Reference Manual

142668-01—iSBX 331 Floating Point Math MULTIMODULE Board (NOT SUPPLIED)

Reference manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3085 Bowers Avenue, Santa Clara, California 95051.
iSBX 332
FLOATING POINT MATH MULTIMODULE BOARD

- iSBX bus compatible high speed floating point math expansion
- 4 MHz operation
- Compatible with proposed IEEE format and existing Intel floating point standard
- Single (32-bit)/double (64-bit) precision arithmetic and data manipulation commands
- Performs functions independently and concurrently with the MULTIBUS host board
- Add, subtract, multiply and divide functions
- End-of-operation and error interrupts
- Software reset control
- Accessed as I/O port locations
- Low power requirements
- iSBX bus on-board expansion eliminates MULTIBUS system bus latency and increases system throughput

The Intel® iSBX 332 Floating Point Math MULTIMODULE Board is a member of Intel's new line of iSBX bus compatible MULTIMODULE products. The iSBX MULTIMODULE board plugs directly into any iSBX bus compatible host board offering incremental on-board expansion. The iSBX 332 module performs single (32-bit) and double (64-bit) precision floating point add, subtract, multiply, and divide functions compatible with the proposed IEEE floating point standard. The command operations run entirely independent of the host board permitting efficient concurrent processing. The iSBX board is closely coupled to the host board through the iSBX bus, and as such, offers maximum on-board performance and frees MULTIBUS system traffic for other system resources. In addition, incremental power dissipation is minimal requiring only 2.73 watts.
FUNCTIONAL DESCRIPTION

The ISBX 332 module uses the Intel® 8232 Floating Point Processor (FPP) to accomplish high speed math operation. The system software may communicate with the ISBX 332 module across the ISBX bus using I/O read/write commands. All transfers, including operand, result, status, and command information, take place over an 8-bit bidirectional data bus. Operands are pushed onto an internal stack and commands are issued to perform operations on the data stack. Results are then available to be retrieved from the stack. A status byte may be read to monitor execution completion and the nature of the result (zero, sign, or errors). In addition, control logic is included on the ISBX 332 module to facilitate single instruction software reset control.

Command Functions

The ISBX 332 module commands fall into three categories: single precision arithmetic, double precision arithmetic and data manipulation (see Table 1). There are four arithmetic operations that can be performed with single precision (32-bit) or double precision (64-bit) floating point numbers: add, subtract, multiply and divide. These operations require two operands. The 8232 assumes that these operands are located in the internal stack as Top of Stack (TOS) and Next on Stack (NOS). The result will always be returned to the previous NOS which becomes the new TOS. Results from an operation are of the same precision and format as the operands.

The results will be rounded to preserve the accuracy. In addition to the arithmetic operations, the 8232 implements eight data manipulating operations. These include changing the sign of a double or single precision operand located in TOS, exchanging single precision operands located at TOS and NOS, as well as copying and popping single or double precision operands. See also the sections on status register and operand formats.

The execution times of the commands are all data dependent. Table 2 shows one example of each command execution time.

Interrupt Requests

There are two interrupt lines from the FPP that may generate an interrupt request to the host: END (MINTR1) and ERINT (MINTR0). The END interrupt line is active upon command completion and the ERINT line is active when the current command execution results in an error condition. The error conditions are: attempt to divide by zero, exponent overflow and exponent underflow. Both the END and ERINT signals are cleared by a reset or status register read.

Installation

The ISBX 332 module plugs directly into the female ISBX connector on the host board. The module is then secured at one additional point with nylon hardware to insure the mechanical security of the assembly (see Figures 1 and 2).

Figure 1. Installation of ISBX 332 Module on a Host Board
### Table 1. Command Summary

<table>
<thead>
<tr>
<th>Command Bits</th>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0 0 0 0 0 1</td>
<td>SADD</td>
<td>Add TOS to NOS single precision and result to NOS. Pop stack.</td>
</tr>
<tr>
<td>0 0 0 0 0 1 0</td>
<td>SSUB</td>
<td>Subtract TOS from NOS single precision and result to NOS. Pop stack.</td>
</tr>
<tr>
<td>0 0 0 0 0 1 1</td>
<td>SMUL</td>
<td>Multiply NOS by TOS single precision and result to NOS. Pop stack.</td>
</tr>
<tr>
<td>0 0 0 0 1 0 0</td>
<td>SDIV</td>
<td>Divide NOS by TOS single precision and result to NOS. Pop stack.</td>
</tr>
<tr>
<td>0 0 0 0 1 0 1</td>
<td>CHSS</td>
<td>Change sign of TOS single precision operand.</td>
</tr>
<tr>
<td>0 0 0 0 1 1 0</td>
<td>PTOS</td>
<td>Push single precision operand on TOS to NOS.</td>
</tr>
<tr>
<td>0 0 0 0 1 1 1</td>
<td>POPS</td>
<td>Pop single precision operand from TOS. NOS becomes TOS.</td>
</tr>
<tr>
<td>0 0 0 1 0 0 0</td>
<td>XCHS</td>
<td>Exchange TOS with NOS single precision.</td>
</tr>
<tr>
<td>0 1 0 1 1 0 1</td>
<td>CHSD</td>
<td>Change sign of TOS double precision operand.</td>
</tr>
<tr>
<td>0 1 0 1 1 1 0</td>
<td>PTO D</td>
<td>Push double precision operand on TOS to NOS.</td>
</tr>
<tr>
<td>0 1 0 1 1 1 1</td>
<td>PO PD</td>
<td>Pop double precision operand from TOS. NOS becomes TOS.</td>
</tr>
<tr>
<td>0 0 0 0 0 0 0</td>
<td>CLR</td>
<td>CLR status.</td>
</tr>
<tr>
<td>0 1 0 1 0 0 1</td>
<td>DADD</td>
<td>Add TOS to NOS double precision and result to NOS. Pop stack.</td>
</tr>
<tr>
<td>0 1 0 1 0 1 0</td>
<td>DSUB</td>
<td>Subtract TOS from NOS double precision and result to NOS. Pop stack.</td>
</tr>
<tr>
<td>0 1 0 1 0 1 1</td>
<td>DMUL</td>
<td>Multiply NOS by TOS double precision and result to NOS. Pop stack.</td>
</tr>
<tr>
<td>0 1 0 1 1 0 0</td>
<td>DDIV</td>
<td>Divide NOS by TOS double precision and result to NOS. Pop stack.</td>
</tr>
</tbody>
</table>

**NOTE:**

X = Don't care. Operation for bit combinations not listed above is undefined.

### Table 2. Execution Times

<table>
<thead>
<tr>
<th>Command</th>
<th>TOS</th>
<th>NOS</th>
<th>Result</th>
<th>Clock Periods</th>
<th>Time (μs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SADD</td>
<td>3F800000</td>
<td>3F800000</td>
<td>40000000</td>
<td>58</td>
<td>14.5</td>
</tr>
<tr>
<td>SSUB</td>
<td>3F800000</td>
<td>3F800000</td>
<td>00000000</td>
<td>56</td>
<td>14.9</td>
</tr>
<tr>
<td>SMUL</td>
<td>40400000</td>
<td>3FC00000</td>
<td>40900000</td>
<td>198</td>
<td>49.5</td>
</tr>
<tr>
<td>SDIV</td>
<td>3F800000</td>
<td>40000000</td>
<td>3F000000</td>
<td>228</td>
<td>57.0</td>
</tr>
<tr>
<td>CHSS</td>
<td>3F800000</td>
<td></td>
<td>BFF00000</td>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>PTOS</td>
<td>3F800000</td>
<td></td>
<td></td>
<td>16</td>
<td>4.0</td>
</tr>
<tr>
<td>POPS</td>
<td>3F800000</td>
<td></td>
<td></td>
<td>14</td>
<td>3.5</td>
</tr>
<tr>
<td>XCHS</td>
<td>3F800000</td>
<td>40000000</td>
<td></td>
<td>26</td>
<td>6.5</td>
</tr>
<tr>
<td>CHSD</td>
<td>3FF000000000000</td>
<td></td>
<td>BFF000000000000</td>
<td>24</td>
<td>6.0</td>
</tr>
<tr>
<td>PTO D</td>
<td>3FF000000000000</td>
<td></td>
<td></td>
<td>40</td>
<td>10.0</td>
</tr>
<tr>
<td>POPD</td>
<td>3FF000000000000</td>
<td></td>
<td></td>
<td>26</td>
<td>6.5</td>
</tr>
<tr>
<td>CLR</td>
<td>3FF000000000000</td>
<td></td>
<td></td>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td>DADD</td>
<td>3FF00000A000000</td>
<td>80000000000000</td>
<td>3FF00000A000000</td>
<td>578</td>
<td>144.5</td>
</tr>
<tr>
<td>DSUB</td>
<td>3FF00000A000000</td>
<td>80000000000000</td>
<td>3FF00000A000000</td>
<td>578</td>
<td>144.5</td>
</tr>
<tr>
<td>DMUL</td>
<td>BFF800000000000</td>
<td>3FF800000000000</td>
<td>C00200000000000</td>
<td>1748</td>
<td>437.0</td>
</tr>
<tr>
<td>DDIV</td>
<td>BFF800000000000</td>
<td>3FF800000000000</td>
<td>BFF000000000000</td>
<td>4560</td>
<td>1140.0</td>
</tr>
</tbody>
</table>

**NOTE:**

TOS, NOS and result are in hexadecimal; clock period is in decimal.
SPECIFICATIONS

**Word Size**

Data — 8 Bits

**I/O Addressing**

<table>
<thead>
<tr>
<th>Function</th>
<th>Type of Operation</th>
<th>ISBX Connector Port Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Transfer</td>
<td>Read or Write</td>
<td>X0, X2, X4, or X6</td>
</tr>
<tr>
<td>Command Transfer</td>
<td>Write</td>
<td>X1, X3, X5, or X7</td>
</tr>
<tr>
<td>Status Transfer</td>
<td>Read</td>
<td>X1, X3, X5, or X7</td>
</tr>
<tr>
<td>Reset</td>
<td>Write</td>
<td>X8 through XF</td>
</tr>
</tbody>
</table>

NOTE:

The port addresses are determined on the host ISBX microcomputer. Refer to the Hardware Reference Manual for your host ISBX microcomputer to determine the first digit (X) of the connector port address.

**Arithmetic Functions**

See Table 1

**Floating Point Format**

**Single Precision Floating Point (32 Bits)**

<table>
<thead>
<tr>
<th>S</th>
<th>E</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>30</td>
<td>23</td>
</tr>
</tbody>
</table>

Bit 31: S = Sign of the mantissa. 1 represents negative and 0 represents positive.

Bits 23–30: E = These 8 bits represent a biased exponent. The bias is \(2^7 - 1 = 127\).

Bits 0–22: M = 23-bit mantissa. Together with the sign bit, the mantissa represents a signed fraction in sign-magnitude notation. There is an implied 1 beyond the most significant bit (bit 22) of the mantissa. In other words, the mantissa is assumed to be a 24-bit normalized quantity and the most significant bit, which will always be 1 due to normalization, is implied. The FPP restores this implied bit internally before performing arithmetic, normalizes the result, and strips the implied bit before returning the results to the external data bus. The binary point is between the implied bit and bit 22 of the mantissa.

**Double Precision Floating Point (64 Bits)**

<table>
<thead>
<tr>
<th>S</th>
<th>E</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>62</td>
<td>52</td>
</tr>
</tbody>
</table>

Bit 63: S = Sign of the mantissa. 1 represents negative and 0 represents positive.

Bits 52–62: E = Biased exponent. The bias is \(2^{10} - 1 = 1023\).

Bits 0–51: M = 51-bit mantissa. Together with the sign bit, the mantissa represents a signed fraction in sign-magnitude notation. There is an implied 1 beyond the most significant bit (bit 51) of the mantissa. In other words, the mantissa is assumed to be a 53-bit normalized quantity and the most significant bit, which will always be 1 due to normalization, is implied. The FPP restores this implied bit internally before performing arithmetic, normalizes the result, and strips the implied bit before returning the result to the external data bus. The binary point is between the implied bit and bit 51 of the mantissa.
Status Byte
Contains the following information:

<table>
<thead>
<tr>
<th>BUSY</th>
<th>SIGN</th>
<th>ZERO</th>
<th>RESERVED</th>
<th>DIVIDE EXCEPTION</th>
<th>EXponent UNDERflow</th>
<th>EXponent OVERflow</th>
<th>RESERVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Bit 0  Reserved.
Bit 1  Exponent Overflow (V): When 1, this bit indicates that exponent overflow has occurred. Cleared to zero otherwise.
Bit 2  Exponent Underflow (U): When 1, this bit indicates that exponent underflow has occurred. Cleared to zero otherwise.
Bit 3  Divide Exception (D): When 1, this bit indicates that an attempt to divide by zero has been made. Cleared to zero otherwise.
Bit 4  Reserved.
Bit 5  Zero (Z): When 1, this bit indicates that the result returned to TOS after a command is all zeros. Cleared to zero otherwise.
Bit 6  Sign (S): When 1, this bit indicates that the result returned to TOS is negative. Cleared to zero otherwise.
Bit 7  Busy: When 1, this bit indicates the APU is in the process of executing a command. It will become zero after the command execution is complete. All other status bits should be considered to be undefined if this bit is set.

Access Time
Read — 1900 ns (max.)
Write — 1900 ns (max.)

NOTE:
Actual transfer speed is dependent upon the cycle time of the host microcomputer. The listed times assume no operation in progress. If an operation is executing when an access is attempted, the command execution time must be added to the above times for all accesses except status read.

Interrupts
Two interrupt requests may originate from the FPP indicating command completion (END) and error conditions (ERINT).

Interface
iSBX Bus — All signals TTL compatible

Physical Characteristics
Width — 6.35 cm (2.50 in.)
Length — 9.40 cm (3.70 in.)
Height* — 2.04 cm (0.80 in.) iSBX 332 Board
— 2.86 cm (1.13 in.) iSBX 332 Board + Host Board
Weight — 51 gm (1.79 oz)
*See Figure 2

Electrical Characteristics
DC Power Requirements
\[ V_{CC} = +5V \pm 5\% \quad I_{CC} = 365 \text{ mA max.} \]
\[ V_{DD} = +12V \pm 5\% \quad I_{DD} = 75 \text{ mA max.} \]

Environmental
Operating Temperature — 0°C to 55°C
Free moving air across the base board and iSBX board.

Reference Manual
9803204-01 — iSBX 332 Floating Point Math MULTIMODULE Board (NOT SUPPLIED)

Reference Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Ave., Santa Clara, California 95051.
iSBX 350
PARALLEL I/O MULTIMODULE BOARD

- iSBX bus compatible I/O expansion
- 24 programmable I/O lines with sockets for interchangeable line drivers and terminators
- Three jumper selectable interrupt request sources
- Accessed as I/O port locations
- Single +5V low power requirement
- iSBX bus on-board expansion eliminates MULTIBUS system bus latency and increases system throughput

The Intel® iSBX 350 Parallel I/O MULTIMODULE Board is a member of Intel's new line of iSBX bus compatible MULTIMODULE products. The iSBX MULTIMODULE board plugs directly into any iSBX bus compatible host board offering incremental on-board expansion. The iSBX 350 module provides 24 programmable I/O lines with sockets for interchangeable line drivers and terminators. The iSBX board is closely coupled to the host board through the iSBX bus, and as such, offers maximum on-board performance and frees MULTIBUS system traffic for other system resources. In addition, incremental power dissipation is minimal requiring only 1.6 watts (not including optional driver/terminators).
FUNCTIONAL DESCRIPTION

Programmable Interface

The iSBX 350 module uses an Intel® 8255A-5 Programmable Peripheral Interface (PPI) providing 24 parallel I/O lines. The base-board system software is used to configure the I/O lines in any combination of unidirectional input/output and bidirectional ports indicated in Table 1. Therefore, the I/O interface may be customized to meet specific peripheral requirements. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators. Hence, the flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and driver/termination characteristics for each application. In addition, inverting bidirectional bus drivers (8226) are provided on sockets to allow convenient optional replacement to non-inverting drivers (8216). The 24 programmable I/O lines, signal ground, and +5 volt power (jumper configurable) are brought to a 50-pin edge connector that mates with flat, woven, or round cable.

Interrupt Request Generation

Interrupt requests may originate from three jumper selectable sources. Two interrupt requests can be automatically generated by the PPI when a byte of information is ready to be transferred to the base board CPU (i.e., input buffer is full) or a byte of information has been transferred to a peripheral device (i.e., output buffer is empty). A third interrupt source may originate directly from the user I/O interface (J1 connector).

Installation

The iSBX 350 module plugs directly into the female iSBX connector on the host board. The module is then secured at one additional point with nylon hardware to insure the mechanical security of the assembly (see Figure 1 and Figure 2).
Figure 2. Mounting Clearances (inches)

Table 1. Input/Output Port Modes of Operation

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
<th></th>
<th></th>
<th>Bidirectional</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mode of Operation</td>
<td>Input</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unidirectional</td>
<td></td>
<td>Bidirectional</td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unlatched</td>
<td>Latched &amp;</td>
<td>Latched &amp;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Strobed</td>
<td>Strobed</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>8</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B</td>
<td>8</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X¹</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X¹</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**
1. Part of port C must be used as a control port when either port A or port B are used as a latched and strobed input or a latched and strobed output port or port A is used as a bidirectional port.

**SPECIFICATIONS**

**Word Size**

Data — 8 Bits

**I/O Addressing**

<table>
<thead>
<tr>
<th>8255A-5 Ports</th>
<th>iSBX 350 Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port A</td>
<td>X0 or X4</td>
</tr>
<tr>
<td>Port B</td>
<td>X1 or X5</td>
</tr>
<tr>
<td>Port C</td>
<td>X2 or X6</td>
</tr>
<tr>
<td>Control</td>
<td>X3 or X7</td>
</tr>
<tr>
<td>Reserved</td>
<td>X8 to XF</td>
</tr>
</tbody>
</table>

**NOTE:**
The first digit of each port I/O address is listed as “X” since it will change dependent on the type of host ISBC microcomputer used. Refer to the Hardware Reference Manual for your host ISBC microcomputer to determine the first digit of the port address.

**I/O Capacity**

24 programmable lines (see Table 1)

**Access Time**

Read — 250 ns max.
Write — 300 ns max.

**NOTE:**
Actual transfer speed is dependent upon the cycle time of the host microcomputer.

**Interrupts**

Interrupt requests may originate from the programmable peripheral interface (2) or the user specified I/O (1).

**Interfaces**

iSBX™ Bus — All signals TTL compatible
Parallel I/O — All signals TTL compatible
Parallel Interface Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>No. of Pairs/Pins</th>
<th>Centers (In.)</th>
<th>Connector Type</th>
<th>Vendor</th>
<th>Vendor Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel I/O Connector</td>
<td>25/50</td>
<td>0.1</td>
<td>Female</td>
<td>3M</td>
<td>3415-0001 with Ears</td>
</tr>
<tr>
<td>Parallel I/O Connector</td>
<td>25/50</td>
<td>0.1</td>
<td>Female, Soldered</td>
<td>GTE</td>
<td>6AD01251A1DD</td>
</tr>
</tbody>
</table>

Note: Connector compatible with those listed may also be used.

Line Drivers and Terminators

I/O Drivers — The following line drivers and terminators are all compatible with the I/O driver sockets on the iSBX 350.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I, OC</td>
<td>16</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>16</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I, OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI, OC</td>
<td>16</td>
</tr>
<tr>
<td>7406</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I, OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

Note: I = Inverting, NI = Non-Inverting, OC = Open Collector

Port 1 has 25 mA totem pole drivers and 1 kΩ terminators.

I/O Terminators — 220Ω/330Ω divider or 1 kΩ pull up.

Environmental

Operating Temperature — 0°C to 55°C

Reference Manual

9803191-01 — iSBX 350 Parallel I/O MULTIMODULE Manual (NOT SUPPLIED)

Reference Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Ave., Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBX 350</td>
<td>Parallel I/O MULTIMODULE Board</td>
</tr>
</tbody>
</table>
The Intel® iSBX 351 Serial I/O MULTIMODULE board is a member of Intel's new line of iSBX bus compatible MULTIMODULE products. The iSBX MULTIMODULE board plugs directly into any iSBX bus compatible host board offering incremental on-board I/O expansion. The iSBX 351 module provides one RS232C or RS449/422 programmable synchronous/asynchronous communications channel with software selectable baud rates. Two general purpose programmable 16-bit BCD or binary timers/event counters are available to the host board to generate accurate time intervals under software control. The iSBX board is closely coupled to the host board through the iSBX bus, and as such, offers maximum on-board performance and frees MULTIBUS system traffic for other system resources. In addition, incremental power dissipation is minimum requiring only 3.0 watts (assumes RS232C interface).
FUNCTIONAL DESCRIPTION

Communications Interface

The iSBX 351 module uses the Intel® 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) providing one programmable communications channel. The USART can be programmed by the system software to individually select the desired asynchronous or synchronous serial data transmission technique (including IBM Bi-Sync). The mode of operation (i.e. synchronous or asynchronous), data format, control character format, parity, and baud rate are all under program control. The 8251A provides full duplex, double buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the USART. The command lines, serial data lines, and signal ground lines are brought out to a double edge connector configurable for either an RS232C or RS449/422 interface (see Figure 3). In addition, the iSBX 351 module is jumper configurable for either point-to-point or multidrop network connection.

16-Bit Interval Timers

The iSBX 351 module uses an Intel 8253 Programmable Interval Timer (PIT) providing 3 fully programmable and independent BCD and binary 16-bit
interval timers. One timer is available to the system designer to generate baud rates for the USART under software control. Routing for the outputs from the other two counters is jumper selectable to the host board. In utilizing the iSBX 351 module, the systems designer simply configures, via software, each timer independently to meet system requirements. Whenever a given baud rate or time delay is needed, software commands the programmable timers to select the desired function. The functions of the timers are shown in Table 1. The contents of each counter may be read at any time during system operation.

**Interrupt Request Lines**

Interrupt requests may originate from four sources. Two interrupt requests can be automatically generated by the USART when a character is ready to be transferred to the host board (i.e. receive buffer is full) or a character has been transmitted (i.e. transmit buffer is empty). In addition, two jumper selectable requests can be generated by the programmable timers.

**Installation**

The iSBX 351 module plugs directly into the female iSBX connector on the host board. The module is then secured at one additional point with nylon hardware to insure the mechanical security of the assembly (see Figures 1 and 2).

**Table 1. Programmable Timer Functions**

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal count</td>
<td>When terminal count is reached, an interrupt request is generated. This function is useful for generation of real-time clocks.</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>Output goes low upon receipt of an external trigger edge and returns high when terminal count is reached. This function is retriggerable.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle, and the period from one low going pulse to the next is N times the input clock period.</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>Output will remain high until one-half the count has been completed, and go low for the other half of the count.</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>Output remains high until software loads count (N). N counts after count is loaded, output goes low for one input clock period.</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>Output goes low for one clock period N counts after rising edge counter trigger input. The counter is retriggerable.</td>
</tr>
<tr>
<td>Event counter</td>
<td>On a jumper selectable basis, the clock input becomes an input from the external system. CPU may read the number of events occurring after the counting “window” has been enabled or an interrupt may be generated after N events occur in the system.</td>
</tr>
</tbody>
</table>
**SPECIFICATIONS**

**Word Size**
Data — 8 bits

**I/O Addressing**

<table>
<thead>
<tr>
<th>I/O Address</th>
<th>Chip Select</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>X0, X2, X4, or X6</td>
<td>8251A USART</td>
<td>Write: Data Read: Data</td>
</tr>
<tr>
<td>X1, X3, X5, or X7</td>
<td>8251A USART</td>
<td>Write: Mode or Command Read: Status</td>
</tr>
<tr>
<td>X8 or XC</td>
<td>8253 PIT</td>
<td>Write: Counter 0 (Load Count ≠ N) Read: Counter 0</td>
</tr>
<tr>
<td>X9 or XD</td>
<td>8253 PIT</td>
<td>Write: Counter 1 (Load Count ≠ N) Read: Counter 1</td>
</tr>
<tr>
<td>XA or XE</td>
<td>8253 PIT</td>
<td>Write: Counter 2 (Load Count ≠ N) Read: Counter 2</td>
</tr>
<tr>
<td>XB or XF</td>
<td>8253 PIT</td>
<td>Write: Control Read: None</td>
</tr>
</tbody>
</table>

**Serial Communications**

**Synchronous** — 5 - 8-bit characters; internal character synchronization; automatic sync insertion; even, odd or no parity generation/detection.

**Asynchronous** — 5 - 8-bit characters; break character generation and detection; 1, 1/2, or 2 stop bits; false start bit detection; even, odd or no parity generation/detection.

**Sample Baud Rate:**

<table>
<thead>
<tr>
<th>8253 PIT Frequency1 (kHz, Software Selectable)</th>
<th>8251 USART Baud Rate (Hz)2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous</td>
<td>Asynchronous</td>
</tr>
<tr>
<td>307.2</td>
<td>19200</td>
</tr>
<tr>
<td>153.6</td>
<td>9600</td>
</tr>
<tr>
<td>76.8</td>
<td>4800</td>
</tr>
<tr>
<td>38.4</td>
<td>2400</td>
</tr>
<tr>
<td>19.2</td>
<td>1200</td>
</tr>
<tr>
<td>9.6</td>
<td>600</td>
</tr>
<tr>
<td>4.8</td>
<td>300</td>
</tr>
<tr>
<td>2.4</td>
<td>150</td>
</tr>
<tr>
<td>1.76</td>
<td>1760</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Frequency selected by I/O writes of appropriate 16-bit frequency factor to Baud Rate Register.
2. Baud rates shown here are only a sample subset of possible software-programmable rates available. Any frequency from 18.75 Hz to 614.4 kHz may be generated utilizing on-board crystal oscillator and 16-bit Programmable Interval Timer (used here as frequency divider).

**Access Time**

**Read** — 250 nsec max
**Write** — 300 nsec max

*Note*

Actual transfer speed is dependent upon the cycle time of the host microcomputer.
Interval Timer and Baud Rate Generator

Input Frequency (selectable):
1.23 MHz ±0.1% (.813 μsec period nominal)
153.6 kHz ±0.1% (6.5 μsec period nominal)

Output Frequency:

<table>
<thead>
<tr>
<th></th>
<th>Rate Generator (Frequency)</th>
<th>Real-Time Interrupt (Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>Single Timer¹</td>
<td>18.75 Hz</td>
<td>614.4 kHz</td>
</tr>
<tr>
<td>Single Timer²</td>
<td>2.34 Hz</td>
<td>76.8 kHz</td>
</tr>
<tr>
<td>Dual Timer³</td>
<td>0.000286 Hz</td>
<td>307.2 kHz</td>
</tr>
<tr>
<td>(Counters 0 and 1 in series)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual Timer⁴</td>
<td>0.0000358 Hz</td>
<td>36.4 kHz</td>
</tr>
<tr>
<td>(Counters 0 and 1 in series)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES: 1. Assuming 1.23 mHz clock input.
2. Assuming 153.6 kHz clock input.
3. Assuming Counter 0 has 1.23 mHz clock input.
4. Assuming Counter 0 has 153.6 kHz clock input.

Interrupts

Interrupt requests may originate from the USART (2) or the programmable timer (2).

Interfaces

iSBX Bus — all signals TTL compatible.

Serial — configurable for EIA Standards RS232C or RS449/422

EIA Standard RS232C signals provided and supported:
- Clear to Send (CTS)
- Data Set Ready (DSR)
- Data Terminal Ready (DTR)
- Request to Send (RTS)
- Receive Clock (RXC)
- Receive Data (RXD)
- Transmit Clock (DTE TXC)
- Transmit Data (TXD)

EIA Standard RS449/422 signals provided and supported:
- Clear to Send (CS)
- Data Mode (DM)
- Terminal Ready (TR)
- Request to Send (RS)
- Receive Timing (RT)
- Receive Data (RD)
- Terminal Timing (TT)
- Send Data (SD)

Physical Characteristics

Width — 7.24 cm (2.85 inches)
Length — 9.40 cm (3.70 inches)
Height* — 2.04 cm (0.80 inches)

iSBX 351 Board
- 2.86 cm (1.13 inches)
iSBX 351 Board and Host Board
- 2.04 cm (0.80 inches)

Weight — 51 grams (1.79 ounces)
* (See Figure 2)

Serial Interface Connectors

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Mode²</th>
<th>MULTIMODULE Edge Connector</th>
<th>Cable</th>
<th>Connector 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS232C</td>
<td>DTE</td>
<td>26-pin³, 3M-3462-0001</td>
<td>3M²-3349/25</td>
<td>25-pin⁷, 3M-3482-1000</td>
</tr>
<tr>
<td>RS232C</td>
<td>DCE</td>
<td>26-pin³, 3M-3462-0001</td>
<td>3M²-3349/25</td>
<td>25-pin⁷, 3M-3483-1000</td>
</tr>
<tr>
<td>RS449</td>
<td>DTE</td>
<td>40-pin⁶, 3M-3464-0001</td>
<td>3M³-3349/37</td>
<td>37-pin¹, 3M-3502-1000</td>
</tr>
<tr>
<td>RS449</td>
<td>DCE</td>
<td>40-pin⁶, 3M-3464-0001</td>
<td>3M³-3349/37</td>
<td>37-pin¹, 3M-3503-1000</td>
</tr>
</tbody>
</table>

NOTES: 1. Cable housing 3M-3485-4000 may be used with the connector.
2. DTE — Data Terminal mode (male connector), DCE — Data Set mode (female connector).
3. Cable is tapered at one end to fit the 3M-3462 connector.
4. Cable is tapered to fit 3M-3464 connector.
5. Pin 26 of the edge connector is not connected to the flat cable.
6. Pins 37, 39, and 40 of the edge connector are not connected to the flat cable.
7. May be used with cable housing 3M-3485-1000.
8. Connectors compatible with those listed may also be used.
Electrical Characteristics

DC Power Requirements

<table>
<thead>
<tr>
<th>Mode</th>
<th>Voltage</th>
<th>Amps (Max.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS232C</td>
<td>+5V ±0.25V</td>
<td>460 mA</td>
</tr>
<tr>
<td></td>
<td>+12V ±0.6V</td>
<td>30 mA</td>
</tr>
<tr>
<td></td>
<td>-12V ±0.6V</td>
<td>30 mA</td>
</tr>
<tr>
<td>RS449/422</td>
<td>+5V ±0.25V</td>
<td>530 mA</td>
</tr>
</tbody>
</table>

Environmental Characteristics

Temperature — 0 - 55°C, free moving air across the base board and MULTIMODULE board.

Reference Manual

9803190-01 — iSBX 351 Serial I/O MULTIMODULE Manual (NOT SUPPLIED)

Reference Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Ave., Santa Clara, California, 95051.

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<tbody>
<tr>
<td>SBX 351</td>
<td>Serial I/O MULTIMODULE Board</td>
</tr>
</tbody>
</table>
The iCS 80 Industrial Chassis provides industrially oriented mounting space for Intel single board computer (iSBC) products, associated iSBC power supplies, and related iCS 9XX analog and digital signal conditioning/termination panels. The base unit provides a 4-slot MULTIBUS backplane (iSBC 604) with expansion space and cabling to expand to 12 MULTIBUS backplane slots by adding additional 4-slot iSBC 614s as needed (up to two). All of the 25-plus Intel MULTIBUS bus-compatible iSBC boards can be inserted into any one of the 12 slots. In addition, over 50 products from 30 independent manufacturers have been designed for mounting into the MULTIBUS backplane. Full MULTIBUS compatibility in the iCS 80 chassis also allows configuration of multiple single board computers to share system tasks through communication over the bus (through multimaster bus arbitration built on the multiple iSBC processors).
ICS 80

FUNCTIONAL DESCRIPTION

Self Contained Low Cost Controllers
Small, self contained industrial controllers can be configured with the 4-slot cardcage and iSBC 635 power supply. As shown in Figure 2, this packaging can also accommodate the iCS 9XX series signal conditioning/termination panels.

Or Large Power and Point Counts in a Small Package
At the high end of performance for the iCS 80 chassis, a user can build a 12-slot configuration with the Intel iSBC 640 Power Supply. This iCS 80 chassis can support the iSBC 86/12A 16-bit computer with 112K bytes memory (96K RAM, 16K ROM), 64 differential analog inputs, 180 digital inputs, 52 isolated digital outputs, and 8 analog outputs (four current loops); in total a 304-channel, mixed analog and isolated digital, input and output controller, large enough for most dedicated applications (see Figure 3 for two other examples).

Engineered for Industrial Applications
The MULTIBUS slots are mounted vertically to improve convection cooling and the top, bottom and sides are engineered to allow maximum air flow over the boards. Four fans are provided as standard to increase air flow, allowing users to eliminate or minimize the need for supplementary fans or air conditioning.

Power Supply Flexibility
To provide a modular base on which to build a variety of configurations, no power supply is provided in the iCS 80 Industrial Chassis. Users choose one of the low cost Intel ISBC 635 (14-amp) or ISBC 640 (30-amp) power supplies based on their application. Slide in/out mounting rails are provided to match the iSBC 635 and ISBC 640 supplies, and quick disconnect cabling and connectors are provided for rapid service replacement. An AC wiring barrier strip allows simple wiring connections for integration into larger systems (see Figure 4).

Industrial Rack Mounting
The chassis mounts directly into 19-inch standard width RETMA (Radio-Electronics-Television Manufacturers Association) customer provided rack. Alternately, mounting brackets and power cabling access are provided for mounting directly on a backwall, such as the backwall panel of a NEMA-type (National Electrical Manufacturers Association), front-access-only cabinet.

Front Access Serviceability
To simplify serviceability, front access is provided for all iSBC boards, the power supply, operation indicator lights, interrupt and reset buttons, and the AC power fuse.

Figure 1. iCS 80 Chassis Dimensions
iCS 80

Typical Small Configuration
- 8-bit 8088 processor (iSSC 88/40)
- 4K bytes RAM (8K optional)
- 2K-16K bytes E2PROM or 8K-128K bytes ROM/EPROM
- 16-64 analog inputs
- 8 analog outputs
- 8 isolated digital inputs
- 8 isolated digital outputs

OR
- 12 TTL outputs
- 12 TTL inputs

Figure 2. Small Configuration iCS 80 with iSBC 635, iCS 910 and iCS 930 Signal Conditioning/Termination Panels

Typical Maximum Configuration
- 16-bit 8086 processor (iSSC 86/30 w/RAM MULTIMODULE)
- 768K bytes RAM (2 - iSBC 056)
- 128K bytes EPROM (or 16K E2PROM)
- 240 analog inputs (3 - iSBC 88/40 w/2 ea. iSBX 311)
- 24 analog voltage outputs

OR
- 24 analog current outputs (4-20 mA)
- 72 isolated digital inputs/outputs
- 144 TTL digital inputs/outputs (2 - iSBC 519s)

(All iCS 9XX Signal Conditioning/Termination Panels are not shown)

Figure 3. iCS 80 with 12 MULTIBUS Card Slots and iSBC 640 Power Supply, Large Configuration

Figure 4. Rear View iCS 80 Chassis Showing Power Distribution Panel, and Cabling from iCS 80 Chassis to iCS 9XX RETMA Mounted Signal Conditioning Panels (Top of iCS 80 Chassis)
Lockable Service Panel

To assist in development, checkout and service, two pushbuttons are provided. The RESET button pulls low the initialize line (INIT) on the MULTIBUS backplane. The INTERRUPT button pulls low one interrupt line on the MULTIBUS backplane (INT). Logic within the iCS 80 ensures that these buttons function with all versions of Intel single board computers. From the front of the iCS 80 chassis, without a CRT or other panel, an operator or service person can reset or interrupt on-going system operations to get attention, signal an alarm, or start a self-test operation.

A front panel key provides three positions: OFF (AC power off and key removable), ON (AC power on, pushbuttons enabled, key unremovable), and LOCK (AC power on, pushbuttons disabled, key removable).

Three indicator light emitting diodes record basic chassis status. POWER ON (GREEN); RUN (GREEN); and HALT (RED); the RESET or INTERRUPT buttons will remove the HALT state.

U.L. Approved

The iCS 80 chassis has received full Underwriters Laboratory approval (F.6 #E70842) as a U.L. listed component under the Underwriters Laboratories Safety Standard for Process Control Equipment, UL1092. When installed as described in the iCS 80 Installation Manual, the iCS 80 chassis provides adequate protection against shock, fire and casualty hazards, and should comply with most local and regional requirements for installation in ordinary locations. In addition, the iCS 80 chassis was designed to comply with the UL requirements for Data Processing Equipment, UL478. It has also been submitted to the Canadian Standards Association and approval is pending under CSA category C22.2 No. 142, the Canadian Standard for Safety for Process Control Equipment and C22.2 No. 154 for Data Processing Equipment.

Mounting Space for Signal Conditioning/Wire Terminations

The cardcages and power supplies in the iCS 80 chassis are recessed behind the front edge of the rack mounting ears to provide mounting space for the iCS 9XX series signal conditioning/termination panels and field wiring. For smaller systems with only one or two iSBC 604/614 cardcages (4 to 8 slots), up to two iCS 910, iCS 920, or iCS 930 signal conditioning/termination panels can be mounted vertically over the area where the second or third cardcage would mount (see Figure 2). The benefit of this design is a completely self-contained industrial chassis with iSBC cards, power supply, signal conditioning and field wiring terminations, all in one enclosure.

SPECIFICATIONS

Capacity

Four slots for MULTIBUS compatible single board computers, memory, I/O or other expansion boards
Expandable to 12 slots using customer plug-together iSBC 614 cardcages

Front Panel Controls

Pushbuttons
RESET: Connected to Initialize/ on MULTIBUS backplane
INTERRUPT: Connected to Interrupt 1/ line on MULTIBUS backplane.

Panel Indicator Lights (LEDs)
POWER ON (green): +5V power exists on the MULTIBUS backplane
RUN (green): CPU is executing an instruction. Light goes out if CPU is in WAIT or HALT state
HALT (red): CPU has executed a HALT instruction

Keylock
OFF: AC power off, key removable
ON: AC power on, pushbuttons enabled, key unremovable
LOCK: AC power on, pushbuttons disabled, key removable

Fuse — AC power (6A)

Equipment Supplied

iCS 80 industrial chassis, three fans for cardcages, one fan for power supply, 4-slot cardcage with MULTIBUS backplane, control panel with switches, indicators, keylock, power distribution barrier strip, AC power fuse, line filter, 115V power cable, and logic for interrupt and reset buttons. An installation package is also provided, including a NEMA cabinet mounting kit, power supply extension cables, and RETMA cabinet mounting screws, 110/230 VAC operation.

Software

See the RMX/80 Real-time Multitasking Executive specifications for industrial related applications. In addition, system monitors for most of the Intel single board computers are available in the INSITE (Intel's Software Index and Technology Exchange) User's Program Library.

Physical Characteristics

Height — 39.3 cm (15.7 in.)
Width — 48.5 cm (19.0 in.) at front panel
43.5 cm (17.4 in.) behind front panel
Depth — 30.0 cm (12.0 in.) with all protrusions
Weight — 16.8 kg (37.0 lb) without power supplies

Environmental Characteristics

(Ambient at iCS-80 air intake, bottom of chassis)

Temperature (Ambient)
Operating: 0°C to 50°C (32°F to 122°F)
Non-operating: -40°C to +85°C
Humidity — Up to 90% relative, noncondensing at 40°C
Electrical Characteristics

The iCS 80 chassis provides mounting space for either the iSBC 635 or iSBC 640 power supply. Unless otherwise stated, electrical specifications apply to both power supplies when installed by user in iCS 80 chassis.

Input Power

Frequency: 47 to 63 Hz. Voltage (Nominal)
(Single Phase): 100, 115, 215, or 230 VAC +10%, jumper selectable.

<table>
<thead>
<tr>
<th>Current (Including fans)</th>
<th>With iSBC 635</th>
<th>With iSBC 640</th>
<th>Input Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.0A max</td>
<td>5.6A max</td>
<td>105 VAC</td>
</tr>
<tr>
<td></td>
<td>1.5A max</td>
<td>2.8A max</td>
<td>206 VAC</td>
</tr>
<tr>
<td>Power, max:</td>
<td>315 watts</td>
<td>580 watts</td>
<td></td>
</tr>
</tbody>
</table>

Output Power

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Output Current (max)</th>
<th>Overvoltage Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>+12V</td>
<td>2.0A</td>
<td>+14V to +16V</td>
</tr>
<tr>
<td>+5V</td>
<td>14.0A</td>
<td>+5.8V to +6.6V</td>
</tr>
<tr>
<td>-5V</td>
<td>0.9A</td>
<td>-5.8V to -6.6V</td>
</tr>
<tr>
<td>-12V</td>
<td>0.8A</td>
<td>-14V to -16V</td>
</tr>
</tbody>
</table>

Combined Line/Load Regulation — ±1% at ±10% static line change and ±50% static load change, measured at the output connector (±0.2% measured at the power supply under the same conditions).

Remote Sensing — Provided for +5 VDC output line regulation.

Output Ripple and Noise — 10 mV (iSBC 635 and iSBC 640 supply) peak-to-peak, max (DC to 500 kHz)

Output Transient Response — Less than 50 μsec for ±50% load change.

Maximum Watts Dissipation (load plus losses) — 500W (iSBC 640 supply), 250W (iSBC 635 supply)

Installation

Complete instructions for installation are contained in the iCS 80 Site Planning and Installation Guide, including RETMA and NEMA cabinet mounting, and field signal, ground wiring and cooling suggestions.

Warranty

The iCS 80 Industrial Chassis is warranted to be free from defects in materials and workmanship under normal use and service for a period of 90 days from date of shipment.

Reference Manuals

9800799A — iCS 80 Industrial Chassis Hardware Reference Manual (SUPPLIES)
9800798 — iCS 80 Industrial Systems Site Planning and Installation Guide (SUPPLIED)
9800708A — iSBC 604/614 Cardcage Hardware Reference Manual (SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

The iCS 80 Industrial Chassis must be ordered as a kit with an Intel power supply of your choice. Ordering as a kit will ensure shipment of the power supply and iCS 80 chassis at the same time. Typical configurations and ordering instructions are:

**Part Number** | **Description**
--- | ---
ICS 80 Kit 635 | iCS 80 system consisting of:
iCS 80 Industrial Chassis
iSBC 635 Power Supply
ICS 80, Kit 640 | iCS 80 system consisting of:
iCS 80 Industrial Chassis
iSBC 640 Power Supply
The iCS 910/920/930 Signal Conditioning/Termination Panels are heavy duty printed circuit boards with screw terminations which allow industrial customers to easily connect their heavier gauge field signal wiring to Intel's line of 8- and 16-bit single board computers, and ISBC analog and digital I/O boards. Flat ribbon cables connect the iCS 910 panels to any of the Intel ISBC 700 series analog input and output board pin-outs. Flat ribbon cables also connect the iCS 920 panels and iCS 930 panel to the 50-pin digital I/O ports (8255 or UPI) on Intel's single board computers and digital I/O boards. Power for opto-isolators or line drivers (+5 VDC) can be supplied via this cable from the ISBC boards. Jumpers and a screw terminal block are provided on the iCS 920/930 panels to allow an external supply of +5V power. A similar jumper/terminal block is provided on the iCS 910 panel to allow users to connect external +15V (or greater) compliance voltage for larger analog output loads.
FUNCTIONAL DESCRIPTION COMMON TO iCS 910/920/930

Large Wire or Spade Lug Connections
The barrier strip screw terminations on the iCS 910/920/930 panels provide familiar connection points for factory electricians to terminate the heavier gauge wiring often pulled through conduits from sensors or control elements. These screw terminals securely connect up to 14 AWG gauge wire size (16-gauge on iCS 910/920 panels). Alternately, spade lugs can be crimped on field wiring and inserted under the screw terminals.

Mounting Flexibility and Serviceability
The iCS 910/920/930 panels were designed to be physically separate from iSSC boards or the iCS 80 chassis to allow maximum mounting flexibility and ease of serviceability. The panels and field wiring can be mounted in one area of the cabinet where electricians have access. Flat ribbon cable can then be run to the area where control electronics technicians have access.

The iCS 910/920/930 panels may be mounted horizontally in a 19" standard width (RETMA) rack using a recessed mounting panel (see Figure 1). Alternately, the panels can be mounted on a cabinet wall (e.g., NEMA cabinet backwall) using standoffs provided (see Figure 2). Or, for the most compact packaging, users can mount up to two iCS 910/920/930 panels vertically, directly on the front of the iCS 80 chassis using standoffs and holes provided (see Figure 3).

A black metal labeling strip is provided with each iCS 910/920/930 panel. White, blank gummed labels are included so that users can custom identify each input or output channel. A clear plastic cover is provided to protect against inadvertent touching or damage to the screw terminals or customer mounted components.

iCS 910 ANALOG SIGNAL CONDITIONING/TERMINATION PANEL

Mixed Analog Input and Output Signals
A single iCS 910 panel connects up to 32 single ended analog inputs (or 16 differential analog inputs plus shield) to the iSBC 711 or iSBC 732 analog input boards. In addition, the same iCS 910 panels can connect up to four analog output voltages from the iSBC 724 analog output board, or two voltage or 4 to 20 mA current loop outputs from the iSBC 732 combination analog input/output board. Three flat ribbon cables are included in the iCS 910 installation kit (two analog inputs, one analog output) to route signals to iSBC 711/724/732 boards.
Engineered Signal Conditioning Mounting Space

Printed circuit traces on the iCS 910 panel connect each screw terminal analog input channel to the flat ribbon cable connector. Users can jump straight through signal connections if they desire. Each input channel trace, however, passes through a custom engineered printed circuit area onto which users may mount components to signal condition analog input signals. Pad traces and holes are designed to allow easy mounting of R-C noise filters, input voltage resistor/divider networks, current loop input resistors, open circuit detection resistors, or to supply thermistor bias current (see Figure 4 for schematic of a typical analog input channel).

![Diagram of iCS 910 Analog Input Signal Conditioning Examples](image)

iCS 920 DIGITAL SIGNAL CONDITIONING/TERMINATION PANEL

The iCS 920 panel interconnects up to 24, 2-wire digital input or output channels from barrier strip screw terminals to the 16- or 24-bit digital I/O ports, standard on many Intel single board computers and digital I/O expansion boards. Screw terminals allow for one each 16 AWG size wire for differential (2-wire) connections or two each AWG 18-gauge wire for daisy chaining grounds or power for external contact sensing.

Flexibility in Isolation and Serviceability

Dual-in-line sockets are in series with each channel (see Figure 5) to allow customer jumpering for straight through connections (TTL I/O), or for insertion of popular DIP packaged opto-isolators or digital output high current driver transistors. Circuit pads are available for mounting voltage divider/threshold resistors and protection diodes.

Groups of four inputs can have mixed voltage levels, opto-isolation, or straight through connections in groups of two. Output groups of four can be mixed opto-isolated or high current drive in groups of two. DIP components from a wide variety of vendors are selected and inserted by users based on their application. The iCS 920 manual recommends several alternative components and offers design assistance for your I/O configuration. Digital signal conditioning examples for several common industrial voltages are shown in Table 1 and in the diagrams below (see Figure 5).

Active Channel Indicators

Light emitting diodes (LEDs) are mounted adjacent to each channel’s screw terminals and may be jumpered in to indicate the Hi-Lo status of each of the 24 input or output channels.
CURRENT LIMITING AND THRESHOLD RESISTORS IN FROM FIELD SCREW TERMINALS

OPTO-ISOLATOR SOCKETS (e.g. TIL 117)

1 OF 2 CHANNELS

560K

OPTICALLY ISOLATED DC INPUT EXAMPLE (ICS-920 panel)

OPTICALLY ISOLATED DC OUTPUT EXAMPLE (ICS-920 panel)

CURRENT DRIVER OUTPUT (55V, 300 mA) EXAMPLE (ICS-920 panel)

Figure 5. Digital Signal Conditioning Examples
Table 1. ICS 920 Digital I/O Signal Conditioning Plug-In Component Examples

<table>
<thead>
<tr>
<th>Input/Output Load Voltage</th>
<th>Maximum Input Current (mA)</th>
<th>Threshold Voltage (V)</th>
<th>Opto-Isolators*</th>
<th>Diode Protection*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opto-Isolated Input</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 VDC</td>
<td>50</td>
<td>3</td>
<td>TIL117</td>
<td>1N4002</td>
</tr>
<tr>
<td>12 VDC</td>
<td>50</td>
<td>6</td>
<td>TIL117</td>
<td>1N4002</td>
</tr>
<tr>
<td>24 to 26 VDC</td>
<td>40</td>
<td>6</td>
<td>TIL117</td>
<td>1N4002</td>
</tr>
<tr>
<td>48 VDC</td>
<td>20</td>
<td>12</td>
<td>4N36</td>
<td>1N4002</td>
</tr>
<tr>
<td>Opto-Isolated Output</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 VDC</td>
<td>100</td>
<td></td>
<td>—</td>
<td>TIL113</td>
</tr>
<tr>
<td>24 VDC</td>
<td>100</td>
<td></td>
<td>—</td>
<td>TIL119</td>
</tr>
<tr>
<td>48 VDC</td>
<td>100</td>
<td></td>
<td>—</td>
<td>MCS 2</td>
</tr>
<tr>
<td>Current Drivers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55 VDC</td>
<td>300</td>
<td></td>
<td>TIL75472</td>
<td>—</td>
</tr>
<tr>
<td>Half Wave Rectifier Outputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 VAC SCR</td>
<td>300</td>
<td></td>
<td>—</td>
<td>GE4N40</td>
</tr>
<tr>
<td>115 VAC SCR</td>
<td>150</td>
<td></td>
<td>—</td>
<td>MCS 2</td>
</tr>
</tbody>
</table>

*Example component — alternate source components are listed in the ICS 920 Hardware Reference Manual.

ICS 930 AC Signal Conditioning/Termination Panel

The ICS 930 panel interconnects 16 2-wire digital input or output channels from barrier strip screw terminals to 16 bits of the digital I/O ports available on many Intel single board computers and digital I/O expansion boards. The ICS 930 panel differs from the ICS 920 digital signal conditioning/termination panel in that the ICS 930 panel handles higher AC or DC voltages and currents (up to 280V, 3A), such as those found on many 115 VAC machines, motor starters, and industrial control panels. The ICS 930 panel is also recommended for optically isolated DC outputs greater than 100 mA.

The ICS 930 panel accepts up to 14 AWG size wires each for differential (2 wires per channel) connections, or two 14 AWG size wires for daisy chaining grounds or power from external sources.

Modular Isolation/Switching with Easy Serviceability

Each ICS 930 panel accepts up to 16 user supplied, optically isolated input modules or optically isolated solid state switches, for either AC or DC voltages (see Figure 6). Each module is screw mountable/replaceable and can be mixed for AC or DC input, or AC or DC output, in groups of four. Among groups of four inputs (or outputs) each channel can be individually mixed for AC or DC input (or AC or DC output). The user pays only for those channels implemented. User supplied compatible modules are shown in Table 2.

DC and AC input modules are current actuated and thus provide a 5-ms filter against spurious noise spikes or contact bounce. AC solid state output modules provide zero crossing turn on to minimize arcing.

Protection Circuitry

Each of the 16 channels contain a socketed fuse to protect against overload. In addition, mounting pads are available on each channel output for user supplied voltage transient RC “snubber” components or inductive pulse suppression, e.g., metallic-oxide-varistor (MOV) for large motor starting.

Active Channel Indicators

Light emitting diodes (LEDs) are mounted adjacent to each channel’s screw terminals and opto-module to indicate Hi-Lo status of that channel and to assist in troubleshooting servicing.

Examples of ICS 930 input and output schematics are shown in Figure 6.
Table 2. Optically Isolated Modules Compatible with iCS 930 Signal Conditioning/Termination Panel

<table>
<thead>
<tr>
<th>Signal Conditioning Desired</th>
<th>Voltage Rating</th>
<th>Maximum Input Current</th>
<th>Opto-22 Number*</th>
<th>Motorola Number*</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Input — 115 VAC 220 VAC</td>
<td>95 to 130 VAC 180 to 280 VAC</td>
<td>10 mA 10 mA</td>
<td>IAC5 IAC5A</td>
<td>IAC5</td>
</tr>
<tr>
<td>DC Input — 5 µsec Filter Fast, 50 µsec On</td>
<td>10 to 32 VDC 4 to 16 VDC</td>
<td>32 mA 14 mA</td>
<td>IDC5 IDC5B</td>
<td>IDC5</td>
</tr>
</tbody>
</table>

Output Current Rating

<table>
<thead>
<tr>
<th>Signal Conditioning Desired</th>
<th>Voltage Rating</th>
<th>Maximum Input Current</th>
<th>Opto-22 Number*</th>
<th>Motorola Number*</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Output</td>
<td>12 to 140 VAC 24 to 280 VAC</td>
<td>3A 3A</td>
<td>OAC5 OAC5A</td>
<td>OAC5</td>
</tr>
<tr>
<td>DC Output</td>
<td>10 to 60 VDC 200 VDC</td>
<td>3A 1A</td>
<td>ODC5 ODC5A</td>
<td>ODC5</td>
</tr>
</tbody>
</table>

*Motorola and Opto-22 sales offices are located in North America, Europe, and Japan.

Figure 6. Typical iCS 930 Signal Conditioning Examples
SPECIFICATIONS
(For iCS 910/920/930 panels unless otherwise specified)

Number of Lines
iCS 910 Panel
Analog Inputs — Sixteen 3-wire (differential signal plus shield) or 32 single ended
Analog Outputs — Four 2-wire voltage output (iSBC 724 Analog Board) or two 2-wire current output (iSBC 732 Analog Board)
iCS 920 Panel — Zero to 24 digital inputs or outputs in groups of four
iCS 930 Panel — Zero to 16 digital inputs or outputs in groups of four

Isolation Characteristics
Line-to-Line Isolation — 250 VDC or RMS AC (iCS 910/920 panels), 500 VDC or RMS AC (iCS 930 panel)
Input/Output Isolation — 250 VDC or RMS AC (iCS 920 panel), 500 VDC or RMS AC (iCS 930 panel)

Physical Characteristics
Width: 36.63 cm (14.65 in.)
Height: 8.13 cm (3.25 in.)
Thickness: 0.24 cm (0.093 in.), iCS 910/920 panel
0.32 cm (0.125 in.), iCS 930 panel

Maximum Distance from iSBC Boards
The iCS 910/920/930 panels are shipped with 4-ft. long cables. With customer provided 50-conductor or twisted pair ribbon cable, however, the iCS 910/920/930 panels can be mounted remote from the iSBC analog or digital I/O boards. In electrically quiet environments using normal iSBC board line driver/receivers, the iCS 910/920/930 panels should be able to operate up to 25 ft. (7.69m) from the iSBC board.
**Electrical Characteristics**

**Power Requirements**
- iCS 920 panel — +15V ±5%, 25 mA max if iSBC 724 or iSBC 732 ±15V power is used for user mounted open circuit detection, or thermistor bias components. Additional power must be supplied via +15V terminal block.
- iCS 920 panel — +5V ±5%, 1.46A max (24 channels high current drive)

<table>
<thead>
<tr>
<th>ICS 920 Channel Configuration</th>
<th>Maximum per Channel Current (includes pullups, LEDs, isolators, drivers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTL in</td>
<td>23 mA</td>
</tr>
<tr>
<td>TTL out</td>
<td>23 mA</td>
</tr>
<tr>
<td>Opto-isolated in</td>
<td>23 mA</td>
</tr>
<tr>
<td>Opto-isolated out</td>
<td>41 mA</td>
</tr>
<tr>
<td>Open collector driver output</td>
<td>61 mA</td>
</tr>
</tbody>
</table>

**Note:** Both ICS 920 and ICS 930 panels have jumpered provision for externally supplied +5V power via a screw terminal block.

- iCS 930 panel — +5V ±5%, 320 mA max. Output AC or DC channel: 20 mA/chan max; Input AC or DC channel: 12 mA/chan max.

**Maximum Power Dissipation**
- ICS 910 panels — 3 watts with 16 channels analog input signal conditioning and +15V external compliance voltage
- ICS 920 panels — 12 watts with 24 channels each containing high current driver outputs
- ICS 930 panels — 80 watts with 16 channels of AC or DC output

**Underwriters Laboratory (UL) Recognition**
The iCS 910/920/930 signal conditioning/termination panels have been submitted to Underwriters Laboratories for approval as a UL recognized component under the UL safety standard for process control equipment, UL 1092.

**Environmental Characteristics**
- **Operating Temperature** — 0 to 70°C (32°F to 158°F)
- **Relative Humidity** — 0 to 90%, noncondensing

**Hardware Supplied**
- **ICS 910** — Analog Signal Conditioning/Terminating Panel, three 4-ft, 50-conductor flat ribbon cables with connectors, and installation kit below
- **ICS 920** — Digital Signal Conditioning/Termination Panel, one 4-ft, 50-conductor flat ribbon cable with connectors, and installation kit below
- **ICS 930** — AC Signal Conditioning/Termination Panel, one 4-ft, 50-conductor ribbon cable with connectors, and installation kit below

**Installation**
Complete instructions for installation and service are contained in the applicable ICS 910/920/930 Hardware Reference Manual. Additional system level information is available in the ICS 80 Systems Site Planning and Installation Guide, including RETMA and NEMA cabinet mounting, field signals, ground wiring and cooling suggestions.

**Warranty**
The ICS 80 Industrial Chassis is warranted to be free from defects in materials and workmanship under normal use and service for a period of 90 days from date of shipment.

**DOCUMENTATION Supplied**
A schematic diagram and assembly diagram are supplied with each ICS 910/920/930 panel.

**Reference Manuals**
- **9800800A** — ICS 910 Analog Signal Conditioning/Termination Panel Hardware Reference Manual (NOT SUPPLIED)
- **9800801A** — ICS 920 Digital Signal Conditioning/Termination Panel Hardware Reference Manual (NOT SUPPLIED)
- **9800802A** — ICS 930 AC Signal Conditioning/Termination Panel Hardware Reference Manual (NOT SUPPLIED)
- **9800798A** — ICS 80 Systems Site Planning and Installation Guide (NOT SUPPLIED), but supplied with ICS 80 Industrial Chassis

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.
iSBC 941
INDUSTRIAL DIGITAL PROCESSOR

- Provides measurement and control of common industrial digital input and output signals
  - Sense change state
  - Pulse counting
  - Pulse generation
  - Period measurement
  - Frequency measurement
- Off-loads host processor from time-consuming task of digital I/O processing
- Simplified command protocol with MCS 80/85/86 “Master” Processor
- Compatible with 8041A Universal Peripheral Interface (UPI-41A) sockets such as those provided on Intel iSBC 80/30 and the iSBC 569 Intelligent Digital Processor
- Applications include
  - Switch sensing
  - Motor speed control
  - Stepper motor actuation
  - Serial communications
- 16 programmable I/O lines, TTL compatible
- Single +5V supply

The iSBC 941 Industrial Digital Processor is a 40-pin DIP device which provides the user with easy-to-use processing of digital input and output signals desired in many industrial automation environments. One of nine digital I/O functions can be selected at any one time for measuring, counting, or controlling up to 16 separate I/O lines. Additional utility commands allow reading or setting the condition of unused I/O lines. Simplex serial input and output modes can assemble or disassemble bytes transmitted asynchronously over TTL lines, including insertion and deletion of start/stop bits. The device has two 8-bit, TTL compatible I/O ports.
FUNCTIONAL DESCRIPTION

Industrial Digital Processor

Designed to operate as a slave device, the iSBC 941 processor may be requested to implement one of nine Primary Functions. These Primary functions are subroutines which are stored in program memory of the iSBC 941 device. Each Primary Function has a specific I/O task. Available Primary Functions include:

EVENT — Monitors and counts up to eight input lines for event counting or comparison to a preset count for each line. Interrupts may be generated or counter can be read 'on-the-fly' without changing its state.

FCOUNT — Measures frequency of one of eight digital inputs over a programmable period. Inputs may be selected under user program control or iSBC 941 processor may be requested to automatically scan inputs in sequential order, update, and hold or interrupt for reading each 16-bit counter. Input frequencies up to 18 KHz may be measured.

FREQ — Generates up to eight gated frequency outputs with separately programmable pulse width and periods and complementary synchronous outputs.

PERIOD — Measures the period of up to four inputs (single cycle).

SCAN — Monitors up to 16 input lines for change-of-state and direction of change. Change-of-state interrupts may be generated. User can individually disable inputs.

SERIN — Enables simplex reception and 8-bit byte assembling of asynchronously transmitted serial data bits for communications applications. Includes detection/deletion of start/stop bits. Baud rates up to 1200 baud may be programmed.

SEROUT — Enables simplex transmission of asynchronous serial data bits for communications applications. Includes insertion of start/stop bits. Baud rates up to 1200 baud may be programmed.

SHOT1 — Emulates a gated one-shot pulse generator (edge triggered and retriggerable modules) with programmable delay and period. Complimentary, synchronous one-shots can be created on separate output lines, on up to eight lines.

STEPPER — Generates up to eight programmable outputs that may be used for control of stepper motors. Step rate, step count, and step direction are user defined.

Any of the sixteen UPI processor I/O lines that are not used by a Primary Function are available for general purpose use; e.g., direct status reads or latched digital outputs, through the use of Utility Commands.

Commands recognized by the iSBC 941 Industrial Digital Processor are defined by one of two categories, Control Commands or Utility Commands. Control Commands are used to start and stop a Primary Function. Utility Commands are typically associated with moving a byte of information or reading the status of the iSBC 941 processor through the COMMAND/DATA Bus Buffer.

Control Commands available are:

ENFLAG — Enables the iSBC 941 processor to send interrupts via its I/O lines to the host processor.

INITPF — Selects the desired Primary Function and initializes parameters used by the Primary Function.

LOOP — Continuously executes the selected Primary Function at a specific rate.

PACIFY — Resets all iSBC 941 processor I/O lines to the input state and clears all control variables.

PAUSE — Commands the iSBC 941 processor to exit the LOOP or INITPF mode.

Utility Commands include:

CLRP1 — Sets (to logic level 0) selected iSBC 941 processor Port 1 (Port 2) output lines. All other lines are unaffected.

CLRP2

ENP1IN — Enables user-defined mask to inhibit the writing of '0's by the iSBC 941 processor to Port 1 (Port 2) input lines. This function is used by SETP1 (SETP2), CLRPR1 (CLRP2), STEP and LOOP.

IDEN — Requests the identity code of the iSBC 941 processor accessed.

LATCH — Transfers to holding area for reading all eight counters used by the EVENT Primary Function.

RDEC — Enables host processor to read one of eight user-specified event accumulators used by the EVENT Primary Function.

RDFQ — Reads bytes from the iSBC 941 processor's
Simple Command Protocol

iSBC 941 functions may be implemented with minimum software overhead required of the host processor. An easy-to-implement protocol ensures that communication between the iSBC 941 processor and host CPU is straightforward and uncomplicated.

Implementing a Primary Function involves simple programming; the host processor transmits to the iSBC 941 processor a command byte followed by parameter bytes (the number of parameter bytes required is dependent upon the Primary Function selected). For example, to execute the Primary Function SCAN:

1. Initialize iSBC 941 processor (Command byte)
2. Select SCAN as Primary Function and select internal or external time reference (Parameter byte)
3. Program Time Reference Period (Parameter byte) (scan rate — this byte is required only if internal time reference was selected in (2))
4. Define return message format (Parameter byte)

5. Enable selected SCAN input lines (Parameter byte) (enabled in groups of eight)
6. Terminate parameter list (Command byte)
7. Enable iSBC 941 processor interrupt outputs (Command byte)
8. Request execution (Command byte)

PIN DESCRIPTION

<table>
<thead>
<tr>
<th>Signal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D0-D7</td>
<td>Three-state, bidirectional COMMAND/DATA BUS BUFFER lines used to interface the iSBC 941 processor to an 8-bit master system data bus.</td>
</tr>
<tr>
<td>P10-P17</td>
<td>8-bit, PORT 1 quasi-bidirectional I/O lines.</td>
</tr>
<tr>
<td>P20-P27</td>
<td>8-bit, PORT 2 quasi-bidirectional I/O lines. Control can configure P24 as OBF (Output Buffer Full), P25 as IBF (Input Buffer Full) to send interrupt signals to master CPU.</td>
</tr>
<tr>
<td>WR</td>
<td>I/O write input which enables the master CPU to write data and command words to the iSBC 941 COMMAND/DATA BUS BUFFER.</td>
</tr>
<tr>
<td>RD</td>
<td>I/O read input which enables the master CPU to read data and status words from the COMMAND/DATA BUS BUFFER or status register.</td>
</tr>
<tr>
<td>CS</td>
<td>Chip select input used to select one iSBC 941 processor out of several connected to a common data bus.</td>
</tr>
<tr>
<td>A0</td>
<td>Address input used by the master processor to indicate whether byte transfer is data or command.</td>
</tr>
<tr>
<td>T0, T1</td>
<td>Input pins used by various iSBC 941 processor routines.</td>
</tr>
<tr>
<td>X1, X2</td>
<td>Inputs for a crystal, LC or an external timing signal to determine the internal oscillator frequency.</td>
</tr>
<tr>
<td>SYNC</td>
<td>Output signal which occurs once per iSBC 941 instruction cycle. SYNC can be used as a strobe for external circuitry.</td>
</tr>
<tr>
<td>RESET</td>
<td>Input used to reset status flip-flops and to prepare iSBC 941 processor to receive commands.</td>
</tr>
<tr>
<td>VCC</td>
<td>+5V power supply pin.</td>
</tr>
<tr>
<td>VDD</td>
<td>+5V during normal operation.</td>
</tr>
<tr>
<td>VSS</td>
<td>Circuit ground potential.</td>
</tr>
<tr>
<td>EA</td>
<td>Circuit ground potential.</td>
</tr>
<tr>
<td>SS</td>
<td>Connect to +5V through 10K-ohm pull-up resistor.</td>
</tr>
</tbody>
</table>
ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Ambient Temperature Under Bias ........... 0°C to 70°C
Storage Temperature .................. -65°C to +150°C
Voltage on Any Pin With Respect to Ground .................. 0.5V to +7V
Power Dissipation .................. 1.5 Watt

D.C. and Operating Characteristics

$T_A = 0°C$ to 70°C, $V_{SS} = 0V$, $V_{CC} = +5V$ ± 5%

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IL}$</td>
<td>Input Low Voltage (All Except $X_1$, $X_2$)</td>
<td>-0.5</td>
<td>0.8</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{IH1}$</td>
<td>Input High Voltage (All except $X_1$, $X_2$, RESET, WR, CS)</td>
<td>2.0</td>
<td>$V_{CC}$</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{IH2}$</td>
<td>Input High Voltage ($X_1$, $X_2$, RESET)</td>
<td>3.0</td>
<td>$V_{CC}$</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{IH3}$</td>
<td>Input High Voltage (WR, CS)</td>
<td>2.2</td>
<td>$V_{CC}$</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{OL1}$</td>
<td>Output Low Voltage ($D_2$-$D_7$, Sync)</td>
<td>0.45</td>
<td>V</td>
<td>$I_{DL} = 2.0$ mA</td>
<td></td>
</tr>
<tr>
<td>$V_{OL2}$</td>
<td>Output Low Voltage (All Other Outputs Except Prog)</td>
<td>0.45</td>
<td>V</td>
<td>$I_{DL} = 1.6$ mA</td>
<td></td>
</tr>
<tr>
<td>$V_{OH1}$</td>
<td>Output High Voltage ($D_0$-$D_7$)</td>
<td>2.4</td>
<td>$V_{CC}$</td>
<td>V</td>
<td>$I_{OH} = -400$ $\mu$A</td>
</tr>
<tr>
<td>$V_{OH2}$</td>
<td>Output High Voltage (All Other Outputs)</td>
<td>2.4</td>
<td>V</td>
<td>$I_{OH} = -50$ $\mu$A</td>
<td></td>
</tr>
<tr>
<td>$I_{IL}$</td>
<td>Input Leakage Current ($T_0$, $T_1$, RD, WR, CS, $A_{0}$)</td>
<td>± 10</td>
<td>$\mu$A</td>
<td>$V_{SS} &lt; V_{IN} &lt; V_{CC}$</td>
<td></td>
</tr>
<tr>
<td>$I_{OZ}$</td>
<td>Output Leakage Current ($D_0$-$D_7$, High Z State)</td>
<td>± 10</td>
<td>$\mu$A</td>
<td>$V_{SS} + 0.45 &lt; V_{IN} &lt; V_{CC}$</td>
<td></td>
</tr>
<tr>
<td>$I_{IL1}$</td>
<td>Low Input Load Current ($P_{10}$-$P_{17}$, $P_{20}$-$P_{27}$)</td>
<td>0.5</td>
<td>mA</td>
<td>$V_{IL} = 0.8$ V</td>
<td></td>
</tr>
<tr>
<td>$I_{IL2}$</td>
<td>Low Input Load Current (RESET, SS)</td>
<td>0.2</td>
<td>mA</td>
<td>$V_{IL} = 0.8$ V</td>
<td></td>
</tr>
<tr>
<td>$I_{DD}$</td>
<td>$V_{DD}$ Supply Current</td>
<td>15</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{CC} + I_{DD}$</td>
<td>Total Supply Current</td>
<td>125</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A.C. Characteristics

$T_A = 0°C$ to 70°C, $V_{SS} = 0V$, $V_{CC} = V_{DD} = +5V$ ± 5%

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{AR}$</td>
<td>$CS$, $A_{0}$ Setup to $RD^+$</td>
<td>0</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{RA}$</td>
<td>$CS$, $A_{0}$ Hold After $RD^+$</td>
<td>0</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{RR}$</td>
<td>$RD^+$ Pulse Width</td>
<td>250</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{AD}$</td>
<td>$CS$, $A_{0}$ to Data Out Delay</td>
<td>225</td>
<td>ns</td>
<td>$C_L = 150$ pF</td>
<td></td>
</tr>
<tr>
<td>$t_{RD}$</td>
<td>$RD^+$ to Data Out Delay</td>
<td>225</td>
<td>ns</td>
<td>$C_L = 150$ pF</td>
<td></td>
</tr>
<tr>
<td>$t_{RDF}$</td>
<td>$RD^+$ to Data Float Delay</td>
<td>100</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{RV}$</td>
<td>Recovery Time Between Reads And/Or Write</td>
<td>300</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{CY}$</td>
<td>Cycle Time</td>
<td>2.5</td>
<td>15 $\mu$s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DBB WRITE

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{AW}$</td>
<td>$CS$, $A_{0}$ Setup to WR$^+$</td>
<td>0</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{WA}$</td>
<td>$CS$, $A_{0}$ Hold After WR$^+$</td>
<td>0</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{WW}$</td>
<td>WR Pulse Width</td>
<td>250</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{DW}$</td>
<td>Data Setup to WR$^+$</td>
<td>150</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{WD}$</td>
<td>Data Hold After WR$^+$</td>
<td>0</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. READ OPERATION—DATA BUS BUFFER REGISTER.

2. WRITE OPERATION—DATA BUS BUFFER REGISTER.

Reference Manuals

9803077 — ISBC 941 Industrial Digital Processor User's Guide (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 941</td>
<td>Industrial Digital Processor</td>
</tr>
</tbody>
</table>
iRMX 80
REAL-TIME MULTI-TASKING EXECUTIVE

- Designed for Intel® ISBC 80/10B, ISBC 80/20-4, 80/24 and ISBC 80/30 based applications
- Completely user configurable through interactive configuration utility
- Priority-oriented scheduling
- Small, efficient nucleus
- Simple user task interface
- Comprehensive I/O support
- Library of flexible modules
- Structured application environment

The Intel® iRMX 80 Real-Time Multi-Tasking Executive is an easy-to-use, sophisticated software system which operates on Intel's 8-bit single board computers and System 80 packaged systems. The iRMX 80 executive provides real-time facilities for priority-based resource allocation, intertask communications, standard I/O device control, and other features suitable for many applications including medical electronics, industrial process control, instrumentation, test systems, and data communications. The iRMX 80 package provides the framework that allows system developers to begin immediate application software implementation. The implementation and integration process is aided by the Interactive Configuration Utility (ICU80) program, a configuration tool which accelerates the development process.

Figure 1. Structure Diagram
FEATURES
The iRMX 80 executive provides users of Intel Single Board Computers simple, easy-to-use tools for creating a wide range of application systems. The most popular features of the iRMX 80 are:

Structured Environment
The iRMX 80 executive provides a consistent structure, as diagrammed in Figure 1, from application to application thus allowing experience gained on one system to be easily transferred to others. Often, entire programs may be used in multiple applications.

Simple Interface
The iRMX 80 executive provides a simple, straightforward program interface for user programs. This interface is consistent throughout the range of facilities offered, reducing the number of concepts which must be learned.

Library Modules
The iRMX 80 executive is constructed in a thoroughly modular manner with the full range of facilities being offered in multiple library modules, see Table 1, allowing easy selection of the exact facilities required.

Small Nucleus
The iRMX 80 nucleus provides a small, efficient foundation upon which application systems may be easily built. A wide range of multi-tasking, real-time facilities such as intertask communication and control are included.

Priority-Oriented Scheduler
The iRMX 80 scheduler insure that the highest priority task which is ready to execute is given system control, allowing the application system to be responsive to its external world.

Comprehensive I/O Support
The iRMX 80 libraries contain support for a wide range of I/O boards supplied by Intel, simplifying the addition of peripherals to an application system. For applications which require custom boards the iRMX 80 device handler philosophy allows easy addition of user written handlers.

Interactively Configurable
The Interactive Configuration Utility (ICU80) program provides the user with an easy-to-use method of configuration of iRMX 80-based applications. Responding to questions from the ICU80 program running on the Intellic Microcomputer Development System, the user tailors the application system by selecting modules, e.g., nucleus flexibility as shown in Figure 2, from the wide variety of iRMX 80 facilities. The resultant system contains only the modules necessary for its use, allowing the iRMX 80 executive to fit a wide range of applications from small special purpose dedicated applications to large general purpose systems.

Figure 2. Configuration Flexibility Provides Application Freedom. The iRMX 80 executive allows you the freedom to choose from a wide range of ISBC family processors and peripherals upon which your application may be built. It allows you to break the software "chain" which ties your application to a single processor type and thereby gain application freedom.
iRMX 80

Board Technological Support
The iRMX 80 executive provides support for a range of processor technologies from the 8080-based iSBC 80/10 Single Board Computer to the 8085-based iSBC 80/30 Single Board Computer. Applications are offered an easy upgrade path with the iRMX 80 executive which allows greater price/performance to be achieved without expensive software modification.

Extensive Debugging Aids
The iRMX 80 executive provides two user-oriented, interactive software debugging aids. The debuggers allow memory examination and modification, execution breakpoints, and automatic stack overflow monitoring. These powerful aids allow simplified task debugging and faster application system development.

FACILITIES
The various facilities offered by the iRMX 80 executive are provided as independent library modules, thus allowing simple inclusion or exclusion, depending on the user’s specific requirements. These facilities are described below.

Nucleus
The iRMX 80 executive provides nuclei for operation on various iSBC single board computers. The nuclei provide real-time scheduling, interrupt handling, intertask communications, and task control. The services offered are:

- Send a message from one task to another
- Accept a message from another task
- Wait for a message to be transmitted from another task
- Transmit a special interrupt message to a task
- Suspend execution of a task temporarily
- Continue execution of a previously suspended task.

Disk File System
The iRMX 80 Disk File System (DFS) provides for the filing and retrieving of data using disks. The iRMX 80 DFS allows for either Intellic Development Systems, ISIS-II compatible media format, or a user specified format. iRMX 80 DFS offers the following services in an ISIS-II compatible media format:

- OPEN a file for processing
- READ data from a file
- WRITE data to a file
- SEEK to a specific location within a file
- CLOSE a file to further processing
- RENAME a file
- DELETE a file.

For those applications which require unique media formats the iRMX 80 executive offers a level of processing which allows complete user flexibility in formatting data. The services offered are:

- SEEK to a specific track
- READ a sector
- WRITE a sector
- FORMAT a track
- RECALIBRATE to Track 0
- VERIFY a sector
- DELETE a sector.

Terminal Handler
The iRMX 80 terminal handler provides a data path between a console device (CRT or TTY) and user tasks. Communications between task and device are affected by using the nucleus services SEND and WAIT. Two versions of the terminal handler are offered:

1) Full Terminal Handler — The full terminal handler has a built-in interface to the debugger. It also provides for:

- Correction of data previously input
- Automatic buffering of data prior to a read request
- Priority output path which allows "emergency" messages to bypass any other messages which may be queued for output
- Automatic baud rate search to determine communications terminal speed.

Table 1. iRMX 80 Memory Requirement

<table>
<thead>
<tr>
<th>Module</th>
<th>Nucleus</th>
<th>Full Terminal Handler</th>
<th>Minimal Terminal Handler</th>
<th>Free Space Manager</th>
<th>Disk File System</th>
<th>Disk I/O</th>
<th>Analog I/O</th>
<th>Bootstrap Loader &amp; Initializer</th>
<th>Operating System</th>
<th>Memory Size (Bytes)</th>
<th>Minimum Diskette Drives</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROM*</td>
<td>2K</td>
<td>3K</td>
<td>600</td>
<td>1K</td>
<td>5.5K</td>
<td>700</td>
<td>800</td>
<td>600</td>
<td>ISIS-II</td>
<td>64K RAM</td>
<td>2</td>
</tr>
<tr>
<td>RAM</td>
<td>250</td>
<td>950</td>
<td>120</td>
<td>250</td>
<td>1.6K</td>
<td>100</td>
<td>50</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Indicates amount of code which can be configured in PROM.
**All figures are approximate.
2) **Minimal Terminal Handler** — The minimal terminal handler provides a limited feature version of the full terminal handler for memory space critical applications. The minimal terminal handler provides for correction of data previously input.

**Free Space Manager**
The iRMX 80 free space manager provides the capability of dynamically allocating RAM memory based upon user requests. Requests may be made for any size memory blocks and will be accommodated based on memory availability. The free space manager services are:

- Request memory
- Release memory.

**Analog Handlers**
The iRMX 80 analog handlers provide a convenient mechanism for obtaining and transmitting analog values between user tasks and Intel's iSBC 711, 724 and 732 Analog Boards. The analog handlers offer a full range of services including:

- Repetitive channel input
- Sequential channel/single gain input
- Sequential channel/variable gain input
- Random channel/variable gain input
- Random channel output.

The input and output modules are individually configurable allowing greater application flexibility.

**Bootstrap Loader**
The iRMX 80 bootstrap loader allows those applications using disk to create essentially a "soft" system that may be loaded into RAM from disk rather than being permanently PROM resident. This provides greater application flexibility in building and supporting disk-based systems.

**Interactive Configuration**
The Interactive Configuration Utility (ICU80) program provides relief from the burden of manually creating hardware configuration tables and combining selected software components. Using the environment information, the iRMX 80 nucleus effectively controls and orchestrates the application system.

The iRMX 80 package provides two avenues for configuring applications; an effective macro mechanism allows specific detail manipulation of structures for the experienced iRMX 80 user or, secondly, an easy-to-use interactive ICU80 utility program generates the structures automatically. This latter program displays a clear and concise set of questions on the terminal of the Intellec Development System and elicits the configuration information about the application system, e.g. CPU TYPE: 80/30, or TERM HNDLER: FULL. After describing the application system configuration the ICU80 program will initiate the housekeeping chores (linking and locating), thereby supplying the target iRMX 80 application. The result is the rapid development of the target iRMX 80 application system.

The iRMX 80 generation process allows application programs written in PL/M-80, FORTRAN-80, BASIC-80, or 8080/8085 Assembly Language to be merged with the specific iRMX 80 modules desired, see Figure 3. The system may then be debugged using Intel's sophisticated In-Circuit Emulation (ICE™) products or iRMX 80 debugger. The final application system is then available for either PROM or disk-based systems.
**SPECIFICATIONS**

**Supported Hardware**

**SINGLE BOARD COMPUTERS**
- iSBC 80/10A
- iSBC 80/10B
- iSBC 80/20
- iSBC 80/20-4
- iSBC 80/24
- iSBC 80/30

**MASS STORAGE CONTROLLERS**
- iSBC 202
- iSBC 204

**ANALOG BOARDS**
- iSBC 711
- iSBC 711A
- iSBC 724
- iSBC 724A
- iSBC 732
- iSBC 732A

**iRMX 80 Executive Shipping Package**

Single and double density diskettes containing:
- iSBC 80/10, 80/20, and 80/30 Nuclei
- Terminal Handler
- Minimal Terminal Handler

**Free Space Manager**
**Disk File System**
**Analog Handlers**
**Debuggers**
**Bootstrap Loader**
**Configuration Macros**
**Interactive Configuration Utility Program (ICU80)**
**Problem Reports**
**Reference Manuals**

**Reference Manuals**
- 9800522 — iRMX 80 User's Guide (SUPPLIED)
- 9803087 — iRMX 80 Installation Instructions (SUPPLIED)
- 142603 — iRMX 80 Interactive Configuration Utility User's Guide (SUPPLIED)
- 143238 — Introduction to the iRMX 86/88 Real-Time Multitasking Executives

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<table>
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<tr>
<th>Part Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>RMX 80</td>
<td>Real-Time Multi-Tasking Executive</td>
</tr>
</tbody>
</table>
iMMX 800
MULTIBUS® MESSAGE EXCHANGE SOFTWARE

- Supports 8 and 16-bit multiprocessing on the MULTIBUS® system bus
- Provides a uniform easily-used interface for iRMX™ 80, iRMX™ 86, iRMX™ 88-based distributed microcomputer processing applications
- Supports variable-length message transfers, up to 64K bytes, between MULTIBUS® devices
- Manages shared address space and transfers 8 and 16-bit data
- Meets the Intel MULTIBUS® Inter-processor Protocol (MIP) standard for reliable process-to-process message transfers
- Supports iSBC™ 550 Ethernet* Communications Controller with an iRMX™ I/O system driver interface

The iMMX 800 MULTIBUS Message Exchange Software implements the MIP standard process-to-process message transfer protocol for loosely-coupled multiprocessing on the MULTIBUS bus. The iMMX 800 software reliably transfers a message, using shared memory, between processes based on iRMX 80, iRMX 88 Executives or the iRMX 86 Operating System residing on different iSBC board products (iSBC 80/24, iSBC 80/30, iSBC 86/05, iSBC 86/12A, iSBC 88/25, iSBC 88/40, iSBC 544, iSBC 550, iSBC 569 boards and compatible customer-designed products). The iMMX software provides a standard, easy-to-use system call to implement multiprocessing solutions for greater total application throughput; functions can be assigned to separate iSBC microcomputers, yet the communication and sharing of data remains straightforward. New functions can be added to an existing system using the standard iMMX routine, thereby extending the useful life of a system.

Figure 1. iMMX 800 Real-Time Executive Interface
FUNCTIONAL DESCRIPTION

The iMMX 800 MULTIBUS Message Exchange Software provides the iRMX 80, iRMX 88 Real-Time Executives and the iRMX 86 Operating System a standardized, process-to-process communications protocol. This protocol provides the fundamental capabilities needed to exchange data between multiple 8-bit and 16-bit microcomputers residing on the same MULTIBUS system bus. User-defined application tasks, on different devices, can exchange messages in a consistent manner. iMMX software supports error detection and reporting such that the user task can take appropriate action to ensure reliable message transfers.

MULTIBUS®-Based Networking

The iMMX 800 software supports a loosely-coupled MULTIBUS-based network system. The software interface is composed of simple, easy-to-use, modules (see Table 1). By supporting the addressing, data transfer, control, and memory management functions, the software, as shown in Figure 2, divides the operation into three functions; the virtual interface, the logical protocol, and the physical protocol.

<table>
<thead>
<tr>
<th>Table 1. iMMX 800 Software Memory Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive</td>
</tr>
<tr>
<td>iRMX™ 80</td>
</tr>
<tr>
<td>iRMX™ 88</td>
</tr>
<tr>
<td>iRMX™ 86</td>
</tr>
</tbody>
</table>

The virtual interface is the application task's access to the iMMX services. Through this interface, Task A can request connection (CONNECTION-ID) to an identified Task B. Using the CONNECTION-ID for Task B, Task A requests the iMMX memory manager to transfer a message via that CONNECTION-ID.

The logical protocol supports a message manager function. The Message Manager prepares the message for delivery to a specific destination port based on the connection specified. In addition, the logical protocol returns status information about the transfer.

The physical protocol is totally concerned with the hardware-related elements of message delivery. These elements are data flow control, mutual exclusion mechanics, address recognition and interactive signalling requirements.

Four different inter-device signalling mechanisms are supported. These asynchronous mechanisms include MULTIBUS interrupt-mapped, memory-mapped (i.e., "flag" bytes), polling, and I/O port-mapped.

8 and 16-Bit Distributed Microcomputing

The application solution can be a heterogeneous set of processors and real-time executives as shown in Figure 1. The iMMX 800 software provides a uniform interface to applications and manages a myriad of hardware combinations including multiple-function boards, single-function boards, master boards, slave boards, dual-port,
private or public memory, 8-bit or 16-bit data transfers, and inter-device interrupt signalling methods. In particular, programs written to access 8 or 16-bit data through iMMX software can do so independently of actual data format.

iRMX™ Uniform Interface
The iMMX software package provides a uniform interface across all iRMX-based software environments. The iMMX software services are provided as a set of tasks, system procedures, and interrupt drivers.

Support is supplied for the iAPX 86/88-based microcomputers that support the iRMX 86 Operating System and the iRMX 88 Executive. In addition, software support is provided for the iRMX 80 Executive for the Intel 8085-based products: the ISBC 80/24 and ISBC 80/30 processor boards, and the ISBC 569 and ISBC 544 intelligent slave boards.

Message Transfer Mechanism
The iMMX software operational model is based on a message-passing model. Based on available memory space, the maximum message size is 64K bytes.

Shown in Table 2 are five different services available: Find Port, Activate Port, Transfer Message, Deactivate Port and Lose Port.

FIND PORT
The Find Port service returns a CONNECTION-ID, which is used by iMMX 800 software to pass messages to the destination port.

ACTIVATE PORT
The Activate Port service allows a task to receive messages sent via iMMX software. The application utilizes a convenient virtual-level interface, and does not have to maintain configuration-dependent information.

TRANSFER MESSAGE
The Transfer Message service causes messages to be delivered via the specified CONNECTION-ID. The competition status on the message's delivery is returned as a status variable.

DEACTIVATE PORT
The Deactivate Port service closes an active system-port. All successive messages sent to that system-port are returned to the sender.

LOSE PORT
The CONNECTION-ID provided by the initial Find Port request loses further reference to the system port. The CONNECTION-ID is no longer usable.

Shared Address Space
The iMMX 800 software package provides a memory management service that supports shared memory address spaces. An application transfers a message through a locally addressed port. The iMMX 800 memory manager maps that message, via a shared memory address, to the receiving port's same or aliased memory space. The receiving port then accesses the port through local addressing.

Interprocessor Protocol Architecture
The Intel MULTIBUS Interprocessor Protocol (MIP) specifies an architecture by which processes executing on different MULTIBUS single board computers can communicate with one another in a reliable, controlled manner within that system. A system can consist of a heterogeneous set of processors, executing a heterogeneous set of real-time executives and application software.

Based on a simple internal structure, the MIP specification defines a functional consistency across several product lines and provides the means to support efficient operation in multiple processor environments.

Table 2. System Calls

<table>
<thead>
<tr>
<th>Function</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIND PORT</td>
<td>CQFIND</td>
<td>Find the system-port and return a CONNECTION-ID.</td>
</tr>
<tr>
<td>ACTIVATE PORT</td>
<td>CQACTV</td>
<td>Activate a local system-port for receiving messages from other tasks.</td>
</tr>
<tr>
<td>TRANSFER MESSAGE</td>
<td>CQXFER</td>
<td>Transfer the message to the system-port identified by the CONNECTION-ID.</td>
</tr>
<tr>
<td>DEACTIVATE PORT</td>
<td>CQDACT</td>
<td>Deactivate an active system-port. Messages addressed to it are no longer delivered, and are returned to the sender.</td>
</tr>
<tr>
<td>LOSE</td>
<td>CQLOSE</td>
<td>Loses the active CONNECTION-ID to a port.</td>
</tr>
</tbody>
</table>
iRMX™ I/O System Driver

Since an iRMX-based application may be using the iRMX I/O System's independent device driver interface, the iMMX 800 software is usable by device drivers.

An example of maintaining the iRMX-based application interface, the iMMX 800 package provides an iSBC 550 Ethernet Communications Controller device driver. This device driver uses iMMX 800 routines to communicate to the iSBC 550 controller (see Figure 3).

SPECIFICATIONS

iSBC™ Supported Hardware

SINGLE BOARD COMPUTERS
iSBC 80/24
iSBC 80/30
iSBC 86/05
iSBC 86/12A
iSBC 88/25
iSBC 88/40

INTELLIGENT CONTROLLERS

iSBC 544 (Communications)
iSBC 550 (Communications)
iSBC 569 (Digital)

Reference Manual (Supplied)

143808 — iMMX 800 Reference Manual and Users' Guide

ORDERING INFORMATION

Description

The iMMX 800 MULTIBUS Message Exchange Software is a licensed product that provides users of Intel Single Board Computers and the iRMX 80, iRMX 86, and iRMX 88 (Version 1.0) Real-Time Executives software implementing a standardized, memory-based, task-to-task communication protocol. This protocol provides the capabilities needed to exchange data between multiple 8-bit and 16-bit microcomputers residing on the same MULTIBUS system bus.

Part Number Description

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMX 800 ARO</td>
<td>Single Density ISIS Media. Requires incorporation fee for each derivative work.</td>
</tr>
<tr>
<td>MMX 800 BRO</td>
<td>Double Density ISIS Media. Requires incorporation fee for each derivative work.</td>
</tr>
<tr>
<td>MMX 800 DRO</td>
<td>Single Density iRMX 86 Media. Requires incorporation fee for each derivative work.</td>
</tr>
<tr>
<td>MMX 800 ABY</td>
<td>Single Density ISIS Media. Includes incorporation fee buyout.</td>
</tr>
<tr>
<td>MMX 800 BBY</td>
<td>Double Density ISIS Media. Includes incorporation fee buyout.</td>
</tr>
<tr>
<td>MMX 800 DBY</td>
<td>Single Density iRMX 86 Media. Includes incorporation fee buyout.</td>
</tr>
<tr>
<td>MMX 800 AWX</td>
<td>Single Density ISIS Media. Update service for an additional year.</td>
</tr>
<tr>
<td>MMX 800 BWX</td>
<td>Double Density ISIS Media. Update service for an additional year.</td>
</tr>
<tr>
<td>MMX 800 DWX</td>
<td>Single Density iRMX 86 Media. Update service for an additional year.</td>
</tr>
<tr>
<td>MMX 800 LST</td>
<td>Human readable source listings for the iMMX 800 software modules.</td>
</tr>
</tbody>
</table>
The Intel iRMX 86 Operating System is an easy to use, comprehensive multiprogramming software system for Intel iSBC 86 and 88 Single Board Computers and other iAPX 86 and iAPX 88-based microcomputers. The iRMX 86 Operating System extends the architecture of the underlying processor by providing a collection of new operations that act on the Operating System objects provided by the system or user created extensions. The multiprogramming environment of the iRMX 86 Operating System, based on a real time, event-driven scheduler, provides an efficient foundation for applications including process control, intelligent terminals, office systems, data communications and medical electronics.

Each layer of the operating system simplifies user access to the underlying hardware by taking advantage of the mechanisms provided by the layers below. Each layer of the iRMX 86 Operating System is configurable to allow applications to customize the system to particular needs.
FUNCTIONAL DESCRIPTION

Services provided by the iRMX 86 Operating System include facilities for executing programs concurrently, sharing resources and information, servicing asynchronous events, and interactively controlling system resources and utilities. In addition, the iRMX 86 Operating System provides all major real time facilities including priority-based system resource allocation, means for concurrently monitoring and controlling multiple external events, real time clock control, interrupt management, and task dispatching. The iRMX 86 Operating System contains the following modules: An object-oriented Nucleus; Device Independent Basic and Extended I/O Systems; Terminal Handler; Bootstrap and Application Loaders; Human Interface with complete command line interpreter; and an interactive, object-oriented Debugger.

Because the modules and services provided by the operating system are user selectable, application specific operating systems can be created by iRMX 86 users. The iRMX 86 Operating System therefore eliminates the need for custom operating system design, thereby reducing development time, cost, effort, and risk.

FEATURE OVERVIEW

The iRMX 86 Operating System provides users with simple, easy-to-use, quality software tools for creating a wide range of application systems. Some important features are:

Structured Application Environment

The iRMX 86 Operating System provides a consistent structure from application to application, and CPU to CPU, thus allowing experience gained on one system to be easily transferred to others. Often entire programs can be ported from one application to another.

Object-Oriented Architecture

The iRMX 86 Operating System extends the capability of the underlying CPU by adding a number of new data structures (objects) and a number of functions to operate on these objects. This architecture provides a simple, symmetric, and easy to learn interface to a comprehensive system. The Nucleus provides the means to create, manipulate, and delete the basic objects necessary for any application. It also provides a mechanism for users to create their own object definitions and use them as part of the basic operating system. Each of the outer layers of the system add to the list of available objects by using this same extension mechanism.

(P)ROM or RAM Based

The iRMX 86 Operating System can be made resident in (P)ROM or can be loaded into RAM from a secondary storage device using one of the supplied Loaders. Being able to place all system software in (P)ROM offers three benefits: 1) Systems may be moved to harsh environments that preclude the use of disks; 2) The overhead expense of providing mass storage devices can be eliminated; and 3) System performance can be increased by eliminating the wait states required for most RAM's, and disk accesses required for most disk-based operating systems.

User Configurable

Users of the iRMX 86 Operating System are able to use a wide range of features or select only those which meet the specific requirements of a particular application. Each system call provided by the operating system may be removed from the system if it is not used. Each task can specify the use of the 8087 Numeric Data Processor. Jobs can be configured with specific running environments. Individual I/O port addresses are also configurable, making the system ideal for component level applications.

This complete modularity along with many other user options allows users to configure systems in a cost-effective manner regardless of the application environment. Each layer of the system may be configured in this manner, or (with the exception of the Nucleus) left out of the system altogether.

Nucleus

The Nucleus of the iRMX 86 Operating System provides the foundation upon which a variety of applications systems can be built. It includes the facilities to manage the basic objects of the system necessary to perform multiprogramming, multitasking, critical section management, and extensive task-to-task communication and control.

Embedded in the Nucleus are the facilities to support concurrent program execution and handling
of simultaneous asynchronous events. These facilities allow interrupts coming from specialized peripheral devices to be serviced in an efficient manner. The iRMX 86 Operating System allows the CPU hardware to be used by multiple applications, thus reducing the overall system size, complexity, and cost. These facilities are built from four key concepts:

**OBJECT MANAGEMENT** — Just as floating point numbers are data structures using operators such as multiply and subtract to operate on them, iRMX 86 objects are data structures with system calls to manipulate them. Because of the uniform structure of the system, users have a foundation on which to tailor the Nucleus to the application by removing system calls not necessary for the application and by adding objects and system calls customized for the application. The basic objects of the Nucleus are:

- **SEGMENTS** — Store data in dynamically created RAM buffers with a specified length.

- **MAILBOXES** — Provide a mechanism for inter-task and interprogram object and data transfer. Mailboxes are locations for objects to be sent and received. For example, using a mailbox for intertask communication permits a time-critical task to forward data to a non-time-critical task for processing. Mailboxes are generally used to pass data segments from task to task, although any object (user or system defined) may be transferred.

- **SEMAPHORES** — Manage mutual exclusion and synchronization. A semaphore is used to signal another task when processing has been completed or when resources are available. A semaphore provides a low-overhead signalling mechanism.

- **REGIONS** — Control access to critical sections by allowing only one task at any given time to access a portion of code. Examples are non-reentrant procedure or code for controlling a peripheral device that can only service one request at a time. In addition, regions can be used to protect data structures from being manipulated by more than one procedure at a time.

- **TASKS** — Perform the actual work of the application by executing software modules. Each task in the system has the characteristics of a unique processor. It has its own code, priority, stack, data area, and status. If the task is designated as using the 8087 Numeric Data Processor, it also has its own copy of the NDP registers, stack, and status. Task execution is based on an event-driven, priority-based scheduling algorithm.

- **JOBS** — Permit isolation of application tasks, objects, and memory to provide a multiprogramming environment. Jobs encapsulate an application and limit the degree of interaction between sets of tasks.

- **COMPOSITE OBJECTS** — Permit users to create objects not found in the set of Nucleus objects. These new objects appear to other facilities in the iRMX 86 system as if they are part of the original system. This means that Composite objects can be manipulated using the Mailboxes and Object Directories in exactly the same manner as other objects.

**SCHEDULING** — The iRMX 86 Nucleus offers a priority-oriented, event-driven scheduling mechanism that supports up to 255 different priority levels. The scheduler uses the task priority to determine which task receives control of the CPU, and to ensure that the highest priority task ready to execute is given control of the system. That task will continue to run until a higher priority interrupt occurs, or until the running task requests resources that are not available. This priority scheduling allows the system to be responsive to the external environment while allocating resources among the application tasks.

**INTERRUPT MANAGEMENT** — The iRMX 86 Operating System provides two levels of interrupt management: Interrupt Handlers and Interrupt Tasks. The first optimizes response time, the other optimizes response capabilities. Interrupt tasks allow use of all iRMX 86 system calls and mask only lower priority interrupts. Interrupt handlers permit direct control over the CPU's interrupt logic and only allow the use of interrupt system calls. This structure allows users to easily perform buffering of data while leaving complex processing of the data to interrupt tasks.

For systems requiring more than the 8 interrupt levels of the master 8259A interrupt controller, the iRMX 86 Operating System allows applications to configure up to 7 slave 8259A's. Using the slave devices, systems can respond in real time to as many as 57 interrupt sources.

**ERROR MANAGEMENT** — When a task issues an iRMX 86 system call, the results may not always
be what the task expects to achieve. For example, the task may request memory that is not available, or it may use an invalid parameter. The iRMX 86 Operating System may be configured to provide two levels of comprehensive error management: hierarchical error handling and selective error processing.

Hierarchical error handling permits a task to handle various errors at different levels of the system. Errors common to a number of tasks can be addressed by system-wide error handlers. Application-specific errors can be routed to job-level handlers. In addition, if a task has a need for a unique error handler, an error handler can be specified for that task. This flexibility means global error handlers can be created for the majority of the errors, reducing the amount of error handling software to be written.

In addition, each application can select the type of error to be processed by the error handlers. The errors are divided into two categories: programmer errors such as invalid parameters; and environmental condition errors such as detection of insufficient memory to meet requirements.

**Terminal Handler**

The Terminal Handler supports real time, asynchronous I/O between the operator's terminal and application tasks. It provides a line buffer which stores ASCII characters as they are input from the console. Special editing characters are used to control the terminal and the buffer contents, and are not entered into the data. The Handler may be configured as an output-only version to support those applications not requiring terminal input.

**I/O System**

The iRMX 86 I/O System provides an extensive facility for device independent I/O through a series of supplied device drivers, or any number of user supplied device drivers that can be configured to operate at any I/O port address. The Basic I/O System (BIOS) implements an asynchronous interface to the device drivers allowing users to explicitly overlap I/O functions with other operations. The Extended I/O System (EIOS) performs all of the synchronization necessary to do read-ahead and write-behind buffering automatically, and to reference files with logical names. By configuring the appropriate interface, applications can develop an I/O subsystem with the optimum degree of device control while requiring a minimum of design time and effort. Furthermore, the device-independent nature of the system allows use of different devices without redesign.

The I/O System provides access to three types of files:

- **NAMED FILES** — allow applications to refer to collections of bytes (files) by using a name. These names are cataloged in directories to allow file access by different tasks and jobs. Directories are special named files that store directory and access information about other named files and directory files.

- **PHYSICAL FILES** — provide a mechanism to make actual physical connections to storage devices. This type of file is typically used to communicate with simple devices such as printers and terminals.

- **STREAM FILES** — are mechanisms for communicating between tasks and jobs as if the data were written and then read from a FIFO file.

The named files may be organized in a hierarchical structure as shown in Figure 1, where the triangular files are named data files, and the rectangular files represent directories. This hierarchy allows data to be grouped logically and accessed with a minimum of overhead.

**Loaders**

The iRMX 86 Operating System contains two loaders: A Bootstrap Loader capable of loading a file from mass storage into system RAM; and an Application Loader available to tasks as I/O system calls.

---

**Figure 1. Example of Named-File Tree**

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The Bootstrap Loader can be configured to load from a specific device, or to use the first device that becomes ready after the system has been started. It can also be configured to load a file specified by the operator at the system console.

The Application Loader provides a simple mechanism for loading application code and data files into the system. It can be used to load absolute code into a fixed location, or to load relocatable code into dynamically allocated memory locations. It can also be used to support code overlay functions.

Human Interface

The Human Interface is the uppermost layer of the iRMX 86 Operating System. It supports the user by providing a number of utilities useful in typical applications. It also provides the application programmer with a number of tools to generate custom utilities using the basic system utilities or by interfacing directly to the Command Line Interpreter.

Human Interface commands supplied with the iRMX 86 Operating System include commands to perform: creating a directory file; creating, copying, deleting, and renaming files; loading and starting application programs; formatting a device volume; and submitting a command file in a batch mode. The Human Interface also provides some utilities useful in debugging applications: a debug command enabling users to start commands via the system debugger, and a file copying facility used in conjunction with the iSBC 957A Monitor to convert MDS files to and from the iRMX 86 file format.

Interactive System Debugger

The iRMX 86 Operating System provides a comprehensive tool for interactive software debugging. The Debugger has two capabilities that greatly simplify the process of debugging a multitasking system. First, the Debugger allows users to debug several tasks while the balance of the application system continues to run in real-time. Second, the Debugger allows programmers to interactively view and modify system constructs as well as the system RAM and CPU registers. The debugger is structured to enable system designers to track system-wide problems easily. It can also remain in the final application as a continuous maintenance tool.

SPECIFICATIONS

iSBC™ Supported Hardware

SINGLE BOARD COMPUTERS
iSBC 88/40
iSBC 86/05
iSBC 86/12A

MASS STORAGE
iSBC 204 Flexible disk controller
iSBC 206 Hard disk controller
iSBC 208 Flexible disk controller
iSBC 215A Winchester disk controller
iSBC 215B Winchester disk controller
iSBC 220 SMD disk controller
iSBC 254 Bubble Memory board

MULTIMODULE™ BOARDS
iSBX 218 Flexible disk controller (when used with the iSBC 215)
iSBC 337 Numeric data processor
iSBC 351 Serial I/O channel

User iAPX 86 and iAPX 88 Based Systems

The iRMX 86 system runs on user designed boards with the following components:
8253 Programmable Interval Timer
8259A Programmable Interrupt Controller
8251A USART (When the Terminal Handler is configured into the system)
8087 Numeric Data Processor (when NDP tasks are configured into the system)
ORDERING INFORMATION

The ordering options for the iRMX 86 Operating System are listed below. All options include a full year of update service. All the options including the word “KIT” are shipped with a complete set of manuals, the iSBC 957B system monitor for the iSBC 86/12A and iSBC 88/40 Single Board Computers, and an iRMX 86 Customer Training Course credit voucher that is valid for 6 months after the date of purchase.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMX 86 KIT ARO,</td>
<td>Single and double density OEM license requiring an Incorporation Fee for each derivative work</td>
</tr>
<tr>
<td>and RMX 86 KIT BRO:</td>
<td></td>
</tr>
<tr>
<td>RMX 86 KIT AST,</td>
<td>Single and double density license for one additional development site</td>
</tr>
<tr>
<td>and RMX 86 KIT BST:</td>
<td></td>
</tr>
<tr>
<td>RMX 86 KIT ABY,</td>
<td>Single and double density OEM Buy-out requiring no further Incorporation Fee</td>
</tr>
<tr>
<td>and RMX 86 KIT BBY:</td>
<td></td>
</tr>
<tr>
<td>RMX 86 AWX,</td>
<td>Single and double density update service for an additional year.</td>
</tr>
<tr>
<td>and RMX 86 BWX:</td>
<td></td>
</tr>
<tr>
<td>RMX 86 LST:</td>
<td>Source listings provided on Microfiche.</td>
</tr>
</tbody>
</table>
The iRMX 86 Languages provide users of Intel's iAPX 86/88 or iSBC 86/88 microcomputers with full "on-the-target-system" development capability. This allows OEMs to provide their end-users with the facility to make on-the-spot modifications and add additional capability to their applications. All languages generate code which is compatible with Intel's Universal Run-Time Interface. This ensures users that their application system will run on the iRMX 86 or iRMX 88 Operating System using any iSBC 86/88 or iAPX 86/88-based system supporting the Universal Run-Time Interface. The iRMX 86 Languages are fully compatible with Series III Development System-based language products.

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June, 1981

143878
FEATURES AND BENEFITS

Major features of the iRMX 86 Languages and their benefits include:

Target System Development

OEMs may accomplish application software development on their target application hardware. This provides the greatest possible utility of the OEM's application system. Additionally, OEMs may provide an entirely new dimension in flexibility — reprogrammability of his system by the end-user.

Since they are resident on the iRMX 86 Operating System, the languages allow users to reduce the learning curve investment necessary for new application systems with only one operating system to learn.

New Technology Languages

The iRMX 86 Languages provide OEMs with the newest programming languages available. iRMX 86 PASCAL is fully compatible with the proposed ISO language standard. iRMX 86 FORTRAN provides the majority of the ANS 77 FORTRAN language features, including IF-THEN-ELSE, Zero Case Do-Loops, and Direct Access I/O. The complex arithmetic capability, the only missing major feature, will be supplied in a later release.

Efficient Application Code

The iRMX 86 Language products are optimized to provide a maximum efficiency in object code generation. This provides users with the smallest, fastest programs which a high-level language can generate.

Full Language Compatibility

The iRMX 86 Language products are compatible in three ways. They provide a Universal Run-Time environment for application programs, allow object modules to be linked together regardless of compiler used, and are fully source and object compatible with the Series III Development System language products.

The Universal Run-Time environment allows users to create their application software without regard for which Intel operating system it will run on. This allows maximum flexibility in allowing applications to easily move from one processor to another, and from one operating system to another.

All iRMX 86 Languages generate code compatible with the Intel Object Module Format (OMF) standard. This provides users with the capability to mix languages on a single application system. In this way a user can select exactly the right language tool for specific parts of the application rather than a project as a whole.

Intel Series III Development System languages provide all of the same benefits described, allowing users to develop their software on a system optimized for program development and then easily move it to the final system for test, debug and minor redevelopment.

Full REALMATH Support

The iRMX 86 Languages support the REALMATH floating point standard. This allows users of all iRMX 86 languages to access the iAPX 86/20 or iAPX 88/20 Numeric Data Processors or iSBC 337 MULTIMODULE™ board. These numeric processors offer over 100 times greater performance than comparable software-implemented algorithms, and reduce the system memory requirements by at least 16 KB. The REALMATH standard (proposed IEEE standard) provides universal consistency in results of numeric computations. The iRMX 86 Languages provide efficient object code generation and access to the highest performance floating point package available on microcomputers.

Complete Set of Languages and Utilities

The iRMX 86 Languages offer a broad selection of modern, highly efficient language products and a complete set of target system software.

iRMX 86 Languages allow you to select the correct language for your application.

- Technical — FORTRAN or PASCAL
- Systems Programming — PL/M
- Commercial — PASCAL
- Size Optimized — MACRO ASSEMBLER

All necessary software for development is provided, including EDIT, LINK, LOCATE, and LIB.
SOFTWARE DEVELOPMENT PROCESS

The iRMX 86 Languages allow OEMs to choose from a broad spectrum of specific language features and “on-the-target-system” development utilities.

IRMX 86 PASCAL (IRMX 861)

The IRMX 86 PASCAL compiler provides a strict implementation of the proposed ISO language standard. All source programs are validated by the compiler to ensure its conformance to the standard. Many extensions to the language are avail-
iRMX™ 86 LANGUAGES

able which allow PASCAL programs to be written specifically for microcomputers. Features such as separate module compilation and iAPX 86/20, 88/20 Numeric Data Processor support are a few of its many. The ISO standard "source evaluator" can be switched off to accept these extensions. For more information on iRMX 86 PASCAL features, see the PASCAL 86/88 Software Package data sheet (121680).

iRMX 86 FORTRAN (iRMX 862)
The iRMX 86 FORTRAN compiler provides users total compatibility with existing FORTRAN 66 language-generated code, plus many new language features provided by the FORTRAN 77 language standard. These new features offer FORTRAN programmers many new capabilities, including "IF-THEN-ELSE", random access I/O and character variables. For a more detailed explanation of iRMX 86 FORTRAN, see the FORTRAN 86/88 Software Package data sheet (400630).

iRMX 86 PL/M (iRMX 863)
The iRMX 86 PL/M compiler provides users with a powerful, microcomputer-oriented system programming language. The PL/M 80 Language was introduced in 1976 by Intel. It was the first microcomputer-oriented, block structured, high-level language available. Since 1976, thousands of users, shipping over millions of microcomputer-based systems, have generated their system software with PL/M 80 and PL/M 86.

iRMX 86 PL/M 86 is a compatible superset of PL/M 80 which offers easy portability of software across the full range of microcomputers supplied by Intel. For more information about iRMX 86 PL/M, see the PL/M 86/88 Software Package data sheet (402175).

iRMX 86 Utilities (iRMX 860)

iRMX 86 EDIT
The iRMX 86 EDIT program provides users with a powerful, sophisticated, line-oriented editing facility. EDIT delivers a range of capability suitable for novice users as well as advanced capabilities for sophisticated users. Its key features include a macro processor capable of creating and executing complex strings of commands, which ease the editing chore, as well as defining blocks of text which may be included anywhere in the text file. EDIT offers variable command sourcing, symbolic line numbering and reference by symbol.

The facilities of EDIT allow users to create, maintain and manipulate extensive libraries of source code with minimal effort. For more information on iRMX 86 EDIT, see the EDIT Software Package data sheet (143883).

iRMX 86 LINK/LOCATE
The iRMX 86 LINK program connects object modules which have been individually compiled into a single, relocatable object module. The input object code may have been produced by any Object Module Format-compatible compiler. Output object modules may be recombined into larger object modules, allowing work from a large programming staff to be easily integrated into an application system.

The iRMX 86 LOCATE program maps the relocatable object code into the iAPX 86/88 memory segments. Modules may be targeted for specific memory types. For example, those portions of the application which must be PROM resident can be mapped directly to the appropriate address range.

Both iRMX 86 LINK and LOCATE provide listings of resultant memory and symbol maps for easy reference and simplified debug. For more information on iRMX 86 LINK and LOCATE, see the 8086/8088 Software Development Package data sheet (9800757-04).

iRMX 86 LIB
The iRMX 86 LIB "Library manager" allows creation and maintenance of object module libraries. These libraries allow easy collection of related object code to reduce the overhead of maintaining many separate modules. Users may create new libraries, add and delete object modules, as well as list the contents of the library and their public symbols. Individual modules within the library will automatically be included in a total application system by the iRMX 86 LINK program. For more information on iRMX 86 LIB, see the 8086/8088 Software Development Package data sheet (9800757-04).
iRMX™ 86 LANGUAGES

SPECIFICATIONS

Required Hardware
Any iAPX 86/88 or iSBC 86/88-based system capable of running the iRMX 86 Operating System, version 1.4 or later.

With:
• 96 KB of additional memory for the iRMX 86 Languages and utilities.
• Two iRMX 86-compatible disks (flexible and/or hard) with one flexible disk required for soft-distribution.
• System console device

Optional Hardware
iAPX 86/20, iAPX 88/20 or iSBC 337 Numeric Data Processors for support of the REALMATH standard.

Required Software
iRMX 86 Operating System, version 1.4 or later, including BIOS, EIOS, HI (128 KB of memory). An additional 96 KB is required for dynamic work space for the languages.

Documentation Packages

<table>
<thead>
<tr>
<th>Package</th>
<th>Manual Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>iRMX 861 PASCAL 86/88 User’s Guide (121539)</td>
<td></td>
</tr>
<tr>
<td>iRMX 862 FORTRAN 86/88 User’s Guide (121539)</td>
<td></td>
</tr>
<tr>
<td>iRMX 863 PL/M 86/88 User’s Guide (121636)</td>
<td></td>
</tr>
<tr>
<td>iRMX 860 — EDIT User’s Guide (143587)</td>
<td></td>
</tr>
<tr>
<td>— Macro Assembly Language Reference Manual (9800640)</td>
<td></td>
</tr>
<tr>
<td>— Software Development Utilities Manual (980639)</td>
<td></td>
</tr>
</tbody>
</table>

ORDERING INFORMATION

The products listed below require the signing of an Intel® Master Software License Agreement. All DRO products below include 1 year of update service.

<table>
<thead>
<tr>
<th>Ordering Code</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>iRMX 86 Utility Package</td>
<td>(EDIT, LINK, LOCATE, LIB, MACRO ASSEMBLER)</td>
</tr>
<tr>
<td>iRMX 860 DRO</td>
<td>Single density, iRMX 86 compatible diskettes</td>
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<tr>
<td>iRMX 860 DWX</td>
<td>Update service on single density diskettes</td>
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<table>
<thead>
<tr>
<th>iRMX 86 PASCAL 86/88</th>
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<tr>
<td>iRMX 861 DRO</td>
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<tbody>
<tr>
<td>iRMX 863 DRO</td>
</tr>
<tr>
<td>iRMX 863 DWX</td>
</tr>
</tbody>
</table>
iRMX™ 88
REAL-TIME MULTITASKING EXECUTIVE

- Event-driven multitasking executive software supports iSBC™ 86/05, 86/12A, 88/25, 88/40 or iAPX 86, 88 based applications
- Supports component or iSBC™-based system generation through Interactive Configuration Utility
- Small, high-performance, PROMable executive supports high sample rates
- I/O system provides compatible iRMX™ 86 files and device independent I/O interface
- Provides simple, intertask communications and synchronization
- I/O system supports the User Run-time Interface (URI) for PL/M, PASCAL and FORTRAN coded application tasks
- Supports the 8087 Numeric Processor Extension (NPX) for arithmetic applications
- Memory management of full megabyte iAPX 86, 88 memory
- Supports component or iSBC™-based system generation through Interactive Configuration Utility
- I/O system provides compatible iRMX™ 86 files and device independent I/O interface
- Small, high-performance, PROMable executive supports high sample rates
- I/O system supports the User Run-time Interface (URI) for PL/M, PASCAL and FORTRAN coded application tasks
- Supports the 8087 Numeric Processor Extension (NPX) for arithmetic applications
- Memory management of full megabyte iAPX 86, 88 memory

The iRMX 88 Real-Time Multitasking Executive is a small, event-driven single-user executive system. Designed for dedicated computer applications using iSBC 86/05, 86/12A, 88/25, 88/40 or iAPX 86, 88 custom products, the modular software package provides real-time application support for PASCAL, FORTRAN, PL/M, and assembler coded tasks. Application tasks utilize intertask communications, asynchronous I/O control, priority-based resource allocation and file support for the iSBC 204, 208, 215, 215/218, and 220 Disk Controllers, and the iSBC 254 Bubble Memory product.

The small, high performance iRMX 88 Executive can be located in EPROM or bootstrapped into RAM memory. The iRMX 88 Executive offers features that are suitable for performance-critical process control applications, production test stand units, sophisticated laboratory analysis, instrumentation, specialized data acquisition systems or monitoring stations. The iRMX 88 design, based upon the iRMX 80 Real-Time Executive, offers iRMX 80-like interfaces for those 8-bit applications which are upgrading to 16-bit solutions for the 1 Megabyte addressing, expanded application functions, and higher performance data sampling requirements.

Figure 1. Module Representation
FUNCTIONAL DESCRIPTION

The iRMX 88 Real-Time Multitasking Executive Software package provides facilities for executing tasks concurrently, managing resources and servicing asynchronous events to users of Intel's single board computers and custom iAPX 86, 88-based products. The foundation modules support real-time dedicated computer applications with priority-based task scheduling, interrupt dispatching, real-time clock control with 1 ms resolution, multiple event monitoring and control, and file services for flexible, hard, Winchester, SMD disk units and bubble memory devices. The software package includes the primary modules: Nucleus, Free Space Manager, Terminal Handler, I/O System and Bootstrap Loader. The Interactive Configuration Utility (ICU) executes on a Series III Intellec System, or iRMX 86 Operating System with a Universal Development Interface (UDI).

FEATURE OVERVIEW

Event-Driven Multitasking

The iRMX 88 Executive provides a control software foundation called a Nucleus. The iRMX 88 Nucleus provides two major functions: first, the facility for concurrent task execution; secondly, the facility for handling simultaneous asynchronous events.

The structured multitasking environment permits segmenting of the application tasks. The number of tasks, managed by the Nucleus, is limited only by the available 1 Megabyte memory space. The tasks are prioritized such that the highest-ranked task is executing, e.g., an alarm event preempts the lower priority executing task. The Nucleus supports 255 priority levels.

Since internal or external events (interrupts) occur randomly, the Nucleus synchronizes the event with a task. The Nucleus supports either an interrupt service routine or an interrupt task. The interrupt service routine offers high-speed performance flexibility since it masks all interrupts and supports burst-rate data sample gathering. The interrupt task is useful for lower frequency interrupts, masking only lower priority interrupts.

Small High-Performance Executive

The iRMX 88 Executive software utilizes a simple, straightforward architecture which minimizes the memory requirements, as shown in Table 1. In addition, the modules are designed to be totally EPROM resident for those systems where mass storage devices cannot be used because of the danger of contamination.

Real-time microcomputer solutions require the recognition of interrupts. The performance of the system is with respect to data sample rates. If there is no activity in progress when an interrupt occurs, the time to handle that interrupt is dependent on the number of instructions executed, e.g., 175 microseconds interrupt latency time on an iSBC 86/12A board. Most real-time solutions have multiple events occurring and background operations in progress. Seldom does a background task have critical sections of code which cannot be interrupted.

Intertask Communications

The iRMX 88 Nucleus provides a simple, easy-to-use intertask communications mechanism based upon a message. Messages are transferred between tasks with two basic procedure calls, a send (RQSEND) and a wait (RQWAIT). Task "A" requests the Nucleus to RQSEND the pointer to a message buffer to Task "B" (see Figure 2). The Nucleus controls the message flow by activating the higher-priority Task B, or queuing the message if a lower-priority Task B is not waiting for the message. The receiving task does an RQWAIT to get the message pointer and can now access the data which may be for synchronization or real-time control operations.

Table 1. iRMX™ 88 Module Memory Requirements

<table>
<thead>
<tr>
<th>MODULE</th>
<th>NUCLEUS</th>
<th>TERMINAL HANDLER</th>
<th>FREE SPACE MANAGER</th>
<th>I/O SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PHYSICAL**</td>
</tr>
<tr>
<td>EPROM*</td>
<td>3.0</td>
<td>1.3</td>
<td>0.6</td>
<td>20.0</td>
</tr>
<tr>
<td>(K bytes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* amount of code configured in EPROM; all numbers are approximate
** includes one 3K byte device driver (named file plus physical file is 34.0K bytes)
**Numeric Data Processor**

The iRMX 88 Nucleus fully supports the 8087 Numeric Processor Extension (NPX) functions for high-speed arithmetic functions of real-time applications. High-performance numeric processing applications, which utilize 8-, 16-, 32- and 64-bit integers, 32-, 64- and 80-bit floating point or 18-digit BCD operations, are accelerated up to 100 times over a iAPX 86, 88 software solution. The NPX functions, including trigonometric, logarithmic and exponential functionals, are essential in scientific, engineering, navigational or military applications.

**Nucleus Primitives**

The Nucleus performs other functions as shown in Table 2, in addition to the message communications management. Some primitives like CREATE TASK and DELETE TASK allow dynamic creation/deletion of tasks during run-time. This dynamic capability allows the Nucleus tables to

![Diagram of Intertask Communications](image)

**Table 2. Nucleus Primitives**

<table>
<thead>
<tr>
<th>NAME</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCEPT</td>
<td>Accept a message from specified exchange. Returns message address if available, zero otherwise.</td>
</tr>
<tr>
<td>CREATE TASK</td>
<td>Create task by building new Task Descriptor based on specified Static Task Descriptor.</td>
</tr>
<tr>
<td>CREATE EXCHANGE</td>
<td>Create exchange at specified RAM address.</td>
</tr>
<tr>
<td>DISABLE INTERRUPT</td>
<td>Disable specified interrupt level.</td>
</tr>
<tr>
<td>DELETE EXCHANGE</td>
<td>Delete specified exchange.</td>
</tr>
<tr>
<td>DELETE TASK</td>
<td>Delete the task specified.</td>
</tr>
<tr>
<td>ENABLE INTERRUPT</td>
<td>Initialize message portion of the Interrupt Exchange Descriptor associated with the specified interrupt level (the first time called only), and enable specified interrupt level.</td>
</tr>
<tr>
<td>END INTERRUPT</td>
<td>Signals specific end-of-interrupt for the specified interrupt exchange in a user-supplied interrupt service routine.</td>
</tr>
<tr>
<td>INTERRUPT SEND</td>
<td>Send an interrupt message to the specified interrupt exchange.</td>
</tr>
<tr>
<td>RESUME</td>
<td>Resume a task that has previously been suspended.</td>
</tr>
<tr>
<td>SEND</td>
<td>Send the message located at “msg-addr” to the exchange specified by “exch-addr.”</td>
</tr>
<tr>
<td>SET INTERRUPT</td>
<td>Set interrupt vector address. An interrupt is to be serviced by the user-supplied routine starting at the address, thus bypassing Nucleus interrupt software.</td>
</tr>
<tr>
<td>SUSPEND TASK</td>
<td>Suspend execution of the task specified by the Task Descriptor.</td>
</tr>
<tr>
<td>WAIT</td>
<td>Wait at the specified exchange until a message is available or time limit expires. Return address of system timeout message or user message.</td>
</tr>
</tbody>
</table>
expand and accommodate infrequently used tasks which are loaded into memory from a mass storage device.

Interactive System Generation

The iRMX 88 Executive is constructed in a thoroughly modular manner with the full range of facilities being offered in library modules. By selecting the appropriate features and combining them with the user-written application tasks the generated system is tailored to the application's requirements minimizing memory overhead for unused features.

An Interactive Configuration Utility provides a query-based tool that configures the iRMX 88-based application. Responding to questions from the ICU utility program executing on a Series III Intellec Microcomputer Development System or an iRMX 86-based system, the user quickly tailors the real-time application system.

I/O System

The iRMX 88 I/O System provides an extensive facility for device-independent I/O. Through a series of supplied iRMX 86 compatible device drivers, the I/O System supports a wide-range of ISBC peripheral controllers. Custom peripheral controllers are supported through user-written device drivers which are integrated with the I/O System at system configuration time. The device-independent nature of the system allows use of different devices without application redesign.

The I/O System (IOS) procedures manage real-time file operations supporting both sequential and random access (see Table 3). The IOS maximizes system throughput by allowing multiple disk operations to proceed in parallel. For example, files can be "double buffered" so that the task can be processing data in one buffer while the IOS is filing another.

The IOS provides access to two types of files:

- Named Files allow applications to refer to collections of bytes (files) by using a name. These names are cataloged in a directory which allows files to be accessed by different tasks.
- Physical Files allow applications to make a physical connection to a storage device. Typically used for simple devices such as printers, terminals or sequential data logging where file structures are not necessary.

The file types are a compatible subset of the iRMX 86 Basic I/O System with a flat (non-hierarchical) directory.

Bootstrap Loader

The iRMX 88 IOS has a Bootstrap Loader which loads a file from mass storage into system memory. The configurable Bootstrap Loader loads the file from a specific device, automatically from the first-ready device of a designated device list, or accepts the file name from a terminal. Storing the system software on disk allows easier future changes to the application system.

Run-Time Interface

The iRMX 88 Executive provides the User Run-time Interface (URI). This URI interface, in addition to encompassing the I/O System services, provides additional functionality for tasks. The additional functionality includes a trap function and memory management routines which provide the run-time foundation for PASCAL-86, FORTRAN-86, or PL/M-86 coded application tasks.

| Table 3. I/O System Services |
|-------------------------------|-----------------|-----------------|
| **Data Transfer Services** | **SERVICE** | **FUNCTION** |
| CLOSE | Closes a file connection. |
| OPEN | Opens a file connection for access. |
| READ | Reads a number of bytes from a file. |
| SEEK | Seeks to the indicated position. |
| TRUNCATE | Truncates a file. |
| WRITE | Writes a number of bytes to that file. |
| ATTACH | Attaches to a file connection. |
| CREATE | Creates a file and returns a file connection. |
| CONNECTION STATUS | Returns the file connection status. |
| DELETE | Marks the file for deletion. |
| DETACH | Detaches a file connection. |
| RENAME | Renames an existing file. |
| FORMAT | Formats the disk for files. |
| File Connection Services | **SERVICE** | **FUNCTION** |
| Volume Preparation | **SERVICE** | **FUNCTION** |

5-24
SPECIFICATIONS

Intellec® System Configuration and Generation Requirements
Series III Intellec Microcomputer Development System with UDI support and a minimum of 2 diskette drives.

iRMX™-Based Configuration and Generation Requirements
iRMX 86-based system with UDI support and a minimum of 2 diskette drives.

Supported Hardware

iSBC™ SUPPORTED MICROCOMPUTERS
iSBC 86/05 Board
iSBC 86/12A Board
iSBC 88/25 Board
iSBC 88/40 Board

MASS STORAGE
iSBC 204 Flexible Diskette Controller
iSBC 208 Flexible Disk Controller
iSBC 215A Winchester Disk Controller
iSBC 215B Winchester Disk Controller
iSBC 220 SMD Disk Controller
iSBC 254 Bubble Memory Board

MULTIMODULE™ BOARDS
iSBX 218 Flexible Disk Controller (when used with the iSBC 215 Controller)
iSBC 337 Numeric Data Processor
iSBX 351 Serial I/O Board

CUSTOM iAPX 86, 88-BASED SYSTEMS REQUIREMENTS
8253 or 8254 Programmable Interval Timer
8259A Programmable Interrupt Controller
8251A USART or iSBX 351 board (when the Terminal Handler is configured into the system).
8087 Numeric Processor Extension (when NPX tasks are configured into the system).

Reference Manuals (supplied)
143238 — Introduction to the iRMX 80/88 Real-Time Multitasking Executives
143241 — iRMX 88 Installation Instructions
143232 — iRMX 88 Reference Manual
142603 — iRMX 80/88 Interactive Configuration User’s Guide
142926 — Guide to Writing Device Drivers for the iRMX 86 and iRMX 88 I/O Systems
## ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMX 88</td>
<td>Single Density ISIS media. Includes incorporation fee buyout.</td>
</tr>
<tr>
<td>RMX 88 ABY</td>
<td>Double Density ISIS media. Includes incorporation fee buyout.</td>
</tr>
<tr>
<td>RMX 88 BBY</td>
<td>Single Density RMX-86 media. Includes incorporation fee buyout.</td>
</tr>
<tr>
<td>RMX 88 AWX</td>
<td>One year Single Density ISIS media update service.</td>
</tr>
<tr>
<td>RMX 88 BWX</td>
<td>One year Double Density ISIS media update service.</td>
</tr>
<tr>
<td>RMX 88 DBY</td>
<td>Single Density RMX-86 media. Includes incorporation fee buyout.</td>
</tr>
<tr>
<td>RMX 88 DWX</td>
<td>One year Single Density RMX-86 media update service.</td>
</tr>
<tr>
<td>RMX 88 LST</td>
<td>Human readable source listings for iRMX 88 software.</td>
</tr>
<tr>
<td>RMX 88 LWX</td>
<td>Update service for human readable source listings.</td>
</tr>
<tr>
<td>RMX 88 RF</td>
<td>Incorporation fee.</td>
</tr>
</tbody>
</table>
iSBC™ 957B
iAPX 86, 88 INTERFACE AND EXECUTION PACKAGE

- Supports target system debugging for iSBC™ 86/05, 86/12A, 88/25, 88/40 or iAPX 86, 88-based applications
- Interactively extends the Intellec® development environment to the target system for code execution and symbolic displays of results
- Supports custom and iRMX™ operating systems with application access to ISIS-II files
- Supports the 8087 Numeric Processor Extension (NPX) functions for high-speed arithmetic applications
- Utilizes a parallel or serial connection between the Intellec® Development System and the target system
- Provides an applications bootstrap from iRMX™ 86 and 88 file compatible peripherals

The Intel iSBC 957B package contains the necessary hardware, software, cables, terminator packs and documentation required to interface, through a serial or parallel connection, an iSBC 86/05, 86/12A, 88/25, 88/40 or iAPX 86, 88 target system to an MDS 800, Series II or Series III Intellec Microcomputer Development System for full-speed execution and debugging of application software. The iSBC 957B package supports the OEM’s choice of a custom operating system, iRMX 86 Operating System or iRMX 88 Real-Time Multitasking Executive for the target application system. OEM’s may utilize any iRMX 86, 88 supported target system peripheral for a bootstrap of the application system or have full access to the ISIS-II files of the Intellec system.
FUNCTIONAL DESCRIPTION

Overview
Extending the software development capabilities of the Intellec Microcomputer Development System, the iSBC 957B, iAPX 86, 88 Interface and Execution Package provides a link to executing and debugging in a target system. The application software, developed under the Intellec-resident ISIS-II Operating System, can readily be downloaded to an iSBC 86, 88 Single Board Computer or a custom iAPX 86, 88 system using the included monitor and its powerful, interactive debugging commands via the Intellec console. Programmers can effectively develop applications to ensure timely product availability.

Target System Debugging
The iSBC 957B package includes a communications link and target system resident monitor software for target application debugging. The target system monitor supports debugging through an attached CRT or the Intellec System. The Intellec resident communications software manages the link (serial or parallel) between the Intellec system and the target system. The communications software passes the appropriate console-requested commands to the monitor software. The monitor software, invoked interactively through the Intellec system, effectively exercises the object modules on the target system. Pre-configured EPROM resident monitors are supplied for the iSBC 86/05, 86/12A and 88/40 products. The monitor software is configurable as to the selection of the communication link, processor board, numeric processor extension and the bootstrap loader functions. The OEM would burn the configured monitor into EPROMs for the target system.

The execution command environment (see Table 1) supported by the resident monitor loads object code into memory, executes it at full speed, sets breakpoints and examines the results. The monitor selectively executes portions of program modules based on breakpoints and single stepping requests. The monitor also provides commands to examine memory, manage memory movement by block, search for values, compare contents, and modify its value. Other program debugging information is provided through the displaying, examining or modifying of the iAPX 86, 88 registers.

Numeric Data Processor Support
Arithmetic applications utilizing the 8087 Numeric Processor Extension (NPX) are fully supported by the iSBC 957B Monitor. In addition to executing applications with the full NPX performance, programmers may examine and modify the NPX's registers using decimal and real number format.

Table 1. Monitor Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Bootsstraps an application from the target system's peripheral device.</td>
</tr>
<tr>
<td>C</td>
<td>Compares two memory blocks.</td>
</tr>
<tr>
<td>D</td>
<td>Displays a memory block's contents.</td>
</tr>
<tr>
<td>E</td>
<td>Exits the Intellec®-based (APXLOD) program and returns to the ISIS-II Operating System.</td>
</tr>
<tr>
<td>F</td>
<td>Searches a memory block to find a specified constant.</td>
</tr>
<tr>
<td>G</td>
<td>The GO command transfers execution to the user program.</td>
</tr>
<tr>
<td>I</td>
<td>Inputs and displays data obtained from the input port.</td>
</tr>
<tr>
<td>L</td>
<td>Loads the Intellec® object file into memory.</td>
</tr>
<tr>
<td>M</td>
<td>Moves the specified memory block.</td>
</tr>
<tr>
<td>N</td>
<td>The N command displays an instruction's single step execution.</td>
</tr>
<tr>
<td>O</td>
<td>Outputs data to the output port.</td>
</tr>
<tr>
<td>P</td>
<td>Prints values of literals.</td>
</tr>
<tr>
<td>R</td>
<td>Runs the program after the iAPX 86, 88 object file is loaded.</td>
</tr>
<tr>
<td>S</td>
<td>Substitutes the input value for the memory location.</td>
</tr>
<tr>
<td>T</td>
<td>Transfers a block of memory to an Intellec® file.</td>
</tr>
<tr>
<td>X</td>
<td>Allows iAPX™ 86, 88 or NPX registers to be examined or modified.</td>
</tr>
<tr>
<td>*</td>
<td>Indicates remainder of the line is a comment.</td>
</tr>
</tbody>
</table>
The programmer feels confident that correct and meaningful numbers are entered for the application without having to encode and decode complex real, integer, and BCD hexadecimal formats.

**Easy-To-Use Connection**

The physical interface between the Intellec Microcomputer Development System and the target IAPX 86, 88 system is accomplished with the supplied ISBC 957B cables. The cabling arrangement is either a serial or parallel line and varies depending on whether the development system is of the Intellec MDS 800 family or one of the Intellec Series II or III family. All communication, including data transfer and command requests, occurs over this line.

As shown in Figure 1, the connection to the target ISBC 86/12A system is accomplished with the ISBC 86/12A serial port through an RS232C serial line interconnected to Serial port 1 of an Intellec Series II Model 220 or Model 230 or the CRT port of an Intellec 800 Development System. In some target ISBC application systems, the serial I/O port may not be available for debugging. The example connection, shown in Figure 2, shows how the parallel port of the ISBC 86/12A board is connected through the parallel cable to the UPP port of the Intellec system.

---

**Figure 1. Intellec® Series Models 220, 230 Serial Connection**

**Figure 2. Intellec® Series Models 220, 230, 240 Parallel Connection**
Application Bootstrap Loader

The bootstrap loader, invoked from a stand-alone CRT attached to the iSBC product or the Intellec console, dynamically loads the application system into the target system's memory from an attached peripheral through the iRMX 86, 88 compatible bootstrap loader. This configurable function can be included with the iSBC 957B monitor and installed in the iAPX 86, 88 target system. The programmer may load application code modules or an entire system from bubble memory, floppy diskettes, Winchester disks or other iRMX supported mass storage devices.

Application Access to ISIS-II Files

Application programs have read or write access to the ISIS-II file system from the iAPX 86, 88 target system through simple, easy-to-use, ISIS-like routines (as shown in Table 2). The routines are used by applications running in the target system to transfer files from the ISIS environment into the environment of the target system. User written applications, utilizing the target operating system, can manipulate or store data on the target system's peripherals.

Table 2. Routines for ISIS-II Services Available to Target System Applications

<table>
<thead>
<tr>
<th>Routine</th>
<th>Target System Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTRIB</td>
<td>Changes an ISIS-II file attribute.</td>
</tr>
<tr>
<td>CI</td>
<td>Returns a character input from the console.</td>
</tr>
<tr>
<td>CLOSE</td>
<td>Closes an opened ISIS-II file.</td>
</tr>
<tr>
<td>CO</td>
<td>Transfers a character for console output.</td>
</tr>
<tr>
<td>DELETE</td>
<td>Deletes the specified ISIS-II file.</td>
</tr>
<tr>
<td>ERROR</td>
<td>Displays an error message on the Intellec® console.</td>
</tr>
<tr>
<td>EXIT</td>
<td>Exits to the target system monitor.</td>
</tr>
<tr>
<td>LOAD</td>
<td>Loads target system memory with ISIS-II object code file.</td>
</tr>
<tr>
<td>OPEN</td>
<td>Opens an ISIS-II file for access.</td>
</tr>
<tr>
<td>READ</td>
<td>Reads up to 4096 bytes from an ISIS-II file to memory.</td>
</tr>
<tr>
<td>RENAME</td>
<td>Renames an ISIS-II disk file.</td>
</tr>
<tr>
<td>SEEK</td>
<td>Seeks to the specified ISIS-II file location.</td>
</tr>
<tr>
<td>WRITE</td>
<td>Writes up to 4096 bytes from memory to an ISIS-II file.</td>
</tr>
</tbody>
</table>

SPECIFICATIONS

Intellec® Configuration Environment

The Intellec Microcomputer Development System is utilized for application program development and requires the following to support the iSBC 957B package:

1. 64K bytes RAM
2. Double density diskette or single density diskette subsystem
3. ISIS-II Operating System and associated language translators

Data Transfer Rates

<table>
<thead>
<tr>
<th>Intellec® System Family</th>
<th>Serial K Byes/min</th>
<th>Parallel K Byes/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS-800</td>
<td>37</td>
<td>96</td>
</tr>
<tr>
<td>Series II, III</td>
<td>37</td>
<td>29</td>
</tr>
</tbody>
</table>

iAPX 86, 88 Target System Environment

Supporting the iAPX 86, 88-based final product configuration, the iSBC 957B software package requires:

1. iSBC 957B cable and EPROMmed monitor
2. Serial or parallel interface (8251 USART or 8255 Programmable Peripheral Interface)
3. iSBC 86, 88-based single board computer or custom iAPX 86, 88-based board

Hardware

SUPPORTED iSBC™ MICROCOMPUTERS

- iSBC 86/05 Single Board Computer
- iSBC 86/12A Single Board Computer
- iSBC 88/25 Single Board Computer
- iSBC 88/40 Single Board Computer
- iSBC 337 Numeric Data Processor

SUPPORTED iSBC™ PERIPHERAL CONTROLLERS

- iSBC 204 Flexible Diskette Controller
- iSBC 215 Winchester Disk Controller
- iSBC 220 SDM Disk Controller
- iSBC 254 Bubble Memory Board

SUPPORTED iSBX™ MULTIMODULE™ BOARDS

- iSBX 218 Flexible Disk Controller (when mounted on an iSBC 215 controller)
- iSBX 350 Parallel I/O MULTIMODULE Board
- iSBX 351 Serial I/O MULTIMODULE Board
iSBC™ 957B Package Contents (Supplied)

CABLES
1 — Serial I/O port of iSBC or iAPX 86, 88 compatible product to male RS232C connector
1 — Intellec System RS232C port to female RS232C connector
1 — Parallel load cable to mate between Intellec System UPP port and parallel I/O port on iSBC or iAPX 86, 88 compatible product

PARALLEL INTERFACE ADAPTER
1 — Parallel port status adapter for iSBC products using parallel cable

I/O DRIVER AND TERMINATORS
4 — iSBC 901 - 220 ohm/330 ohm terminator packs
4 — iSBC 902 - 1K ohm terminator packs
4 — 7437 line driver packs

INTERFACE AND EXECUTION SOFTWARE DISKETTES
1 — Single density, ISIS compatible
1 — Double density, ISIS compatible

SYSTEM MONITOR EPROMs

<table>
<thead>
<tr>
<th>Microcomputer</th>
<th>Address</th>
<th>Supports NPX</th>
</tr>
</thead>
<tbody>
<tr>
<td>iSBC™ 86/05, 86/12A</td>
<td>00000H-007FFH</td>
<td>FC000H-FFFFFH</td>
</tr>
<tr>
<td>iSBC™ 88/40</td>
<td>00000H-006FFH</td>
<td>FD000H-FFFFFH*</td>
</tr>
</tbody>
</table>

* Allows 2816 E²PROM to be used at FC000H

Reference Manual (Supplied)
143979-002 — User’s Guide for the iSBC 957B, iAPX 86, 88 Interface and Execution Package

ORDERING INFORMATION

Part Number Description

SBC 957B — Intellec to iAPX 86, 88 Interface and Execution Package including software, cables and EPROMs.
iOSP™ 86
iAPX 86/30 AND iAPX 88/30 SUPPORT PACKAGE

- Development and run-time support for iAPX 86/30 and 88/30 Operating System Processors
- Compatible with Intel® PL/M 86/88, PASCAL 86/88, FORTRAN 86/88, and iAPX 86/88 ASSEMBLER
- Total iRMX™ 86 Operating System software compatibility
- Supports (P)ROM or RAM based system
- Extendable with iRMX™ 86 Operating System calls
- Complete system initialization aids
- Complete system configuration aids

The Intel iOSP 86 Support Package for the iAPX 86/30 and 88/30 Operating System Processors contains a comprehensive set of easy-to-use tools necessary to develop (P)ROM or RAM-based applications that use the 80130 Operating System Firmware component. All of the system initialization and run-time facilities are provided in libraries that may be configured to specific requirements, and linked to application programs written in either iAPX 86 or iAPX 88 Assembler or a high level programming language such as PASCAL 86 and PL/M 86. The iOSP 86 Package provides users with the basic initialization and interface routines needed to build application software based on the fundamental operating system functions of the iAPX 86/30 and 88/30 Operating System Processors. The iOSP 86 Package also enables users to add higher level I/O functions from the fully compatible iRMX 86 Operating System, or to form custom, real-time systems.

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October, 1981

Order Number: 210236-001
FUNCTIONAL DESCRIPTION

The iAPX 86/30 and iAPX 88/30 Operating System Processors (OSPs) provide an easy-to-use foundation on which many real-time applications may be built. They provide the functions and system support needed to implement both simple and complex applications that require multiple tasks to run concurrently (see Figure 1). These services are made possible by the addition of the five new data types integrated into the 80130 Operating System Firmware (OSF) component. The 80130 OSF extends the basic data types of the CPU (integer, byte, character, etc.) by adding new system data types (JOB's, TASK's, MAILBOX's, SEGMENT's, and REGION's), and extensive timer, interrupt, memory, and error management designed to give real-time response to multitasking and multiprogramming applications. As shown in the second half of the figure, other operating system functions such as mass storage I/O services and an easy-to-use Human Interface can be added easily, by using modules from the complete operating system services of the iRMX 86 Operating System. The iOSP 86 Support Package provides both an interface between application software and the Operating System Processors, and development tools designed to make the implementation and initialization of real-time, multitasking systems much simpler.

The iOSP 86 Support Package provides system developers with the configuration options necessary to tailor the iAPX 86/30 and 88/30 Operating System Processors to custom applications. Using the Linking and Locating facilities of either an Intel Intellec Development System, or a suitably equipped iRMX 86 system, the interface libraries provided in the package can be added to application software modules to form easy-to-use initialization routines. They also form a simple interface between application software and the operating system primitives of the 80130 OSF component. The various configuration options include:

Memory and I/O Addressing

The 80130 OSF requires a 16K byte block of memory address space to be reserved for accessing internal functions. The iOSP 86 Support Package is used to specify the base address of the 80130 and the beginning of the initialization routines.

All Interrupt and Timer management of the OSF is controlled via a reserved 16-byte I/O address block that may be selected by the user. In addition, from 1 to 7 slave 8259A interrupt controllers can be specified in order to provide the system with up to 57 priority interrupt sources. The OSF baud rate generator may also be configured to support an optional terminal interface.

Extending the 80130 OSF

The 80130 OSF allows users to add their own operating system extensions. These extensions may take advantage of the detailed and efficient intertask communication and synchronization primitives already provided by the 80130, and/or may utilize custom functions tailored to specific applications. The Support Package also enables users to extend the OSF with the extensive services of Intel's iRMX 86 Operating System, thereby allowing applications to grow without having to change or alter application software already written, or having to write other operating system software. Use of the 80130 with the iRMX 86 Operating system greatly reduces the amount of memory needed for the iRMX 86 Nucleus layer, and enables applications to take advantage of the increased

![Figure 1. Structure of Typical Systems](AFN-02085A)
performance and reduced size requirements inherent in the iAPX 86/30 and 88/30 VLSI Operating System Processors. As each of the services provided by the 80130 is completely iRMX 86-compatible, applications have an automatic upward path to support complete file systems and multiple processor environments.

Application Interfaces

Two interface libraries are included in the iOSP 86 Support Package. The first allows programmers to write application software modules in the Compact Model of computation supported by Intel's compilers. The second provides an interface to program segments written in either the Medium or Large Models.

The interface libraries provide the means of accessing all of the primitives supported by the Operating System Processors. With this interface, and all the memory management primitives of the OSPs, applications have full access to 1M byte of memory, and all of the addressing modes of the CPU.

The iAPX 86/30 and 88/30 OSPs allow applications to take full advantage of the Compact, Medium, and Large models of computation afforded by the segment model of the CPU.

These libraries are fully compatible with object modules produced by the MACRO 86/88 Assembler, and the PASCAL 86/88 and FORTRAN 86/88 and PL/M 86/88 Compilers.

Application Initialization

The iOSP 86 Support Package provides for the configuration of the system Root JOB, and all user application JOB’s that require initialization when the system is started. The user may also specify the configuration of the interrupt system (including slave 8259A interrupt controllers) and the clock rate used for system timing. These choices are automatically programmed into the various devices when the system is initialized.

Operating System Calls

The 80130 OSF performs a total of 35 operating system primitives all of which are completely compatible with the equivalent iRMX 86 Operating System calls. The iOSP 86 Support Package provides user-level interfaces to these primitives to enable applications to create, delete, control, and exchange the new data types provided by the 80130 OSF. In general, these interfaces allow application software to manage all of the resources of an iAPX 86/30 or 88/30 OSP (and an optional 8087 Numeric Processor Extension) system via any of the 35 normal Assembly Language system calls shown in Figure 2.

Required Development Hardware

Use of the iOSP 86 Support Package requires an Intel MDS Development System supporting either single or double density diskettes, or any iRMX 86 system supporting a standard floppy diskette drive and the iRMX 860 Assembler, Linker, and Locator Package. Use of the 80130 requires only a minimal system including either the iAPX 86/30 or 88/30 Operating System Processor, and enough system memory to contain the application programs and approximately 2K bytes of initialization and interface software provided in the iOSP 86 Support Package.

---

**Figure 2. Operating System Primitives**
## ORDERING INFORMATION

Each of the ordering options listed below include all the necessary initialization and interface procedures needed to use the iAPX 86/30 and iAPX 88/30 Operating System Processors. Purchase of the iPSP 86 Package requires verification of an Intel Master Software License. Each package also includes an iOSSP 86 User's Manual (Document Number 143331), and a one-year update service.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSP 86 A</td>
<td>iOSSP 86 Support Package contained on an ISIS-II compatible, single density diskette.</td>
</tr>
<tr>
<td>OSP 86 B</td>
<td>iOSSP 86 Support Package contained on an ISIS-II compatible, double density diskette.</td>
</tr>
<tr>
<td>OSP 86 E</td>
<td>iOSSP 86 Support Package contained on an iRMX 86 format, double density diskette.</td>
</tr>
</tbody>
</table>
Peripheral Controllers
iSBC 204
SINGLE DENSITY FLEXIBLE DISKETTE CONTROLLER

- Full compatibility with iSBC 80, iSBC 86, and iSBC 88 Single Board Computers
- Direct compatibility with most single-density, soft-sectored standard (8") and mini-size (5¼") flexible diskette drives
- Software supported by iRMX 80, iRMX 86 and iRMX 88 Real-Time Multi-tasking Executive disk file system
- DMA input/output allows single board computers to process in parallel with diskette transfer operations
- Programmable track-to-track access, head-settling, and head-load times
- On-board data separation logic
- Read, write, verify, and search on single or multiple sectors
- Single +5V supply

The Intel iSBC 204 Single Density Flexible Diskette Controller is a single board universal diskette controller capable of supporting virtually any software-sectored, single density diskette drive. The standard iSBC 204 Controller can control two drive surfaces (two single-sided drives or one double-sided drive). With the addition of a second (optional) Intel 8271 component, up to four drives can be supported. In addition to the standard IBM 3740 formats, the controller supports sector lengths of up to 4096 bytes plus mini-size drive formats. The iSBC 204's wide range of drive compatibility is achieved without compromising performance. The operating characteristics (track-to-track access, head-load, and head-settling times) are specified under user program control. The controller can read, write, verify, and search either single or multiple sectors.
FUNCTIONAL DESCRIPTION

Intel's 8271 Floppy Disk Controller (FDC) circuit is the heart of the iSBC 204 Controller. On-board data separation logic performs standard FM encoding and decoding, obviating external separation circuitry at the drive. Diskette data transfers are DMA (direct memory access) through an on-board Intel 8257 DMA controller circuit which manages DMA transfers and signals the master iSBC processor on completion of the transfer. A block diagram of the iSBC 204 Controller is shown in Figure 1.

Universal Drive and MULTIBUS Compatibility

Because the iSBC 204 Controller has universal drive compatibility, it can be used to control virtually any standard- or mini-sized single density diskette drive. Moreover, the iSBC 204 Controller fully supports the microcomputer industry standard MULTIBUS system bus and can be used with any single board computer or system compatible with Intel's bus. Because the iSBC 204 Controller is programmable, its performance is not compromised by its universal drive compatibility. The track-to-track access, head-load, and head-settling characteristics of the selected drive model are program specified. Data may be organized in a fully compatible IBM 3740 sector format, in sectors up to 4096 bytes in length, or in formats compatible with the mini-sized diskette drives.

Interface Characteristics

Expandability — Each standard iSBC 204 Controller includes a single 8271 FDC circuit capable of supporting two drive surfaces. Optionally the iSBC 204 may be expanded to support four single-sided (or two double-sided) drives with the insertion of a second 8271 component into an on-board socket.

Simplified Interface — The cables between the iSBC 204 Controller and the drive(s) may be either low cost, flat ribbon cable with mass termination connectors or twisted pair conductors with individually wired connectors. An on-board, cross-connect matrix allows optional drive control and status signals to be connected while maintaining pin-to-pin compatibility.

Programming

The powerful 8271 FDC circuit is capable of executing high-level commands that simplify system software development. The device can read, write, and verify both single and multiple sectors. CRC characters are generated and checked automatically. Up to two tracks on each surface may be designated “bad” and logically removed from the diskette.

Sector Scanning — Scan commands permit sectors to be searched for a specified data pattern or “key”. During scan operations the pattern image from memory is continuously compared with a sector or multiple sectors.

---

**Figure 1. iSBC 204 Single Density Diskette Controller Block Diagram**
read from the diskette. No CPU intervention is required until a match is found or all specified sectors have been searched.

Program Initiation — All diskette operations are initiated by standard input/output (I/O) port operations through an iSBC single board computer. System software first initializes the controller with the operating characteristics of the selected drive. The diskette is then formatted under program control. For subsequent transfers, the starting memory address and transfer mode are specified for the DMA controller. Data transfers occur in response to commands output by the CPU.

Data Transfer — Once a diskette transfer operation has been initiated, the controller acts as a bus master and transfers data over the MULTIBUS at high speed. No CPU intervention is required until the transfer is complete as indicated either by the generation of an interrupt on the bus or by examination of a “done” bit by the CPU.

SPECIFICATIONS

Compatibility

CPU — Any iSBC MULTIBUS computer or system mainframe.

Drive — Single density, standard- (8") and mini-sized (5¼") diskette drives. The standard iSBC 204 Controller supports two single-sided drives or one double-sided drive. By adding an (optional) 8271 FDC, four single-sided or two double-sided drives may be supported. The following drives are known to be compatible:

<table>
<thead>
<tr>
<th>Standard Size</th>
<th>Mini Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDC 9404</td>
<td>PERTEC FD200</td>
</tr>
<tr>
<td>GSI 110</td>
<td>SHUGART SA400</td>
</tr>
<tr>
<td>MEMOREX 550</td>
<td>WANGCO 82</td>
</tr>
<tr>
<td>MEMOREX 552 (dual-sided)</td>
<td></td>
</tr>
<tr>
<td>SHUGART 800</td>
<td></td>
</tr>
<tr>
<td>SHUGART 850 (dual-sided)</td>
<td></td>
</tr>
<tr>
<td>WANGCO 76S</td>
<td></td>
</tr>
<tr>
<td>PERTEC 650 (SD/DD, DBL. Head)</td>
<td></td>
</tr>
</tbody>
</table>

Diskette — Unformatted IBM Diskette 1 (or equivalent single-sided); unformatted IBM Diskette 2 (or equivalent double-sided); unformatted Shugart SA104 Diskette (or equivalent mini).

Data Organization and Capacity

(Standard Size Drives)

<table>
<thead>
<tr>
<th></th>
<th>IBM Format</th>
<th>Non-IBM Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bytes per sector</td>
<td>128 256 512</td>
<td>1024 2048 4096</td>
</tr>
<tr>
<td>Sectors per track</td>
<td>26 15 8</td>
<td>4 2 1</td>
</tr>
<tr>
<td>Tracks per diskette</td>
<td>77</td>
<td>Up to 255</td>
</tr>
<tr>
<td>Bytes per diskette (77 tracks)</td>
<td>256,256 (128-byte sector) 295,680 (256-byte sector) 315,392 (512-byte sector)</td>
<td>315,392</td>
</tr>
</tbody>
</table>

Drive Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Standard Size</th>
<th>Mini Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer rate (KB/sec)</td>
<td>250</td>
<td>125</td>
</tr>
<tr>
<td>Disk speed (RPM)</td>
<td>360</td>
<td>300</td>
</tr>
<tr>
<td>Track-to-track access (programmable)</td>
<td>1 to 255 ms in 1 ms steps 2 to 510 ms in 2 ms steps</td>
<td></td>
</tr>
<tr>
<td>Head settling time (programmable)</td>
<td>0 to 255 ms in 1 ms steps 0 to 510 ms in 2 ms steps</td>
<td></td>
</tr>
<tr>
<td>Head load time (programmable)</td>
<td>0 to 60 ms in 4 ms steps 0 to 120 ms in 8 ms steps</td>
<td></td>
</tr>
</tbody>
</table>

Equipment Supplied

iSBC 204 Controller

Reference Schematic

Controller-to-drive cabling and connectors are not supplied with the iSBC 204 Controller. Cables can be fabricated easily using either flat ribbon cable or twisted pair conductors with commercially available connectors as described in the iSBC 204 Hardware Reference Manual.

Optional Equipment

8271 Flexible Diskette Controller Component — Adding a second 8271 device to the fully tested circuit on the iSBC 204 Controller allows four drive surfaces to be supported.

Physical Characteristics

Width — 6.75 in. (17.15 cm)

Height — 0.5 in. (1.27 cm)

Length — 12.0 in. (30.48 cm)

Shipping Weight — 1.75 lb (0.80 kg)

Mounting — Occupies one slot of iSBC system chassis or iSBC 604/614 cardcage.

Electrical Characteristics

Power Requirements — 5.0V (±5%), 2.5A max

Environmental Characteristics

Temperature — 0°C to 55°C (operating); -55°C to +85°C (non-operating)

Humidity — Up to 90% relative humidity without condensation (operating); all conditions without condensation or frost (non-operating)

Reference Manuals

9800568 — iSBC 204 Diskette Controller Hardware Reference Manual (NOT SUPPLIED).


Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

Part Number | Description
------------|-------------
SBC 204 | Universal Flexible Diskette Controller
iSBC 208
FLEXIBLE DISK CONTROLLER

- Compatible with all iSBC 80, iSBC 86, and iSBC 88 Single Board Computers
- Controls most single and double density diskette drives
- On-board iSBX bus for additional functions
- User-programmable drive parameters allow wide choice of drives
- Phase lock loop data separator assures maximum data integrity
- Read and write on single or multiple sectors
- Single +5V Supply
- Capable of addressing 16M bytes of system memory

The Intel iSBC 208 Flexible Disk Controller is a diskette controller capable of supporting virtually any soft-sectored, double density or single density diskette drive. The standard controller can control up to four drives with up to eight surfaces. In addition to the standard IBM 3740 formats and IBM System 34 formats, the controller supports sector lengths of up to 8192 bytes. The iSBC 208 board's wide range of drive compatibility is achieved without compromising performance. The operating characteristics are specified under user program control. The controller can read, write, verify, and search either single or multiple sectors. Additional capability such as parallel or serial I/O or special math functions can be placed on the iSBC 208 board by utilizing the iSBX bus connection.
FUNCTIONAL DESCRIPTION

Intel's 8272 Floppy Disk Controller (FDC) circuit is the heart of the iSBC 208 Controller. On-board data separation logic performs standard MFM (double density) and FM (single density) encoding and decoding, eliminating the need for external separation circuitry at the drive. Data transfers between the controller and memory are managed by a DMA device which completely controls transfers over the MULTIBUS system bus. A block diagram of the iSBC 208 Controller is shown in Figure 1.

Universal Drives and the iSBC 208 Controller

Because the iSBC 208 Controller has universal drive compatibility, it can be used to control virtually any standard- or mini-sized diskette drive. Moreover, the iSBC 208 Controller fully supports the ISBX bus and can be used with any ISBX module compatible with this bus. Because the iSBC 208 Controller is programmable, its performance is not compromised by its universal drive compatibility. The track-to-track access, head-load, and head-unload characteristics of the selected drive model are program specified. Data may be organized in sectors up to 8192 bytes in length.

Figure 1. iSBC 208 Flexible Disk Controller Block Diagram
Interface Characteristics

The standard iSBC 208 Controller includes an Intel 8272 Floppy Disk Controller chip which supports up to four drives, single or double sided.

SIMPLIFIED INTERFACE—The cables between the iSBC 208 Controller and the drive(s) may be low cost, flat ribbon cable with mass termination connectors. The mechanical interface to the board is a right-angle header with locking tabs for security of connection.

PROGRAMMING — The powerful 8272 FDC circuit is capable of executing high-level commands that simplify system software development. The device can read and write both single and multiple sectors. CRC characters are generated and checked automatically. Recording density is selected at each Read and Write to support the industry standard technique of recording basic media information on Track 0 of Side 0 in single density, and then switching to double density (if necessary) for operations on other tracks.

Program Initiation—All diskette operations are initiated by standard input/output (I/O) port operations through an iSBC single board computer. System software first initializes the controller with the operating characteristics of the selected drive. The diskette is then formatted under program control. For subsequent transfers, the starting memory address and transfer mode are specified for the DMA controller. Data transfers occur in response to commands output by the CPU.

Data Transfer—Once a diskette transfer operation has been initiated, the controller acts as a bus master and transfers data over the MULTIBUS at high speed. No CPU intervention is required until the transfer is complete as indicated either by the generation of an interrupt on the bus or by examination of a "done" bit by the CPU.

iSBX BUS SUPPORT — One connector is available on the iSBC 208 board which supports the iSBX system bus. This connector supports single-byte transfer as well as higher-speed transfers supervised by the DMA controller. Transfers may take place in polled or interrupt modes, user-selected. The presence of the iSBX bus allows many different functions to be added to the board. Serial I/O, parallel I/O and various special-purpose math functions are only a few of the capabilities available on iSBX MULTIMODULE boards.

SPECIFICATIONS

Compatibility

CPU—Any iSBC MULTIBUS computer or system main frame

Devices—Double or single density standard (8") and mini (5¼") flexible disk drives. The drives may be single or double sided. Drives known to be compatible are:

<table>
<thead>
<tr>
<th>Standard (8&quot;)</th>
<th>Mini (5¼&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caldisk 143M</td>
<td>Shugart 450 SA 400</td>
</tr>
<tr>
<td>Remex RFD 4000</td>
<td>Micropolis 1015-IV</td>
</tr>
<tr>
<td>Memorex 550</td>
<td>Pertec 250</td>
</tr>
<tr>
<td>MFE 700</td>
<td>Siemens 200-5</td>
</tr>
<tr>
<td>Siemens FDD 200-8</td>
<td>Tandon TM-100</td>
</tr>
<tr>
<td>Shugart SA 850/800</td>
<td>CDC 9409</td>
</tr>
<tr>
<td>Pertec FD 650</td>
<td>MPI 51/52/91/92</td>
</tr>
<tr>
<td>CDC 9408-3</td>
<td></td>
</tr>
</tbody>
</table>

Diskette—Unformatted IBM Diskette 1 (or equivalent single-sided media); unformatted IBM Diskette 2D (or equivalent double-sided).

Equipment Supplied

iSBC 208 Controller
Reference Schematic
Controller-to-drive cabling and connectors are not supplied with the controller. Cables can be fabricated with flat cable and commercially-available connectors as described in the iSBC 208 Hardware Reference Manual

Physical Characteristics

Width—6.75 inches (17.15 cm)
Height—0.5 inches (1.27 cm)
Length—12.0 inches (30.48 cm)
Shipping Weight—1.75 pounds (0.80 Kg)
Mounting—Occupies one slot of iSBC system chassis or iSBC 604/614 Cardcage/Backplane. With an iSBX MULTIMODULE board mounted, vertical height increases to 1.13 inches (2.87 cm).

Electrical Characteristics

Power Requirements—+5 VDC @ 3.0A
### Data Organization and Capacity

#### Standard Size Drives

<table>
<thead>
<tr>
<th></th>
<th>Double Density</th>
<th>Single Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IBM System 34</td>
<td>IBM System 3740</td>
</tr>
<tr>
<td>Bytes per Sector</td>
<td>256 512 1024</td>
<td>2048 4096 8192</td>
</tr>
<tr>
<td>Sectors per Track</td>
<td>26 15 8 4 2 1</td>
<td>26 15 8 4 2 1</td>
</tr>
<tr>
<td>Tracks per Diskette</td>
<td>77</td>
<td>77</td>
</tr>
<tr>
<td>Bytes per Diskette (Formatted, per diskette surface)</td>
<td>512,512 (256 bytes/sector) 591,360 (512 bytes/sector) 630,784 (1024 bytes/sector)</td>
<td>630,784</td>
</tr>
</tbody>
</table>

#### Drive Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Standard Size</th>
<th>Mini Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Double/Single Density</td>
<td>Double/Single Density</td>
</tr>
<tr>
<td>Transfer Rate (K bytes/sec)</td>
<td>62.5/31.25</td>
<td>31.25/15.63</td>
</tr>
<tr>
<td>Disk Speed (RPM)</td>
<td>360</td>
<td>300</td>
</tr>
<tr>
<td>Step Rate Time (Programmable)</td>
<td>1 to 16 msec/track in 1 msec increments</td>
<td>2 to 32 msec/track in 2 msec increments</td>
</tr>
<tr>
<td>Head Load Time (Programmable)</td>
<td>2 to 254 msec in 2 msec increments</td>
<td>4 to 508 msec in 4 msec increments</td>
</tr>
<tr>
<td>Head Unload Time (Programmable)</td>
<td>16 to 240 msec in 16 msec increments</td>
<td>32 to 480 msec in 32 msec increments</td>
</tr>
</tbody>
</table>

### Environmental Characteristics

**Temperature**—0°C to 55°C (operating); -55°C to +85°C (non-operating)

**Humidity**—Up to 90% Relative Humidity without condensation (operating); all conditions without condensation or frost (non-operating)

### Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 208</td>
<td>Flexible Disk Controller</td>
</tr>
</tbody>
</table>

### Reference Manual

143078-001—iSBC 208 Flexible Disk Controller Hardware Reference Manual (NOT SUPPLIED). Reference manuals may be ordered from any Intel sales representative, distributor office, or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051.
The iSBC 215 Winchester Disk Controller will enhance the mass storage capabilities of any iSBC 80, iSBC 88, or iSBC 86-based MULTIBUS system. The controller will interface to industry standard Winchester disk drives currently available in formatted capacity from 4.5 to 26.7 MB. Recording densities are expected to increase rapidly in the near future and the iSBC 215 controller has been designed to accommodate these increases.

The iSBC 215 board will control up to four 5½", 8” or 14” drives. The iSBC 215A board controls open-loop drives; iSBC 215B board controls closed-loop drives; iSBC 215C board controls ANSI standard 1226 drives.

Two iSBX connectors are provided on the board to interface with the iSBX 218 Flexible Disk Controller, providing up to 4 MB of removable storage.

Increased computing power made available in the iSBC board products has led to a requirement for larger, more reliable mass storage subsystems. The Winchester disk controller provides a high capacity, low cost disk solution that is well matched to single board computer applications.
FUNCTIONAL DESCRIPTION

Programming
Programming the iSBC 215 controller is simplified by the use of memory-based parameter blocks. A linked list technique is used, allowing the user to perform multiple disk operations.

Full On-Board Buffer
The iSBC 215 controller contains enough on-board RAM for buffering one full data sector. The controller is designed to make use of this buffer in all transfers. The on-board sector buffer prevents data overrun errors and allows the iSBC 215 Winchester Disk Controller to occupy any priority slot on the MULTIBUS.

ECC
High data integrity is provided by on-board Error Checking Code (ECC) logic. When writing sector ID or data fields, a 32-bit Fire code, for burst error correction, is appended to the field by the controller. During a Read operation, the same logic regenerates the ECC polynomial and compares this second polynomial to the appended ECC. The ECC logic can detect an erroneous data burst up to 32 bits in length and using an 8089 algorithm can correct an erroneous burst up to 11 bits in length.

iSBX Interface
The software interface and data buffering capabilities used for Winchester drives are also available for both iSBX MULTIMODULE interfaces. Software developed for the iSBC 215 controller can also be used to transfer data to and from an iSBX-compatible I/O device.

Expanded I/O Capability
The iSBC 215 controller allows the user to execute user-written 8089 programs located in on-board or MULTIBUS system RAM. Thus the full capability of the 8089 I/O processor can be utilized for customer I/O requirements.

---

Figure 1. Block Diagram of iSBC 215™ Winchester Disk Controller
Figure 2. Controller to Drive Interfacing

* Data Express is a trademark of Rotating Memory Systems Inc.
SPECIFICATIONS

Compatibility

CPU — Any iSBC MULTIBUS computer or system mainframe

Disk Drives — Winchester Disk Drives; both open-loop and closed-loop head positioner types. The following drives are known to be compatible:

<table>
<thead>
<tr>
<th>Open-Loop (iSBC 215A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shugart SA 1000 Series</td>
</tr>
<tr>
<td>Shugart SA 4000 Series</td>
</tr>
<tr>
<td>Memorex 100 Series</td>
</tr>
<tr>
<td>Quantum Q2000 Series</td>
</tr>
<tr>
<td>Fujitsu 2301, 2302</td>
</tr>
<tr>
<td>CDC 9410</td>
</tr>
<tr>
<td>RMS 5 1/4” Series</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Closed-Loop (iSBC 215B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pertec D8000 Series</td>
</tr>
<tr>
<td>Priam 8” and 14” Drive Series</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANSI (iSBC 215C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3M 8430 Series</td>
</tr>
<tr>
<td>BASF 6170 Series</td>
</tr>
<tr>
<td>IMI 7700 Series</td>
</tr>
<tr>
<td>Kennedy 7300 Series</td>
</tr>
<tr>
<td>Pertec D8000 Series</td>
</tr>
<tr>
<td>Priam 8” Series</td>
</tr>
<tr>
<td>SLI Cheyenne</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>iSBC MULTIMODULE Boards</th>
</tr>
</thead>
<tbody>
<tr>
<td>iSBC 218 Flexible Disk Controller</td>
</tr>
<tr>
<td>iSBC 350 Parallel I/O</td>
</tr>
<tr>
<td>iSBC 351 Serial I/O</td>
</tr>
<tr>
<td>iSBC 311 Analog Input</td>
</tr>
<tr>
<td>iSBC 328 Analog Output</td>
</tr>
</tbody>
</table>

Equipment Supplied

iSBC 215 Winchester Disk Controller
Reference Schematic

Controller-to-drive cabling and connectors are not supplied with the controller. Cables can be fabricated with flat cable and commercially-available connectors as described in the iSBC 215 Hardware Reference Manual.

Physical Characteristics

Width — 6.75 in. (17.15 cm)
Height — 0.5 in. (1.27 cm)
Length — 12.0 in. (30.48 cm)
Shipping Weight — 19 oz (54 kg)

Mounting — Occupies one slot of iSBC system chassis or cardcage/backplane

With an iSBC MULTIMODULE board mounted, vertical height increases to 1.13 in. (2.87 cm).

Electrical Characteristics

Power Requirements
+ 5 VDC @ 3.25A max
− 5 VDC @ 0.15A max
+ 12 VDC @ 0.15A max
− 12 VDC @ 0.03A max

Notes:
1. On-board regulator and jumper allows +12 VDC usage from MULTIBUS.
2. Required for some iSBC MULTIMODULE boards.

Drives per Controller

5 1/4” Winchester Disk Drives — Up to four RMS drives.
8" Winchester Disk Drives — Up to four ANSI, Shugart, Pertec, Quantum or Priam drives; up to two Memorex, CDC, or Fujitsu drives.

14" Winchester Disk Drives — Up to four Priam drivers; up to two Shugart drives.

Flexible Disk Drives — Up to four drives through the optional iSBX 218 Flexible Disk Controller connected to the iSBC 215 board's iSBX connector.

Environmental Characteristics
Temperature — 0° to 55°C (operating); -55°C to +85°C (non-operating)
Humidity — Up to 90% relative humidity without condensation (operating); all conditions without condensation or frost (non-operating)

Data Organization and Capacity

<table>
<thead>
<tr>
<th>Sectors/Track¹</th>
<th>Priam 8&quot;</th>
<th>Priam 14&quot;</th>
<th>RMS/Shugart/Quantum</th>
<th>Memorex</th>
<th>Pertec</th>
</tr>
</thead>
<tbody>
<tr>
<td>128</td>
<td>70</td>
<td>104</td>
<td>54</td>
<td>.64</td>
<td>.69</td>
</tr>
<tr>
<td>256</td>
<td>42</td>
<td>62</td>
<td>31</td>
<td>.38</td>
<td>.42</td>
</tr>
<tr>
<td>512</td>
<td>23</td>
<td>34</td>
<td>17</td>
<td>.21</td>
<td>.24</td>
</tr>
<tr>
<td>1024</td>
<td>12</td>
<td>18</td>
<td>9</td>
<td>.11</td>
<td>.12</td>
</tr>
</tbody>
</table>

Note 1. Maximum allowable for corresponding selection of bytes per sector.

Formatted Capacity/Drive²

<table>
<thead>
<tr>
<th>Bytes/Sector</th>
<th>Shugart</th>
<th>Quantum</th>
<th>Pertec</th>
<th>Priam</th>
<th>Memorex</th>
<th>RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>128</td>
<td>7.08 MB</td>
<td>7.08 MB</td>
<td>12.35 MB</td>
<td>23.29 MB</td>
<td>7.99 MB</td>
<td>8.40 MB</td>
</tr>
<tr>
<td>256</td>
<td>8.12</td>
<td>8.12</td>
<td>15.03</td>
<td>27.94</td>
<td>9.49</td>
<td>9.65</td>
</tr>
<tr>
<td>512</td>
<td>8.91</td>
<td>8.91</td>
<td>17.17</td>
<td>30.62</td>
<td>10.49</td>
<td>10.58</td>
</tr>
<tr>
<td>1024</td>
<td>9.43</td>
<td>9.43</td>
<td>17.18</td>
<td>31.95</td>
<td>10.98</td>
<td>11.21</td>
</tr>
</tbody>
</table>

Note 2. Shugart SA 1004, Quantum Q2010, Priam 3450, Pertec D8000, Memorex 101, RMS 512

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 215A</td>
<td>Winchester Disk Controller (open-loop)</td>
</tr>
<tr>
<td>SBC 215B</td>
<td>Winchester Disk Controller (closed-loop)</td>
</tr>
<tr>
<td>SBC 215C</td>
<td>Winchester Disk Controller (ANSI interface)</td>
</tr>
</tbody>
</table>
iSBX 218
FLEXIBLE DISK CONTROLLER

- iSBX MULTIMODULE controller provides flexibility at low cost
- Controls most single and double density diskette drives
- User-programmable drive parameters allow wide choice of drives
- Phase lock loop data separator assures maximum data integrity
- Read and write on single or multiple sectors
- Single +5V supply

The Intel iSBX 218 Flexible Disk Controller is a double-wide iSBX board diskette controller capable of supporting virtually any soft-sectored, double density or single density diskette drive. The standard controller can control up to four drives with up to eight surfaces. In addition to the standard IBM 3740 formats and IBM System 34 formats, the controller supports sector lengths of up to 8192 bytes. The iSBX 218 board's wide range of drive compatibility is achieved without compromising performance. The operating characteristics are specified under user program control. The controller can read, write, verify, and search either single or multiple sectors.
FUNCTIONAL DESCRIPTION

Intel's 8272 Floppy Disk Controller (FDC) chip is the heart of the iSBX 218 Controller. On-board data separation logic performs standard MFM (double density) and FM (single density) encoding and decoding, eliminating the need for external separation circuitry at the drive. Data transfers between the controller and memory are managed by the intelligent device (usually an Intel 8-bit or 16-bit CPU chip) on the host board. A block diagram of the iSBX 218 Controller is shown in Figure 1.

Universal Drive and iSBX 218 Controller

Because the iSBX 218 Controller has universal drive compatibility, it can be used to control virtually any standard- or mini-sized diskette drive. Moreover, the iSBX 218 Controller fully supports the iSBX bus and can be used with any single board computer which furnishes this bus. Because the iSBX 218 Controller is programmable, its performance is not compromised by its universal drive compatibility. The track-to-track access, head-load, and head-unload characteristics of the selected drive model are program specified. Data may be organized in sectors up to 8192 bytes in length.

Interface Characteristics

The standard iSBX 218 Controller includes an Intel 8272 Floppy Disk Controller chip which supports up to four drives, single or double sided.

SIMPLIFIED INTERFACE—The cables between the iSBX 218 Controller and the drive(s) may be low cost, flat ribbon cable with mass termination connectors. The mechanical interface to the board is a right-angle header with locking tabs for security of connection.

PROGRAMMING — The powerful 8272 FDC circuit is capable of executing high-level commands that simplify system software development. The device can read and write both single and multiple sectors. CRC characters are generated and checked automatically. Recording density is selected at each Read and Write to support the industry standard technique of recording basic media information on Track 0 of Side 0 in single density, and then switching to double density (if necessary) for operations on other tracks.

Figure 1. Block Diagram of iSBX 218 Board
PROGRAM INITIATION—All diskette operations are initiated by standard iSBX bus input/output (I/O) operations through the host iSBC single board computer. System software first initializes the controller with the operating characteristics of the selected drive. The diskette is then formatted under program control. Data transfers occur in response to commands output by the CPU.

DATA TRANSFER—Once a diskette transfer operation has been initiated, the controller will require a data transfer every 13 microseconds (double density) or 26 microseconds (single density). Most CPUs will operate in a polled mode, checking controller status and transferring bytes when the controller is ready. Boards utilizing the Intel 8080 chip, such as the iSBC 80/10B board, will be restricted to single density operation with the iSBX 218 Controller, due to these speed requirements. A programming example illustrating the iSBC 80/10B handler is contained in the Hardware Reference Manual.

SPECIFICATIONS

Compatibility

CPU—Any iSBC single board computer or I/O board compatible with the MULTIBUS system bus and implementing the iSBX bus and connector.

Devices—Double or single density standard (8") and mini (5¼") flexible disk drives. The drives may be single or double sided. Drives known to be compatible are:

<table>
<thead>
<tr>
<th>Standard (8&quot;)</th>
<th>Mini (5¼&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caldisk 143M</td>
<td>Shugart 450/400</td>
</tr>
<tr>
<td>Remex RFD 4000</td>
<td>Micropolis 1015/IV</td>
</tr>
<tr>
<td>Memorex 550</td>
<td>Pertec 250</td>
</tr>
<tr>
<td>MFE 700</td>
<td>Siemens 200-5</td>
</tr>
<tr>
<td>Siemens FDD 200-8</td>
<td>Tandon TM-100</td>
</tr>
<tr>
<td>Shugart SA 850/800</td>
<td>CDC 9409</td>
</tr>
<tr>
<td>Pertec FD 650</td>
<td>MPI 51/52/91/92</td>
</tr>
<tr>
<td>CDC 9406-3</td>
<td></td>
</tr>
</tbody>
</table>

Diskette—Unformatted IBM Diskette 1 (or equivalent single-sided media); unformatted IBM Diskette 2D (or equivalent double-sided).

Equipment Supplied

iSBX 218 Controller

Reference Schematic

Controller-to-drive cabling and connectors are not supplied with the controller. Cables can be fabricated with flat cable and commercially-available connectors as described in the iSBX 218 Hardware Reference Manual.

Nylon Mounting Bolts

Physical Characteristics

Width—2.85 inches (7.24 cm)

Height—0.5 inches (1.27 cm)

Length—7.5 inches (19.05 cm)

Shipping Weight—1 pound (0.46 Kg)

Mounting—Occupies one double-wide iSBX MULTIMODULE position on boards; increases board height (host plus iSBX board) to 1.13 inches (2.87 cm).

Data Organization and Capacity

<table>
<thead>
<tr>
<th>Standard Size Drives</th>
<th>IBM System 34</th>
<th>Non-IBM</th>
<th>IBM System 3740</th>
<th>Non-IBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bytes per Sector</td>
<td>256</td>
<td>512</td>
<td>1024</td>
<td>8192</td>
</tr>
<tr>
<td>Sectors per Track</td>
<td>2048</td>
<td>4096</td>
<td>128</td>
<td>1024</td>
</tr>
<tr>
<td>Tracks per Diskette</td>
<td>77</td>
<td>256</td>
<td>77</td>
<td>256</td>
</tr>
<tr>
<td>Bytes per Diskette</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Formatted, per diskette surface)</td>
<td>512,512</td>
<td>(128 bytes/sector)</td>
<td>256,256</td>
<td>(512 bytes/sector)</td>
</tr>
<tr>
<td></td>
<td>591,360</td>
<td>295,680</td>
<td>(256 bytes/sector)</td>
<td>315,392</td>
</tr>
<tr>
<td></td>
<td>630,784</td>
<td>315,392</td>
<td>(512 bytes/sector)</td>
<td>315,392</td>
</tr>
</tbody>
</table>

6-15
Drive Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Standard Size</th>
<th>Mini Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Double/Single Density</td>
<td>Double/Single Density</td>
</tr>
<tr>
<td>Transfer Rate (K bytes/sec)</td>
<td>62.5/31.25</td>
<td>31.25/15.63</td>
</tr>
<tr>
<td>Disk Speed (RPM)</td>
<td>360</td>
<td>300</td>
</tr>
<tr>
<td>Step Rate Time (Programmable)</td>
<td>1 to 16 msec/track in</td>
<td>2 to 32 msec/track in</td>
</tr>
<tr>
<td></td>
<td>1 msec increments</td>
<td>2 msec increments</td>
</tr>
<tr>
<td>Head Load Time (Programmable)</td>
<td>2 to 256 msec in</td>
<td>4 to 512 msec in</td>
</tr>
<tr>
<td></td>
<td>2 msec increments</td>
<td>4 msec increments</td>
</tr>
<tr>
<td>HeadUnload Time (Programmable)</td>
<td>0 to 240 msec in</td>
<td>0 to 480 msec in</td>
</tr>
<tr>
<td></td>
<td>16 msec increments</td>
<td>32 msec increments</td>
</tr>
</tbody>
</table>

Electrical Characteristics

Power Requirements— +5 VDC @ 0.81A

Environmental Characteristics

Temperature—0°C to 55°C (operating); -55°C to +85°C (non-operating).

Humidity—Up to 90% Relative Humidity without condensation (operating); all conditions without condensation or frost (non-operating).

Reference Manual

121583-001—iSBX 218 Flexible Disk Controller Hardware Reference Manual (NOT SUPPLIED).

Reference manuals may be ordered from any Intel sales representative, distributor office, or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBX 218</td>
<td>Flexible Disk Controller</td>
</tr>
</tbody>
</table>
iSBC™ 220
SMD DISK CONTROLLER

- Controls up to four SMD interface compatible disk drives
- 12 MB to 2.4 GB per controller
- Compatible with all iSBC™ 80, iSBC™ 88, and iSBC™ 86 Single Board Computers
- Intel® 8089 I/O Processor provides two high speed DMA channels as well as controller intelligence
- Software drivers available for iRMX™ 86 and iRMX™ 88 operating systems
- On-board diagnostic and ECC
- Full sector buffering on-board
- Capable of addressing 1 MB of system memory
- SMD interface available on 14” Winchester, CMD, SMD and large fixed-media drives

The iSBC 220 SMD Disk Controller brings very large mass storage capabilities to any iSBC 80, iSBC 88, or iSBC 86 MULTIBUS system. The controller will interface to any disk drive conforming to the industry standard SMD interface. Using simplified cable connections, up to four drives may be connected to the iSBC 220 Controller Board to give a total maximum capacity of 2.4 gigabytes. The Intel 8089 I/O Processor simplifies programming through the use of memory-based parameter blocks. A linked list technique allows the user to perform multiple disk operations.
FUNCTIONAL DESCRIPTION

Full On-Board Buffer
The iSBC 220 SMD Controller contains enough on-board RAM for one full sector buffering. The controller is designed to make use of this buffer in all transfers. The on-board sector buffer prevents data overrun errors and allows the iSBC 220 SMD Controller to occupy any priority slot on the MULTIBUS.

ECC
High data integrity is provided by on-board Error Checking Code (ECC) logic. When writing sector ID or data fields, a 32-bit Fire code, for burst error correction, is appended to the field by the controller. During a Read operation, the same logic regenerates the ECC polynomial and compares this second polynomial to the appended ECC. The ECC logic can detect an erroneous data burst up to 32 bits in length and using an 8089 algorithm can correct an erroneous burst up to 11 bits in length.

SMD Interface
High speed, reliable data transfers are a major benefit of using the SMD interface. A data transfer rate of 1.2 MB is accomplished by using separate (radial) differential data line cabling for each drive. Control signals are daisy-chained from drive to drive.

Defective Track Handling
When a track is deemed defective, the host processor reformats the track, giving it a defective track code and enters the address of the next available alternate track. When the controller accesses a track previously marked defective, the controller automatically seeks to the assigned alternate track. The alternate track seek is totally automatic and invisible to the user.

Figure 1. Simplified Block Diagram of iSBC 220™ SMD Disk Controller
SPECIFICATIONS

Compatibility
CPU — Any iSBC MULTIBUS computer or system mainframe
Disk Drive — Any SMD interface-compatible disk drive

Equipment Supplied
iSBC 220 SMD Disk Controller
Reference schematic
Controller-to-drive cabling and connectors are not supplied with the controller. Cables can be fabricated with flat cable and commercially-available connectors as described in the iSBC 220 SMD Disk Controller Hardware Reference Manual.

Physical Characteristics
Width — 6.75 in. (17.15 cm)
Height — 0.5 in. (1.27 cm)
Length — 12.0 in. (30.48 cm)
Shipping Weight — 19 oz (0.54 kg)
Mounting — Occupies one slot of iSBC system chassis or cardcage/backplane

Electrical Characteristics
Power Requirements
+ 5 VDC @ 3.25A max
− 5 VDC @ 0.75A max¹
Note 1: On-board voltage regulator allows optional − 12 VDC usage from MULTIBUS.

Data Organization and Capacity
Bytes per Sector² — 128 256 521 1024
Sectors per Track² — 108 64 35 18
Note 2: Software selectable.

Table 1. Drive Characteristics (Typical)

| Disk (spindle) Speed | 3600 rpm |
| Tracks per Surface | 823 |
| Head Positioning | Closed loop servo type, track following |
| Access Time | Track to Track 6 ms |
| | Average 30 ms |
| | Maximum 55 ms |
| Data Transfer Rate | 1.2 megabytes/second |
| Storage Capacity | 12 to 2.4 gigabytes |

Figure 2. Typical Multiple Drive System
Environmental Characteristics

Temperature — 0°C to 55°C (operating); −55°C to +85°C (non-operating)

Humidity — Up to 90% relative humidity without condensation (operating); all conditions without condensation or frost (non-operating)

Reference Manual

121597-001 — iSBC 220 SMD Disk Controller Hardware Reference Manual (NOT SUPPLIED)

Reference manuals may be ordered from any Intel sales representative, distributor office, or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051.

ORDERING INFORMATION

Part Number Description
SBC 220 SMD Disk Controller
iSBX™ 270
VIDEO DISPLAY CONTROLLER

- Complete video display controller on a double-wide iSBX™ MULTIMODULE™ board
- Interfaces to either black and white or color display monitors
- Displays 7 x 9, 5 x 7 or 6 x 8 character fonts
- High level software interface via a pre-programmed 8041A UPI
- Interchangeable character fonts available in EPROM
- Keyboard and light pen interface provided on-board
- 50 Hz or 60 Hz frame rate operation
- Provides cursor control, reverse video, blinking, underline, highlight and page or scroll mode
- Compatible with all 8/16 bit iSBC™ boards which support the Intel iSBX™ bus
- Graphics capability via pre-defined graphic character fonts

The iSBX 270 Video Display Controller (VDC) is a complete video controller on a standard double wide Intel iSBX MULTIMODULE board. Providing either black and white (B&W) or eight-color displays, the iSBX 270 VDC brings alphanumeric video control to the iSBX bus. Any computer board or system supporting the Intel iSBX MULTIMODULE bus is compatible with the iSBX 270 VDC, including most board and system products from Intel. Additionally, the iSBX 270 VDC supports keyboard and light pen I/O on-board; this simplifies the design of intelligent terminals.

The iSBX 270 module allows the user to add high level video display capability to his/her computer system with a minimal cost and effort. Typical applications for the iSBX 270 VDC include video displays for industrial operator stations, word processing systems, data base management products and many other uses.
FUNCTIONAL DESCRIPTION

iSBX™ Interface

The iSBX 270 VDC interfaces to the Intel iSBX bus via the 8041A Universal Peripheral Interface (UPI) Microcomputer. The 8041A, under firmware control, provides communication between the base board and the iSBX 270 controller circuitry via the iSBX data and control lines. Data may be displayed immediately following power up, using default initialization provided by the 8041A UPI. In addition, eight high-level commands are provided by the iSBX 270 firmware; these eight commands are used to alter the default initialization of the controller and determine status. Following initialization, characters are displayed on the CRT by simply writing to the proper I/O port.

CRT Interface

The iSBX 270 VDC will interface to many B&W and RGB color display monitors. For B&W monitors, the iSBX 270 board provides TTL level signals for video, vertical sync and horizontal sync. Additionally, in B&W, two levels of intensity (normal and highlight) are supported under program control.

When operating in the color mode, the iSBX 270 module provides TTL level 75 ohm line drivers for Red, Green, and Blue Video and sync allowing 8 different colors to be displayed.

Composite video is not provided on the iSBX 270 MULTIMODULE board; however, with minimal external circuitry, composite video can be added (circuit design available; contact the local Intel Sales Office for details).

Table 1 lists several CRT vendors compatible with the iSBX 270 VDC.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>VENDOR</th>
<th>MODEL #</th>
</tr>
</thead>
<tbody>
<tr>
<td>B&amp;W</td>
<td>Ball Brothers</td>
<td>TTL 120, TV 120, TV 50</td>
</tr>
<tr>
<td></td>
<td>Motorola</td>
<td>M3570</td>
</tr>
<tr>
<td></td>
<td>TSD</td>
<td>MDC-15</td>
</tr>
<tr>
<td></td>
<td>ELSTON</td>
<td>DM30-12B0-51-A04</td>
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<tr>
<td>Color</td>
<td>Ball Brothers</td>
<td>7-015-0131</td>
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<tr>
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<td>IDT</td>
<td>19AC</td>
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<td>CONRAC</td>
<td>5711C13</td>
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<td></td>
<td>NEC</td>
<td>1202DH</td>
</tr>
<tr>
<td></td>
<td>MITSUBISHI</td>
<td>C-3419</td>
</tr>
</tbody>
</table>

'NOTE: This in no way constitutes an endorsement by Intel Corporation of these companies’ products. The companies listed are known to provide products compatible with the iSBX 270 board.'
Figure 2. The iSBX™ 270 VDC Interfaces to a User-Supplied Video CRT, Keyboard and Light Pen

CRT Controller
The CRT Controller performs all timing and data buffering functions for the CRT. The iSBX 270 VDC uses the Intel 8275 CRT Controller (for additional details refer to the 8275 data sheet available from Intel).

Screen Refresh
The iSBX 270 VDC contains 4K bytes of high speed static RAM, as well as a high speed DMA controller (8237A). The 8237A, under the control of the 8041A UPI, takes care of both writing data to the screen and refreshing the screen.

Character Generation
The character fonts (128 characters, including alphabetic, numeric, and special characters) that are displayed on the CRT are stored in EPROM. The need may arise to display different character fonts, i.e., those used in international systems or custom symbols which are application specific. With the iSBX 270 VDC the user may modify any or all of the character fonts by simply reprogramming the EPROM. In addition, the user may utilize a larger EPROM to obtain up to 256 characters.

Keyboard Interface
The iSBX 270 VDC also interfaces to a keyboard I/O device via the J1 edge connector. The keyboard interface of the iSBX 270 VDC accepts up to eight TTL parallel data lines and one TTL strobe, either positive or negative. Keyboard input is indicated by a status bit in the 8041A and/or an interrupt. In addition, control lines are provided for visual and/or audible indicators.

Table 2 lists several keyboards that interface to the iSBX 270 VDC.

<table>
<thead>
<tr>
<th>VENDOR</th>
<th>MODEL #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Input Devices</td>
<td>SK-067</td>
</tr>
<tr>
<td>Cherry</td>
<td>B70-05AB</td>
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<tr>
<td>Cherry</td>
<td>CB80-07AA</td>
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<tr>
<td>Chomerics</td>
<td>AN26109/AE26203</td>
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<tr>
<td>Cortron</td>
<td>35-500014</td>
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<td>Keytronic</td>
<td>L1648</td>
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<td>Keytronic</td>
<td>L1752</td>
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<td>Microswitch</td>
<td>66SD6-7</td>
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<td>Microswitch</td>
<td>87SD30-8</td>
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</tbody>
</table>

'NOTE: This in no way constitutes an endorsement by Intel Corporation of these companies' products. The companies listed are known to provide products compatible with the iSBX 270 board.

Light Pen Interface
Light pen I/O devices may be directly interfaced to the iSBX 270 VDC. A light pen hit is triggered on the rising edge of the light pen signal and is indicated by a status bit in the UPI 8041A and/or an interrupt.

Table 3 lists a light pen vendor whose product interfaces to the iSBX 270 VDC.

<table>
<thead>
<tr>
<th>VENDOR</th>
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</tr>
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<tr>
<td>Information Control Co.</td>
<td>LP-700</td>
</tr>
</tbody>
</table>

'NOTE: This in no way constitutes an endorsement by Intel Corporation of this company's products. The company listed is known to provide products compatible with the iSBX 270 board.
SPECIFICATIONS

Controller Characteristics

DISPLAY
Programmable to a maximum of 35 rows x 80 columns of characters.

CRT OUTPUTS
B&W — TTL level HSYNC, VSYNC, Video.
Color — TTL level, 75 ohm line drivers for RGB and combined sync provide 8 different display colors.

FRAME RATE
50 Hz or 60 Hz via jumper settings (non-interlaced).

CHARACTER FONTS
5 x 7, 7 x 9 or 6 x 8 jumperable with appropriate crystal. Character generator uses 2716 EPROM. Also compatible with 2732A EPROM’s. For generation of special fonts, please refer to ISBX 270 VDC Hardware Reference Manual.

VIDEO CONTROL
Reverse video, blinking, underline, highlight, cursor control and page or scroll mode.

TV MONITOR
Most video display monitors with a 10 MHz bandwidth or better.

LIGHT PEN INPUT
TTL level pulse, maximum 50 ns rise time, minimum 100 ns hold time.

Compatibility

CPU
Any ISBC single board computer or I/O board compatible with the MULTIBUS system bus and implementing the ISBX bus and connector.

Physical Characteristics

Width — 3.08 inches (7.82 cm)
Height — 0.8 inches (2.05 cm)
Length — 7.5 inches (19.05 cm)
Shipping Weight — 0.5 pounds (0.175 Kg)
Mounting — Occupies one double-wide ISBX MULTIMODULE position on boards; increases board height (host plus ISBX board) to 1.14 inches (2.90 cm).

Electrical Characteristics

Power Requirements + 5 Vdc @ 1.3A.

Environmental Characteristics

Temperature — 0°C to 55°C (operating); — 55°C to + 85°C (non-operating).
Humidity — Up to 90% relative humidity without condensation (operating); all conditions without condensation or frost (non-operating).

Equipment Supplied

ISBX 270 VDC Controller
Reference Schematic
Cabling and connectors from the VDC controller to the CRT, keyboard and light pen are not supplied with the controller. Cables can be fabricated with commercially available cable and connectors as described in the ISBX 270 Hardware Reference Manual.

Reference Manual

143444-001 — ISBX 270 Video Display Controller Hardware Reference Manual (NOT SUPPLIED).
Reference manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051.

ORDERING INFORMATION

Part Number Description
SBX 270 Video Display Controller
MULTIMODULE Board
Memory Expansion Boards
The iSBC012B RAM memory board is a member of Intel's complete line of iSBC memory and I/O expansion boards. The board interfaces directly to any iSBC 86, iSBC 88 or iSBC 80 Single Board Computer via the MULTIBUS interface to expand system RAM capacity. The iSBC 012B board contains 512K bytes of read/write memory implemented using dynamic RAM components. An on-board dynamic RAM controller refreshes a portion of these components every 16 microseconds. Each refresh cycle utilizes memory for 550 nanoseconds (maximum).

The iSBC012B board generates byte oriented parity during all write operations and performs parity checking during all read operations. When a parity error is detected, the board can generate an interrupt on the MULTIBUS interface. In addition, the row and bank of the RAM array containing the error are stored in a Parity Flag Register. This register is accessible as a MULTIbus I/O port. An on-board LED also provides a visual indication that a parity error has occurred.
SPECIFICATIONS

Word Size
8 bits and 16 bits

Memory Size
524,288 bytes (iSBC 012B)

Access Time
330 nsec (worst case)
300 nsec (typical)

Cycle Times (Worst Case)
Read — 500 ns max.
Write — 500 ns max.
Refresh — 550 ns max.

Interface
All address, data and command signals are TTL compatible.

Address Selection
Memory — Base address is jumper selectable on any 16K byte boundary in a 16 megabyte address space. On-board RAM cannot cross a 4 megabyte address boundary.
Parity Flag Register — The I/O address of the Parity Flag Register is jumper selectable to be between 00H to 0FH or 40H to 4FH.

Connector
Edge connector — 86 pin double-sided PC edge connector with 0.156 in. contact centers.
Mating connector — Viking 3KH43/9AMK12 or equivalent.

Auxiliary Power
An auxiliary power bus is provided to allow separate power to RAM array for systems requiring battery backup of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

Memory Protect
An active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM on the board. This input is provided for the protection of RAM contents during system power-down sequences.

Physical Characteristics
Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 14 oz. (397 gm)

Electrical Characteristics
D.C. POWER REQUIREMENTS
All configurations require only +5 volts ± 5%.
Normal System Operation (max.)
4.8A (worst case)
3.46A (typical)
Auxiliary Power No RAM Access (max.)
1.35A (worst case)
0.88A (typical)

Environmental Characteristics
Operating Temperature — 0°C to +55°C
Relative Humidity — to 90% (without condensation)

Reference Manual
143865-001 — iSBC 056B/012B Hardware Reference Manual (not supplied)
Manuals may be ordered from any Intel sales representative, distributor office, or from Intel Literature Dept., 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

Part Number Description
SBC 012B  512K-Byte RAM Board with Parity
iSBC™ 016A/032A/064A/028A/056A
RAM MEMORY BOARDS

- iSBC 86, iSBC 88 and iSBC 80 board RAM expansion through direct MULTIBUS® interface
- 16K, 32K, 64K, 128K or 256K bytes of read/write memory
- On-board parity generator/checker and error status register
- Requires a single +5 volt power supply
- Assignable anywhere within a 16 megabyte address space
- Jumper selectable base address on any 4K byte boundary
- Auxiliary power bus and memory protect control logic for battery backup RAM requirements

The iSBC 016A, iSBC 032A, iSBC 064A, iSBC 028A and iSBC 056A RAM memory boards are members of Intel's complete line of iSBC memory and I/O expansion boards. Each board interfaces directly to any iSBC 80, iSBC 88 or iSBC 86 Single Board Computer via the MULTIBUS interface to expand system RAM capacity. The iSBC 016A, iSBC 032A, iSBC 064A, iSBC 028A and iSBC 056A boards contain 16K, 32K, 64K, 128K or 256K bytes of read/write memory implemented using dynamic RAM components. An on-board LSI dynamic RAM controller refreshes a portion of these components every 14 microseconds. Each refresh cycle utilizes memory for 480 nanoseconds (maximum).

The iSBC 032A, iSBC 064A, iSBC 028A and iSBC 056A boards generate byte oriented parity during all write operations and perform parity checking during all read operations. When a parity error is detected, these boards can generate an interrupt on the MULTIBUS interface. In addition, the row and bank of the RAM array containing the error are stored in a Parity Flag Register (see Figure 1). This register is accessible as a MULTIBUS I/O port. An on-board LED also provides a visual indication that a parity error has occurred. To facilitate testing of these boards, parity generation and checking can be changed from even to odd under software control.
**SPECIFICATIONS**

**Word Size**
8 bits and 16 bits

**Memory Size**
- 16,384 bytes (iSBC 016A);
- 32,768 bytes (iSBC 032A);
- 65,536 bytes (iSBC 064A);
- 131,072 bytes (iSBC 028A);
- 262,144 bytes (iSBC 056A)

**Access Time**
- **iSBC 016A/032A/064A**
  - 400 ns max. (worst case)
  - 360 ns max. (typical)
- **iSBC 028A**
  - 500 ns max. (worst case)
  - 460 ns max. (typical)
- **iSBC 056A**
  - 570 ns max. (worst case)
  - 530 ns max. (typical)

**Cycle Times (Worst Case)**

**Read**
- **iSBC 016A/032A/064A/028A** — 600 ns max.
- **iSBC 056A** — 650 ns max.

**Write**
- **iSBC 016A/032A/064A/028A** — 600 ns max.
- **iSBC 056A** — 650 ns max.

**Refresh**
- **iSBC 016A/032A/064A/028A** — 480 ns max.
- **iSBC 056A** — 600 ns max.

**Interface**
All address, data and command signals are TTL compatible.

**Address Selection**

**Memory** — Base address is jumper selectable on any 4K byte boundary in a 16 megabyte address space. On-board RAM cannot cross a megabyte address boundary.

**Parity Flag Register** — The I/O address of the Parity Flag Register is jumper selectable to be between 00H to 0FH or 40H to 4FH.

**Connector**

**Edge connector** — 86 pin double-sided PC edge connector with 0.156 in. contact centers.

**Mating connector** — Viking 3KH43/9AMK12 or equivalent.

**Auxiliary Power**
An auxiliary power bus is provided to allow separate power to RAM array for systems requiring battery backup of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

**Memory Protect**
An active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM on the board. This input is provided for the protection of RAM contents during system power-down sequences.
Physical Characteristics
Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 14 oz. (397 gm)

Electrical Characteristics
D.C. POWER REQUIREMENTS
All configurations require only +5 volts ± 5%.
Normal System Operation (max.)
iSBC 016A — 3.3A (worst case)
2.65A (typical)
iSBC 032A/064A — 4.0A (worst case)
3.20A (typical)
iSBC 028A/056A — 4.57A (worst case)
3.66A (typical)
Auxiliary Power No RAM Access (max.)
iSBC 016A — 0.37A (worst case)
0.30A (typical)

iSBC 032A/064A — 0.41A (worst case)
0.33A (typical)
iSBC 028A/056A — 0.55A (worst case)
0.45A (typical)

Environmental Characteristics
Operating Temperature — 0°C to +55°C
Relative Humidity — to 90% (without condensation)

Reference Manual
143572-001 — iSBC 016A/032A/064A/028A/056A
Hardware Reference Manual (not supplied)

Manuals may be ordered from any Intel sales representative, distributor office, or from Intel Literature Dept., 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION
Part Number Description
SBC 016A 16K-Byte RAM Board
SBC 032A 32K-Byte RAM Board with Parity
SBC 064A 64K-Byte RAM Board with Parity
SBC 028A 128K-Byte RAM Board with Parity
SBC 056A 256K-Byte RAM Board with Parity
iSBC™ 064
RAM MEMORY BOARDS

- iSBC™ 80, iSBC™ 86 and iSBC™ 88 RAM memory expansion through direct MULTIBUS® interface
- 64K bytes of read/write memory
- On-board hardware for refresh of all dynamic memory elements
- Read/write data buffers
- Auxiliary power bus and memory protect control logic provided for battery backup RAM requirements
- Jumper selectable starting address on any 64K boundary in a megabyte address space
- TTL compatible data, address, and command signal interface

The iSBC 064 RAM Memory Board is a member of Intel’s complete line of iSBC memory and I/O expansion boards. Each board interfaces directly to any Intel iSBC 80, iSBC 86 or iSBC 88 single board computer via the MULTIBUS interface to expand RAM memory capacity. The iSBC 064 contains 64K bytes of read/write memory implemented using dynamic RAM memory components. On-board refresh hardware refreshes a portion of RAM memory every 14 microseconds. Each refresh cycle utilizes memory for 585 nanoseconds. If a read or write cycle is in progress when a refresh cycle is scheduled to begin, the refresh cycle is postponed until the end of the cycle. Read/write buffers reside on each board to buffer all data written into or read from the memory array. All data, address, and command signals on the bus interface are TTL compatible.
Figure 1. RAM Memory Expansion Boards Block Diagram

**SPECIFICATIONS**

**Word Size**
8 bits and 16 bits

**Memory Size**
65,536 bytes

**Access Time**
450 ns max

**Cycle Times**
Read Cycle — 700 ns max  
Write Cycle — 600/1240 ns max  
Refresh Cycle — 700 ns max

**Interface**
All address, data, and command signals TTL compatible.

**Address Selection**
Jumper selection of a 64K byte page in a megabyte address space.

**Connectors**
Edge Connectors — 86-pin double-sided PC edge connector with 0.156-in. contact centers.

Mating Connector — Viking 3KH43/9AMK12

**Auxiliary Power**
An auxiliary power bus is provided to allow separate power to RAM for systems requiring battery back up of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

**Memory Protect**
An active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during system power-down sequences.

**Physical Characteristics**
Width — 12.00 in. (30.48 cm)  
Height — 6.76 in. (17.15 cm)  
Depth — 0.50 in. (1.27 cm)  
Weight — 14 oz (415.2 gm)

**Electrical Characteristics**

**DC Power Requirements**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Normal System Operation (max)</th>
<th>AUX Power RAM Access (max)</th>
<th>AUX Power No RAM Access (max)</th>
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<tbody>
<tr>
<td>$V_{CC}$</td>
<td>$+5V \pm 5%$</td>
<td>$I_{CC} = 3.2A$</td>
<td>$1.7A$</td>
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<tr>
<td>$V_{DD}$</td>
<td>$+12V \pm 5%$</td>
<td>$I_{DD} = 600 mA$</td>
<td>$600 mA$</td>
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<tr>
<td>$V_{BB}$</td>
<td>$-5V \pm 5%$</td>
<td>$I_{BB} = 10 mA$</td>
<td>$10 mA$</td>
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</table>

**Notes**
1. All current values include AUX power.
2. RAM chips and RAM control logic powered via auxiliary power bus.
3. Power necessary to refresh RAMs and maintain data, as after system power failure.

**Environmental Characteristics**
Operating Temperature — 0°C to +55°C

**Reference Manual**
9800488B — iSBC 032/048/064 Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>SBC 064</td>
<td>64K-Byte RAM Board</td>
</tr>
</tbody>
</table>
iSBC 090™ MEMORY SYSTEM

- 512K, 768K or 1024 K-byte capacities
- 8-bit or 16-bit word transfer
- Compatible with Intellec Model 286 Series III development system
- Error logger and display isolates single bit errors to the memory device level
- Error check and correcting (ECC) circuitry provides single-bit correction and double-bit detection
- Switch-selectable starting address on any 4K byte boundary
- Field expandability

The Intel® iSBC 090 Memory System is a random-access dynamic memory system to be used with Intel’s MULTIBUS™ System and iSBC 80/86™ product line. The iSBC 090 Memory System can provide up to 1 Megabyte of memory in 256K-byte increments or up to 512K-bytes in 128K-byte increments. It consists of a MULTIBUS Interface Board and a Series 90 Random Access Dynamic Memory. The Interface Board plugs directly into the MULTIBUS backplane, and through four ten-foot cables interfaces the MULTIBUS system and the memory.

The Interface Board is a 12.0 inch by 6.75 inch printed circuit board that occupies any one slot in the MULTIBUS backplane. It allows the user to select the beginning and ending addresses to which the iSBC 090 Memory System will respond; it permits either 8-bit or 16-bit bus masters, or mixes of both, as well as supporting the normal read, write, refresh, and inhibit RAM cycles of the MULTIBUS system. Operating power for the interface is supplied by the MULTIBUS chassis and is not affected by increases in memory capacity.

The memory is a self-contained unit measuring 5.21 inches high by 19.00 inches wide and by 19.5 inches deep. It includes a memory storage area, which provides up to 1 Megabyte of memory. In addition, its control interface provides single-bit error detection and correction, double-bit error detection, and refresh arbitration. The memory also includes an error logger and error display, as well as its own power supplies and blower assembly. It is available as a table-top system with either 115 or 220 VAC input power.

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AUGUST 1981
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FUNCTIONAL DESCRIPTION

The memory portion of the iSBC 090 Memory System (Figure 1) provides the memory storage area and the error detection and correction functions for the system.

The MULTIBUS Interface Board provides address compatibility between the MULTIBUS system and the memory; supports the four types of data transfer across the MULTIBUS interface; and generates the required control and status signals. Interface Board address circuits permit the iSBC 090 System to fit any address space from 4K-bytes to one megabyte, starting at any 4K boundary.

The Error Logger and Display records error, syndrome, and status signals, then on request displays them for quick location of memory errors.

Capacity

The iSBC 090 Memory System provides up to one megabyte of memory in 256K increments. Each 256K-byte increment is provided by adding one memory module in the memory. Three standard system capacities are offered: 512K, 768K and 1024K-bytes. The 768K-byte and 512K systems can be expanded to 1024K-bytes by the addition of one or two memory modules respectively.

Addressability

The address space which the iSBC 090 Memory System will occupy in the MULTIBUS addressing scheme is determined by two eight-position DIP switches on the Interface Board. The switches allow the memory to be any size, ranging from 4K-bytes to one megabyte, starting and ending on any 4K boundary.

Error Logger and Display

The Error Logger is a random-access memory which stores (logs) ECC syndrome bits that identify the failing bit and its location. The logger memory can store a maximum of 4096 single and double-bit errors. A display panel shows error information for user reference.

The error logger operates in three modes: log (write), scan (read), and clear. In normal system operation, the logger is operated in log mode and accessed only when one or more of the syndrome bits go active, indicating an error condition. The syndrome pattern identifying the error and the address of the error location are stored in the logger memory.

To look at the stored error information, the logger is placed in scan mode, taking it off-line. The logger memory is sequentially scanned until error information is reached. Scanning stops and the memory card identification, the card row, the data byte and the data bit are displayed on the logger display panel. The scan can be resumed using a scan control button.

INSTALLATION

The MULTIBUS Interface Board plugs directly into the MULTIBUS backplane. All operating power is furnished through the MULTIBUS connectors. Interface to the memory portion of the iSBC 090 Memory System is made using four 50-pin flat-ribbon cables, supplied with the System.

Figure 1. iSBC 090™ Memory System, Block Diagram
The iSBC 090 is available as a 19-inch rack-mounted unit with slide attachments or as a table top configuration with side covers instead of slides.

Depending on the configuration selected, the memory is connected to either 115 VAC, 50/60 Hz, single-phase, or 220 VAC, 50/60 Hz, single-phase power.

**SPECIFICATIONS**

**Storage Capacity**
512K, 768K, 1024K bytes

**Word Length**
8/16 bits plus 6 bits for ECC

**Operating Cycles**
Read Cycle
Write Cycle
Inhibit RAM Cycle
Refresh Cycle

**Read Access Time (8- or 16-Bit Transfer)**
450 nsec max (MRDC* to XACK*)

**Write Access Time**
8-Bit Transfer — 485 nsec max (MWTC* to XACK*)
16-Bit Transfer — 150 nsec max (MWTC* to XACK*)

*MWTC = Memory Write Command
XACK = Transfer Acknowledge
MRDC = Memory Read Command
(Reference MULTIBUS Manual 9800683)

**Read Cycle Time (8- or 16-Bit Transfer)**
485 nsec max

**Write Cycle Time**
8-Bit Transfer — 700 nsec max
16-Bit Transfer — 400 nsec max

**Refresh Cycle Time (8- or 16-Bit Transfer)**
450 nsec max

**Logic Levels Input**
Logic High — +2.0V to 5.25V
Logic Low — -0.5V to ±0.80V

**Logic Levels Output**
Logic High — +2.5V to +5.25V at 0.1 mA
Logic Low — 0.0V to +0.5V at 16.0 mA

**Physical Characteristics**
iSBC Interface Board
Height — 6.75 in. (17.15 cm)
Width — 12.0 in. (30.48 cm)
Thickness — 0.5 in. (1.27 cm)
Weight — 3 lbs. (1.4 Kg) (with interface cables)

Series 90 Memory System
Height — 5.21 in. (13.2 cm)
Width — 19.0 in. (48.25 cm)
Depth — 19.5 in. (49.53 cm)
Weight — 30 lbs. (13.5 Kg) max.
Mounting — table top

**Electrical Characteristics**
MULTIBUS Interface Board
+5V ± 6.0%
2 Amps typical
3 Amps worst case

Series 90 Memory System
115 VAC, 50/60 Hz, 2.8A
220 VAC, 50/60 Hz, 1.6A

**Environmental Requirements**
Ambient Operating Temperature — 0°C to 50°C
Relative Humidity — 10 to 90% without condensation

**REFERENCE MANUAL**
The iSBC 090 Memory System is supported by a full line of documentation, as listed below:
111710, Technical Manual for iSBC 090™ Memory System
111784, Technical Manual for Series 90 Random Access Memory Systems with CI-9000 Control Interface
111784, Technical Manual for Series 90, CM-90 Dynamic Memory Module
ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC-090-x1K</td>
<td>512K Byte Multibus-compatible dynamic RAM memory system with ECC. Expandable to 1024K Bytes using CM-90100-H22 memory module (below). &quot;x&quot; in model number must be specified per NOTE below to define input voltage and chassis configurations.</td>
</tr>
<tr>
<td>SBC-090-x1L</td>
<td>768K Byte memory system. Otherwise identical to SBC-090-x1K.</td>
</tr>
<tr>
<td>SBC-090-x1M</td>
<td>1024K Byte memory system. Not expandable. Otherwise identical to above SBC-090-x1K.</td>
</tr>
<tr>
<td>CM-90100-H22</td>
<td>256K Byte memory module for expansion of SBC-090-x1K or L.</td>
</tr>
<tr>
<td>SBC-090/556 Kit</td>
<td>768K Byte memory system—provides an enhanced compile environment when used with the Model 556 Functional Series III Upgrade Package for Intellec Series II/80, Series II/85 Microcomputer Development System (110V/60Hz or 220V/60Hz).</td>
</tr>
<tr>
<td>SBC-090/556i Kit</td>
<td>768K Byte memory system—provides an enhanced compile environment when used with the Model 556 Functional Series III Upgrade Package which consists of the Model 556 software and hardware performance package and the integrated 8085 processor board (IPC-85). This upgrade package is for Intellec Series II/80 Development System (110V/60Hz or 220V/50Hz).</td>
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**NOTE**

To order SBC 090, the "x" in model no. must be specified as shown below to define input voltage and chassis configuration.

- $x = 2$ for table-top unit, 110 VAC
- $x = 3$ for table-top unit, 220 VAC
iSBC 094
4K-BYTE CMOS RAM MEMORY
BATTERY BACKUP BOARD

- iSBC 80, iSBC 86 and iSBC 88 non-volatile RAM memory expansion through the MULTIBUS
- 4K bytes of low power static CMOS RAM memory
- On-board power-fail interface logic
- Base address selectable to start on any 4K memory address boundary
- On-board rechargeable batteries and charging circuitry for 96-hour data retention
- Single +5V power requirement

The iSBC 094 4K-Byte CMOS RAM Memory/Battery Backup Board is a member of Intel's complete line of iSBC memory and I/O expansion boards. The iSBC 094 interfaces directly to iSBC single board computer via the system bus to expand RAM memory capacity. The board contains 4K bytes of read/write memory, implemented using 32 Intel 5101 CMOS RAM memory components. On-board rechargeable batteries and charging circuitry insure that data contained in RAM will be retained for at least 96 hours after system bus power (+5V) is removed. Critical system parameters stored in the iSBC 094 RAM will thus be saved during temporary system power failures. Full power-fail interface logic is provided on the board to generate a CPU interrupt when system power fails. Orderly system shutdown procedures may then be executed and critical system parameters may be retrieved and stored. The use of CMOS RAM on the iSBC 094 also reduces power dissipation during normal system operation. The iSBC 094 contains jumpers for use in selecting a contiguous 4K-byte address segment beginning on any 4K memory address boundary (0000H, 1000H, 2000H, etc.). Read/write buffers reside on the board to buffer all data written into or read from the memory array. All address, data, and command signals on the bus interface are TTL compatible.
Figure 1. ISBC 094 Memory Backup Board Block Diagram

SPECIFICATIONS

Word Size
8 bits and 16 bits

Memory Size
4096 bytes

Memory Response Time

<table>
<thead>
<tr>
<th>Operation</th>
<th>Access (ns, max)</th>
<th>Cycle (ns, max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td>750</td>
<td>900</td>
</tr>
<tr>
<td>Write</td>
<td>—</td>
<td>900</td>
</tr>
</tbody>
</table>

Interface
All address, data, and command signals are TTL compatible.

Power Fail Interrupt
Control logic is also included for generation of a power-fail interrupt to the MULTIBUS interface, which works in conjunction with the AC low signal from the Intel iSBC 635 Power Supply or equivalent.

Address Selection
4K segments starting at any jumper selectable base address on a 4K-byte boundary (e.g., 0000H, 1000H, ... F000H). The memory will appear in every 64K-byte memory page.

Mating Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (qty)</th>
<th>Centers (in.)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>86</td>
<td>0.156</td>
<td>Viking 3KH43/9AMK12</td>
</tr>
<tr>
<td>Auxiliary</td>
<td>60</td>
<td>0.1</td>
<td>AMP PE5-14559 or TI H311130</td>
</tr>
</tbody>
</table>

Note
1. Connector Dimensions vary from vendor to vendor. Review vendor specifications to ensure that connector heights and wire-wrap pin lengths conform to your system packaging requirements.

Data Retention
96 hours minimum after +5V bus power is removed.

Battery Characteristics
Type — Nickel-Cadmium, rechargeable
Capacity — 150 mA hr
Voltage — 3.6V nominal
Battery Charger Characteristics
Charge Time
14 hours for full charge (150 mA hr)
Full overcharge protection
Full short-circuit protection

Environmental Characteristics
Operating Temperature — 0°C to 55°C

Physical Characteristics
Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.60 in. (1.27 cm)
Weight — 12 oz (340.5 gm)

Electrical Characteristics
Average DC Current
$V_{CC} = +5$V DC ±5%
$I_{CC} = 0.8$A typ, 1.7$A$ max

ORDERING INFORMATION
Part Number Description
SBC 094 4K-Byte CMOS RAM Memory
Battery Backup Board

Reference Manual
9800449B — ISBC 094 Hardware Reference Manual
(NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.
iSBC 108A/116A™
COMBINATION MEMORY AND
I/O EXPANSION BOARDS

8K or 16K bytes of read/write memory (iSBC 108A™, iSBC 116A™ boards respectively).

Sockets for up to 32K bytes of EPROM.

Auxiliary power bus and memory protect control logic provided for battery backup RAM requirements.

RAM and EPROM assignable anywhere within a one megabyte address space.

48 programmable I/O lines with sockets for interchangeable line drivers and terminators.

Synchronous/asynchronous communications interface with RS232C drivers and receivers.

Eight maskable interrupt request lines with a pending interrupt register.

1 msec interval timer.

The iSBC 108A and iSBC 116A Combination Memory and I/O Boards are members of Intel's complete line of iSBC memory and I/O expansion boards. Both boards interface directly with any iSBC 80, iSBC 86 or iSBC 88 single board computer via the MULTIBUS interface to expand RAM, EPROM, serial I/O and parallel I/O capacity. This mixture makes the iSBC 108A and 116A combination boards ideal for small microcomputer systems where the on-board resources of a single board computer are insufficient for incrementing the memory and I/O capacities of larger multiple board systems.
FUNCTIONAL DESCRIPTION

Memory Capabilities

The iSBC 108A board contains 8K bytes and the iSBC 116A board contains 16K bytes of RAM implemented with eight dynamic RAM components. An Intel 8202A dynamic RAM controller is used to provide all timing, control and refresh signals. Starting on a 4K byte boundary, RAM may be located anywhere in the MULTIBUS one megabyte memory address space.

Both combination boards contain four 28-pin sockets for adding up to 4K bytes (using Intel 2708 or 2758 EPROMs), 8K bytes (using Intel 2716 EPROMs), 16K bytes (using Intel 2732 or 2732A EPROMs), or 32K bytes (using Intel 2764 EPROMs) of non-volatile read-only-memory.

Parallel I/O Interface

Each combination board contains 48 programmable I/O lines implemented using two Intel 8255A programmable peripheral interfaces. The system software is used to configure the I/O lines in any combination of unidirectional input/output, and bidirectional ports indicated in Table 1. Therefore, the I/O interface may be customized to meet specified peripheral requirements. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators. Hence, the flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. The 48 programmable I/O lines and signal ground lines are brought out to two 50-pin edge connectors that mate with flat, round, or woven cable.

Communications Interface

A programmable communications interface using Intel's 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) is contained on each board. A jumper selectable baud rate generator provides the USART with all common communications frequencies between 75 Hz and 38.4 kHz. The USART can be programmed by the system software to select the desired asynchronous or synchronous serial data transmission technique (including IBM Bi-Sync). The mode of operation (i.e., synchronous or asynchronous), data format, control character format, parity, and asynchronous serial transmission rate are all under program con-

Figure 1. iSBC 108A/116A™ Combination Memory and I/O Expansion Board Block Diagram
The 8251A provides full duplex, double buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in the USART. The inclusion of a comprehensive RS232C interface on the boards in conjunction with the USART provides a direct interface to CRTs, RS232C compatible cassettes, and asynchronous and synchronous modems. The RS232C, serial data lines, and signal ground lines are brought out to a 26-pin edge connector which mates with RS232C compatible flat or round cables.

**Interrupt Request Lines**

Interrupt requests may originate from eight sources. Four jumper selectable interrupt requests can be automatically generated by the programmable peripheral interfaces when a byte of information is ready to be transferred to the CPU (i.e., input buffer is full) or a character has been transmitted (i.e., output data buffer is empty). Two interrupt request lines may be interfaced directly from user designated peripheral devices via the I/O edge connector. An on-board register contains the status of all eight interrupt request lines, and may be interrogated by the CPU. Each interrupt request line is maskable under program control. Routing for the eight interrupt request lines is jumper selectable. They may be ORed to provide a single interrupt request line for the iSBC 80/10A, or they may be individually provided to the MULTIBUS interface for use by the other iSBC single board computers.

**Interval Timer**

Each board contains a jumper selectable 1 ms interval timer. The timer is enabled by jumpering one of the interrupt request lines from the I/O edge connector to a 1 ms interval interrupt request signal originating from the baud rate generator.

---

### Table 1. Input/Output Port Modes of Operation

<table>
<thead>
<tr>
<th>Port</th>
<th>Lines (qty)</th>
<th>Unidirectional Input</th>
<th>Unlatched</th>
<th>Latched &amp; Strobed</th>
<th>Output</th>
<th>Latched</th>
<th>Latched &amp; Strobed</th>
<th>Bidirectional</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X1</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X1</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X2</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X2</td>
</tr>
</tbody>
</table>

**Notes**

1. Part of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output or port 1 is used as a bidirectional port.

2. Part of port 6 must be used as a control port when either port 4 or port 5 are used as a latched and strobed input or a latched and strobed output or port 4 is used as a bidirectional port.
SPECIFICATIONS

Memory Word Size
8 bits only. 16-bit single board computers may use this memory only for the storage of 8-bit data.

Memory Addressing
EPROM — Up to 4K, 8K, 16K or 32K bytes of read-only-memory may be located anywhere within a one megabyte address range. The base address must be located on a 4K byte boundary. EPROM addresses may not cross 32K byte boundaries.

RAM — 8K (iSBC 108A) or 16K (iSBC 116A) bytes of RAM may be located anywhere in a one megabyte address range. The base address must be located on a 4K byte boundary. RAM addresses may not cross 32K byte boundaries.

Memory Response Time

<table>
<thead>
<tr>
<th>Memory</th>
<th>Access (ns)</th>
<th>Cycle (ns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM</td>
<td>450 max*</td>
<td>580 max*</td>
</tr>
<tr>
<td>EPROM/ROM</td>
<td>450 max</td>
<td>635 max</td>
</tr>
</tbody>
</table>

* Without refresh contention.

I/O Transfer Rate
Parallel — Read or write acknowledge time 575 ns max.
Serial — (USART)

Serial Communications Characteristics
Synchronous — 5 — 8 bit characters; internal or external character synchronization; automatic sync insertion.
Asynchronous — 5 — 8 bit characters; break characters generation; 1, 1½, or 2 stop bits; false start bit detectors.

Interrupts
Eight interrupt request lines may originate from the programmable peripheral interface (4 lines), the USART (2 lines) or user specified devices via the I/O edge connector (2 lines), or interval timer.

Interrupt Register Addresses
XX1 Interrupt mask register
XX0 Interrupt status register

Note
XX is any two hex digits assigned by jumper selection.

Timer Interval
1.003 ms ±0.1% when 110 baud rate is selected.
1.042 ms ±0.1% for all other baud rates.

Interfaces
Bus — All signals TTL compatible
Parallel I/O — All signals TTL compatible
Serial I/O — RS232C
Interrupt Requests — All TTL compatible

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>No. of Centers</th>
<th>Pin No.</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus (P1)</td>
<td>86</td>
<td>0.156</td>
<td>Viking 3KH43/8AMK12</td>
</tr>
<tr>
<td>Parallel I/O</td>
<td>50</td>
<td>0.1</td>
<td>3M 3415-000 or TI H312125</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>28</td>
<td>0.1</td>
<td>3M 3462-000 or TI H312113</td>
</tr>
<tr>
<td>Aux. Power (P2)</td>
<td>60</td>
<td>0.1</td>
<td>AMP PE5-14559 or TI H311130</td>
</tr>
</tbody>
</table>

NOTE: Connector heights and wire-wrap pin lengths are not guaranteed to conform to intel OEM packaging.

I/O Addressing

<table>
<thead>
<tr>
<th>Port</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8255A No. 1 Control</th>
<th>8255A No. 2 Control</th>
<th>USART Data</th>
<th>USART Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>XX4</td>
<td>XX5</td>
<td>XX6</td>
<td>XX8</td>
<td>XX9</td>
<td>XXA</td>
<td>XXB</td>
<td>XXC or XXE</td>
<td>XXD or XXF</td>
<td></td>
</tr>
</tbody>
</table>

Note
XX is any two hex digits assigned by jumper selection.
Auxiliary Power
An auxiliary power bus is provided to allow separate power to RAM for systems requiring battery backup of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

Memory Protect
An active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during system power-down sequences.

Line Drivers and Terminators
I/O Drivers — The following line drivers and terminators are all compatible with the I/O driver sockets on the iSBC 108A/116A board. Ports 1 and 4 have 25 mA totem-pole drivers and 1 kΩ terminators.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I,OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

Note
I = inverting; NI = non-inverting; OC = open collector.

I/O Terminators — 220Ω/330Ω divider or 1 kΩ pullup.

Bus Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Commands</td>
<td>Tri-State</td>
<td>32</td>
</tr>
<tr>
<td>Tri-State</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

Physical Characteristics
Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 14 oz (397.3 gm)

Electrical Characteristics
Average DC Current

<table>
<thead>
<tr>
<th>Function</th>
<th>$V_{DD} = +1215%$</th>
<th>$V_{CC} = +5%$</th>
<th>$V_{BB} = -5%$</th>
<th>$V_{AA} = -12%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>No EPROM or Terminators</td>
<td>250 mA</td>
<td>2.9 A</td>
<td>—</td>
<td>70 mA</td>
</tr>
<tr>
<td>4 2708s and 8 Terminators</td>
<td>520 mA</td>
<td>3.6 A</td>
<td>180 mA</td>
<td>70 mA</td>
</tr>
<tr>
<td>4 2716s and No Terminators</td>
<td>250 mA</td>
<td>3.3 A</td>
<td>—</td>
<td>70 mA</td>
</tr>
<tr>
<td>4 2732s and No Terminators</td>
<td>250 mA</td>
<td>3.5 A</td>
<td>—</td>
<td>70 mA</td>
</tr>
<tr>
<td>Aux. Power RAM Accessed</td>
<td>175 mA</td>
<td>0.45 A</td>
<td>3 mA</td>
<td>—</td>
</tr>
<tr>
<td>Aux. Power No RAM Access</td>
<td>20 mA</td>
<td>0.45 A</td>
<td>3 mA</td>
<td>—</td>
</tr>
</tbody>
</table>

Environmental Characteristics
Operating Temperature — 0°C to +55°C.

Reference Manuals
9800862 — iSBC 108A/116A Board Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.
The iSBC 300 32K-byte RAM expansion module and the iSBC 340 16K-byte EPROM expansion module provide simple, low cost expansion of the memory complement available on the iSBC 86/12A single board computer. Each module utilized individually or together can double the iSBC 86/12A board's on-board RAM and EPROM memory capacity. The iSBC 300 32K-byte RAM expansion module and the iSBC 340 16K-byte EPROM expansion module options for the iSBC 86/12A board offer system designers a new level of flexibility in defining and implementing Intel® single board computer systems. These options allow the systems designer to double the memory complement of an iSBC 86/12A board with a minimum of system implications. Because they expand the memory configuration on-board, they can be accessed as quickly as the existing iSBC 86/12A memory by eliminating the need for accessing the additional memory via the MULTIBUS system bus. With the iSBC 86/12A board mounted in the top slot of an iSBC 604 or iSBC 614 cardcage, sufficient clearance exists for mounting both the iSBC 300 and/or the iSBC 340 expansion module option(s). If the iSBC 86/12A board is inserted into some other slot, the combination of boards will physically (but not electrically) occupy two cardcage slots. Incremental power required by the options is minimal; for instance, only 305 mW is needed for the iSBC 300 RAM expansion module.

*Same product, manufactured by Intel Puerto Rico, Inc.
**FUNCTIONAL DESCRIPTION**

**iSBC 300 32K-Byte MULTIMODULE RAM**

The iSBC 300 module contains sixteen 16K-byte dynamic RAM devices, sockets for the Intel® 8202A Dynamic computer. It expands the iSBC 86/12A board's on-board dual port RAM capacity from 32K bytes to 64K bytes. The iSBC 300 module contains sixteen 16K-byte dynamic RAM devices, sockets for the Intel® 8202 Dynamic RAM Controller and memory interface latching. To install the iSBC 300 module, the latches and controller from the iSBC 86/12A board are removed and inserted into the sockets on the iSBC 300 module. The add-on board is then mounted onto the iSBC 86/12A board. Pins extending from the controller’s and latches' sockets mate with the devices' sockets underneath (see Figure 1). Additional pins mate to supply power and other signals to complete the electrical interface. The module is then secured at three additional points with nylon hardware to insure the mechanical security of the assembly.

To complete the installation, two socketed PROMs are replaced on the iSBC 86/12A board with those supplied with the iSBC 300 kit. These are the on-board memory and MULTIBUS address decode PROMs which allow the iSBC 86/12A board decode logic to recognize its expanded on-board memory complement.

**iSBC 340 16K-byte MULTIMODULE EPROM**

The iSBC 340 module expands the iSBC 86/12A Single Board Computer's on-board EPROM capacity from 16K bytes to 32K bytes. It measures 3.3" by 2.8" and consists of a PC board with six 24-pin special sockets. Two of the sockets have extended pins which mate with two of the EPROM sockets on the iSBC 86/12A board. Two of the EPROMs which would have been inserted on the iSBC 86/12A board are then reinserted in the iSBC 340 module. Additional pins also mate for bringing chip selects for the remaining EPROM devices (see Figure 2). The mechanical interface is similar to that used on the iSBC 300 RAM module and consists of two additional mounting holes and the necessary mounting hardware.

The iSBC 340 module supports Intel® 2732 EPROMs. One section of the iSBC 86/12A on-board memory and MULTIBUS address decode PROMs (the same decode PROMs mentioned for the iSBC 300 module) is already preprogrammed to support the iSBC 340 module with Intel® 2732 EPROMs. This section is selected through the EPROM configuration switches on the iSBC 86/12A board. The iSBC 340 board can optionally be configured by the user to support Intel® 2758 or 2761 EPROMs by programming new iSBC 86/12A decode PROMs to support these devices. Necessary documentation and PROM map listings are in the iSBC 86/12A Hardware Reference Manual (order number 9803074-01).

Figure 1. Installation of iSBC 300 MULTIMODULE RAM on iSBC 86/12A Single Board Computer

7-21
SPECIFICATIONS

Word Size
8 or 16 bits (16-bit data paths)

Memory Size
iSBC 300 Module — 32,768 bytes of RAM
iSBC 340 Module — 16,384 bytes (max) of EPROM

Access Time
iSBC 300 Module — Read: 1 μsec, write: 1.2 μsec
iSBC 340 Module — Standard EPROMs (450 nsec): 1 μsec, fast EPROMs (350 or 390 nsec): 800 nsec

Interface
The interface for the iSBC 300 and iSBC 340 module options is designed only for Intel's iSBC 86/12A Single Board Computer.

Memory Addressing

On-board RAM
CPU Access
iSBC 86/12A board only (32K bytes) — 00000-07FFFH.
iSBC 86/12A board + iSBC 300 module (64K bytes) — 00000-0FFFFH.

MULTIBUS Access — Jumper selectable for any 8K-byte boundary, but not crossing a 128K-byte boundary.

On-board EPROM
iSBC 86/12A board only (16K-bytes max.) — FF000-FFFFFH (using 2758 EPROMs); FE000-FFFFFFH (using 2716 EPROMs); and FC000-FFFFFH (using 2732 EPROMs).

iSBC 86/12A board + iSBC 340 module (32K bytes max) — FE000-FFFFFFH (using 2758 EPROMs); FC000-FFFFFFH (using 2716 EPROMs); F8000-FFFFFFH (using 2732 EPROMs).

On-board EPROM/ROM is not accessible via the MULTIBUS interface.

Auxiliary Power/Memory Protection
The low power memory protection option included on the iSBC 86/12A boards supports the iSBC 300 RAM module.

“Local Only” Memory Protection
The iSBC 86/12A Single Board Computer supports dedication of on-board RAM for on-board CPU access only in 8K, 16K, 24K, or 32K-byte segments. Installation of the iSBC 300 option allows protection of 16K, 32K, 48K, or 64K-byte segments.

Physical Characteristics

<table>
<thead>
<tr>
<th></th>
<th>iSBC 300</th>
<th>iSBC 340</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>5.75&quot;</td>
<td>3.3&quot;</td>
</tr>
<tr>
<td>Length</td>
<td>2.35&quot;</td>
<td>2.8&quot;</td>
</tr>
<tr>
<td>Height of iSBC 86/12A plus mounted option</td>
<td>.718</td>
<td>.718*</td>
</tr>
<tr>
<td>Weight</td>
<td>13 oz.</td>
<td>5 oz.</td>
</tr>
</tbody>
</table>

*Includes EPROMs

All necessary mounting hardware (nylon, screws, spacers, nuts) are supplied with each kit.

Figure 2. Installation of ISBC 340 MULTIMODULE EPROM Option on ISBC 86/12A Single Board Computer
ISBC 300/340

Electrical Characteristics

DC power requirements:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>ISBC 300</th>
<th>ISBC 340</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5 ±5%</td>
<td>1 mA</td>
<td>120 mA</td>
</tr>
<tr>
<td>+12 ±5%</td>
<td>24 mA</td>
<td>—</td>
</tr>
<tr>
<td>-12 ±5%</td>
<td>1 mA</td>
<td>—</td>
</tr>
</tbody>
</table>

Note:
1. Loaded with Intel 2732 EPROMs.

Environmental Characteristics

Operating Temperature — 0° to +55°C
Relative Humidity — to 90% (without condensation)

Reference Manuals

All necessary documentation for the iSBC 300 MULTIMODULE RAM and iSBC 340 MULTIMODULE EPROM/ROM is included in the iSBC 86/12A Hardware Reference Manual; order #9803074-01. (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051.

ORDERING INFORMATION

Part Number Description

<table>
<thead>
<tr>
<th>SBC 300</th>
<th>32K byte MULTIMODULE RAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 340</td>
<td>16K byte MULTIMODULE EPROM</td>
</tr>
</tbody>
</table>
iSBC™ 301
4K-BYTE RAM
MULTIMODULE™ BOARD

- On-board memory expansion to 8K bytes for iSBC™ 80/24 and iSBC™ 88/40 Single Board Computers
- Provides 4K bytes of static RAM directly on-board
- Uses 5 MHz (8185-2) RAMs
- Single +5V supply
- 0.5 watts incremental power dissipation
- On-board memory expansion eliminates MULTIBUS system bus latency and increases system throughput
- Reliable mechanical and electrical interconnection

The Intel iSBC 301 4K-Byte RAM MULTIMODULE Board provides simple, low cost expansion to double the RAM capacity on the iSBC 80/24 or iSBC 88/40 Single Board Computer to 8K bytes. This offers system designers a new level of flexibility in defining and implementing system memory requirements. Because memory is configured on-board, it can be accessed as quickly as the existing iSBC 80/24 or iSBC 88/40 memory, eliminating the need for accessing the additional memory via the MULTIBUS system bus. As a result, the iSBC 301 board provides a high speed, cost effective solution for systems requiring incremental RAM expansion. Incremental power required by the iSBC 301 module is minimal, dissipating only 0.5 watts.
FUNCTIONAL DESCRIPTION

The iSBC 301 board measures 3.95" by 1.20" and mounts above the RAM area on the iSBC 80/24 or iSBC 88/40 single board computer. It expands the on-board RAM capacity from 4K bytes to 8K bytes. The iSBC 301 MULTIMODULE board contains four 1K byte static RAM devices and a socket for one of the RAM devices on the iSBC 80/24 or iSBC 88/40 board. To install the iSBC 301 MULTIMODULE board, one of the RAMs is removed from the host board and inserted into the socket on the iSBC 301 board. The add-on board is then mounted into the vacated RAM socket on the host board. Pins extending from the RAM socket mate with the device’s socket underneath (see Figure 1). Additional pins mate to the power supply and chip select lines to complete the electrical interface. The MULTIMODULE board is then secured at two additional points with nylon hardware to insure mechanical security of the assembly. With the iSBC 80/24 or iSBC 88/40 board mounted in the top slot of an iSBC 604 or iSBC 614 cardcage, sufficient clearance exists for mounting the iSBC 301 option. If the iSBC 80/24 or iSBC 88/40 board is inserted into some other slot, the combination of boards will physically (but not electrically) occupy two cardcage slots.

Figure 1. Installation of iSBC™ 301 4K-Byte RAM MULTIMODULE™ Board
iSBC 301

SPECIFICATIONS

Word Size
8 bits

Memory Size
4096 bytes of RAM

Access Time

Read:
140 ns (from READ command)
200 ns (from ALE)

Write:
150 ns (from READ command)
190 ns (from ALE)

Memory Addressing

Memory addressing for the iSBC 301 4K-Byte RAM MULTIMODULE Board is controlled by the host board via the address and chip select signal lines and is contiguous with the host board RAM.

- iSBC 80/24 and iSBC 301 board: 02000-02FFF
- iSBC 88/40 and iSBC 301 board: 00000-01FFF

Physical Characteristics

Width — 1.20 in. (3.05 cm)

Length — 3.95 in. (10.03 cm)

Height — .44 in. (1.12 cm) iSBC 301 Board
.56 in. (1.42 cm) iSBC 301 Board + host board

Weight — .69 oz. (19 gm)

Electrical Characteristics

DC Power Requirements:
10 mA at +5 Volts incremental power

Environmental Characteristics

Operating Temperature — 0° to +55° C
Relative Humidity — 90% (without condensation)

Reference Manuals

All necessary documentation for the iSBC 301 MULTIMODULE board is included in the CPU board Hardware Reference Manual (NOT SUPPLIED)

- iSBC 80/24 — Order No. 142648-001
- iSBC 88/40 — Order No. 124978-001

Manuals may be ordered from any Intel sales representative, distributor office, or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 301</td>
<td>4K Byte RAM MULTIMODULE Board</td>
</tr>
</tbody>
</table>
iSBC™ 302
8K-BYTE MULTIMODULE™ RAM

- Expands on-board memory of the iSBC™ 86/05 and iSBC™ 88/25 Single Board Computers
- Uses four Intel® 2168 static RAMs
- Single +5V supply

- On-board memory expansion eliminates system bus latency and increases system throughput
- Reliable mechanical and electrical interconnection

The Intel iSBC 302 8K-Byte MULTIMODULE RAM provides simple, low-cost expansion to double the RAM capacity on the iSBC 86/05 Single Board Computer to 16K bytes or increase RAM capacity on the iSBC 88/25 Single Board Computer to 12K bytes. This offers system designers a new level of flexibility in implementing system memory. Because the MULTIMODULE memory is configured on-board, it can be accessed as quickly as the standard on-board iSBC 86/05 or iSBC 88/25 memory, eliminating the need for accessing additional memory via the MULTIBUS system bus. As a result, the iSBC 302 board provides a high-speed, cost-effective solution for systems requiring incremental RAM expansion.
FUNCTIONAL DESCRIPTION

The iSBC 302 board measures 2.60" by 2.30" and mounts above the RAM area on the iSBC 86/05 or iSBC 88/25 Single Board Computer. The iSBC 302 MULTIMODULE board contains four 4K x 4 static RAM devices and sockets for two of the RAM devices on the iSBC 86/05 board. With the iSBC 86/05 module mounted on the iSBC 88/25 board, the two sockets on the iSBC 302 module may be filled with 4K x 4 static RAMs. The two sockets on the iSBC 302 module have extended pins which mate with two sockets on the base board. Additional pins mate to the power supply and chip select lines to complete the electrical interface. The mechanical integrity of the assembly is assured with nylon hardware securing the module in two places. With the iSBC 86/05 or iSBC 88/25 board mounted in the top slot of an iSBC 604/614 card-cage, sufficient clearance exists for the mounted iSBC 302 option. If the iSBC 86/05 or iSBC 88/25 board is inserted into some other slot, the combination of boards will physically (but not electrically) occupy two card-cage slots.

SPECIFICATIONS

Word Size
8/16 bits

Memory Size
16,384 bytes of RAM

Cycle Time
Provides “no wait state” memory operations on the iSBC 86/05 board at 5 MHz or 8 MHz or the iSBC 88/25 board at 5 MHz.
- 5 MHz cycle time — 800 ns
- 8 MHz cycle time — 500 ns

Memory Addressing
Memory addressing for the iSBC 302 MULTIMODULE board is controlled by the host board via the address and chip select signal lines.

With the iSBC 86/05 board:
The 8K bytes of RAM on the iSBC 302 board occupy the 8K-byte address space immediately after that of the iSBC 86/05 board’s 8K RAM (i.e., default configuration —
iSBC 86/05 board’s RAM — 00000-0FFFH
iSBC 302 board’s RAM — 01000-02FFFH).

With the iSBC 88/25 board:
The 8K bytes of RAM on the iSBC 302 board occupy the 8K byte address space immediately after that of the iSBC 88/25 board’s 4K RAM (i.e., default configuration —
iSBC 88/25 board’s RAM — 0-0FFFH
iSBC 302 board’s RAM — 01000H-02FFFH).

Physical Characteristics
WIDTH — 2.6 in. (6.60 cm)
LENGTH — 2.3 in. (5.84 cm)
HEIGHT — 0.56 in. (1.42 cm) iSBC 302 board + iSBC 86/05 or iSBC 88/25 board
WEIGHT — 1.25 oz (35 gm)

Electrical Characteristics
DC POWER REQUIREMENTS — 720 mA at +5V incremental power

Environmental Characteristics
OPERATING TEMPERATURE — 0°C to +55°C
RELATIVE HUMIDITY — to 90% (without condensation)

Reference Manuals
All necessary documentation for the iSBC 302 MULTIMODULE board is included in the CPU board Hardware Reference Manuals (NOT SUPPLIED).
iSBC 86/05 — Order No. 143153-001
iSBC 88/25 — Order No. 143825-001

Manuals may be ordered from any Intel sales representative, distributor office, or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

Part Number  Description
SBC 302  8K-Byte MULTIMODULE RAM
The iSBC 303 MULTIMODULE Parity option provides on-board parity support for the on-board RAM of the iSBC 86/12A Single Board Computer. Memory parity generation/detection is invaluable for those applications in which execution of erroneous instructions or data must be prevented, as in critical process control, medical and financial transaction systems. When used on single board computers in conjunction with MULTIBUS®-based, parity-protected RAM expansion boards in large memory configurations, the iSBC 303 MULTIMODULE Parity option provides consistent protection throughout all system RAM.
FUNCTIONAL DESCRIPTION

The iSBC 303 MULTIMODULE Parity option is a complete subsystem, providing all necessary logic and display to support the iSBC 86/12A onboard RAM. Operation of the iSBC 303 option, once initialized, is transparent to the system, as the option causes no memory performance degradation. If an error is detected and interrupts are enabled, an interrupt request will be issued to the iSBC 86/12A board. Included on-board is the parity generator/checker and parity memory RAM, the interrupt request logic, error display, command register and the necessary interface for address, data and control (inputs) and interrupt requests (outputs) (See Figure 1). The parity generator/checker is a 74S280 MSI device. The memory devices are four Intel® 2118 dynamic RAMs. Parity is generated/detected on a byte basis; for a 32KB RAM configuration, only two of the parity RAMs are used. When the iSBC 303 board is used in conjunction with the iSBC 300 32KB MULTIMODULE RAM option (which provides a total of 64KB onboard RAM), all four parity RAMs are used. Odd or even parity may be programmatically selected through the command register. This feature also provides the ability to "force errors" to verify operation of the board.

Error Reporting

Two interrupt requests are provided: one which can be connected to the NMI input of the Intel 8086 CPU, and another which can be wired to the Intel 8259A interrupt controller and/or Intel 8255A Programmable Peripheral Interface on the iSBC 86/12A board. The ‘NMI request’ can be enabled/disabled via the command register or optionally with the NMIMASK signal which can be controlled by the 8255A PPI. Additionally, a power fail request signal originating from the system power supply can be “OR’ed” with the parity NMI request, allowing both signals to be issued to the 8086 CPU.

The error display logic contains two LEDs which indicate errors for high and low bytes. High and low byte error signals can also be connected to the 8255A, to read error status under program control. The LEDs and error signals are controlled by the command register.

Base-board Interface

The address, control and data signals are generated by the iSBC 86/12A RAM logic, and are connected to the iSBC 303 module through the sockets of the Intel 8202A RAM controller and the data latches (see Figure 2). The other I/O signals to/from the iSBC 303 board are brought out to an 8-pin connector from which a cable assembly (not supplied) establishes connections to the iSBC 86/12A board. Mechanical integrity is assured by three-point mounting with nylon hardware. The iSBC 86/12A and iSBC 303 boards can be mounted in the end slot of an Intel iSBC 604/614 cardcage. If mounted in other than the top slot, it will physically occupy two slots. The iSBC 86/12A, 300, 303 board combination will not fit in the top slot, and also occupies two cardcage positions when mounted.

---

**Figure 1. iSBC™ 303 Functional Block Diagram**
Programmatic Control

The command register is a 4-bit, memory mapped register through which the operation of the iSBC 303 module is controlled (see Figure 3). Read/write access to all bits is available through either location 0H or 400H (jumper selectable). Initialization software should enable the NMI interrupt and the maskable interrupt and LED, as required. It should also select odd or even parity generation (odd is recommended for detection of catastrophic RAM failure).

Diagnostic Capability

Operation of the iSBC 303 module and the integrity of the RAM can be checked with a diagnostic software routine which can 'force errors' in parity memory. This is accomplished by writing data in one parity mode (e.g. odd), toggling the odd/even bit and then reading data with the complementary parity mode (e.g. even). These reads should cause detectable errors and interrupts will be generated, verifying the error detecting and reporting capability.

Figure 2. iSBC™ 303 Option Installation

Figure 3. iSBC™ 303 Option Command/Status Register
SPECIFICATIONS

Word Size
Byte parity on 8 and 16-bit words.

Cycle Time
Supports ISBC 86/12A memory cycle times with no additional wait states.

Memory Capacity
Supports 32KB of ISBC 86/12A on-board RAM or 64KB with ISBC 300 MULTIMODULE RAM option.

Interface
All signals TTL compatible.

Connector (Not Supplied)

<table>
<thead>
<tr>
<th>Shells</th>
<th>Pins</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reeled</td>
<td>Loose</td>
<td></td>
</tr>
<tr>
<td>AMP 87456-4</td>
<td>86491-3</td>
<td>87045-2</td>
<td></td>
</tr>
<tr>
<td>Berg 65043-033</td>
<td>47564</td>
<td>47744</td>
<td></td>
</tr>
</tbody>
</table>

Auxiliary Power/Memory Protection
The auxiliary power (i.e. battery backup operation) and memory protection (i.e. write disable on out-of-limits power supply voltages) features of the ISBC 86/12A Single Board Computer are supported on the ISBC 303 module.

Physical Characteristics
Width — 6.375 in. (16.2 cm)
Height — Height of ISBC 86/12A board + ISBC 303 module: 0.718 in. (1.82 cm)
Height of ISBC 86/12A board + ISBC 300 module + ISBC 303 module: 1.05 in. (2.66 cm)
Depth — 2.40 in. (6.1 cm)
Weight — 2.3 oz. (28.5 gm)

All necessary mounting hardware (screws, nuts, spacers) are supplied with each kit.

Electrical Characteristics
605 mA max., +5 VDC (±5%)

Environmental Characteristics
Operating Temperature — 0°C to +55°C
Relative Humidity — To 90% (without condensation)

Reference Manual (Not Supplied)
All necessary documentation for the ISBC 303 MULTIMODULE Parity option is contained in the ISBC 86/12A Single Board Computer Hardware Reference Manual; order #9803074-02.

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>SBC 303</td>
<td>MULTIMODULE Parity</td>
</tr>
</tbody>
</table>
The iSBC 341 28-pin MULTIMODULE EPROM board provides simple, low-cost expansion of the on-board memory capacity of the iSBC 86/05 Single Board Computer, the iSBC 88/25 Single Board Computer and the iSBC 88/40 Measurement and Control Computer. Four additional 28-pin sockets support JEDEC 24/28-pin standard devices, including EPROMs, byte-wide static and pseudo-static RAMs.

The MULTIMODULE expansion concept provides the optimum mechanism for incremental memory expansion. Mounting directly on the microcomputer, the benefits include low cost, no additional power requirements beyond the memory devices, and higher performance than MULTIBUS-based memory expansion.
FUNCTIONAL DESCRIPTION

The iSBC 341 28-pin MULTIMODULE EPROM option effectively doubles the number of sockets available for EPROM on the base microcomputer board on which it is mounted. The iSBC 341 board contains six 28-pin sockets. Two of the sockets have extended pins which mate with two of the sockets on the base board. Two of the EPROMs which would have been inserted in the base board are then reinserted in the iSBC 341 sockets. Additional interface pins also connect chip select lines and power. The mechanical integrity of the assembly is assured with nylon hardware securing the unit in two places.

Through its unique interface, the iSBC 341 board can support 8 or 16-bit data paths. The data path width is determined by the base board — being 8 bits for the iSBC 88/40 and iSBC 88/25 microcomputers, and 8/16 bits for the iSBC 86/05 board.

SPECIFICATIONS

Word Size
8 or 8/16 bits (determined by data path width of base board).

Memory Size
32K bytes with available technology (JEDEC standard defines device pin-out to 128K-bit devices).

<table>
<thead>
<tr>
<th>Device Size (Bytes)</th>
<th>EPROM Type</th>
<th>Max. iSBC 341 Capacity (Bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2Kx8</td>
<td>2716</td>
<td>8K</td>
</tr>
<tr>
<td>4Kx8</td>
<td>2732</td>
<td>16K</td>
</tr>
<tr>
<td>8Kx8</td>
<td>2764</td>
<td>32K</td>
</tr>
<tr>
<td>16Kx8</td>
<td>27128</td>
<td>64K</td>
</tr>
</tbody>
</table>

Access Time
Varies according to base board and memory device access time. Consult data sheet of base board for details.

Memory Addressing
Consult data sheet of base board for addressing data.

POWER REQUIREMENTS

<table>
<thead>
<tr>
<th>Devices</th>
<th>Max. Current @ 5V ± 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2716</td>
<td>420 mA</td>
</tr>
<tr>
<td>2732, 2732A</td>
<td>600 mA</td>
</tr>
<tr>
<td>2764</td>
<td>600 mA</td>
</tr>
</tbody>
</table>

NOTE:
1. Incremental power drawn from host board for four additional devices.

Auxiliary Power
There are no provisions for auxiliary power (battery backup) on the iSBC 341 option.

Physical Characteristics
WIDTH — 3.4 in. (8.64 cm)
LENGTH — 2.7 in. (6.86 cm)
HEIGHT — 0.78 in. (1.98 cm) *
WEIGHT — 5 oz (141.5 gm)
*Includes height of mounted memory devices and base board.

All necessary mounting hardware (nylon screws, spacers, nuts) is supplied with each kit.

Environmental Characteristics
OPERATING TEMPERATURE — 0°C to +55°C
RELATIVE HUMIDITY — to 90% (without condensation)

Reference Manuals
All necessary documentation for the iSBC 341 module is included in the CPU board Hardware Reference Manuals (NOT SUPPLIED)

iSBC 86/05 — Order No. 143153-001
iSBC 88/25 — Order No. 143825-001
iSBC 88/40 — Order No. 124978-001

Manuals may be ordered from any Intel sales representative, distributor office, or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

Part Number  Description
SBC 341     28-Pin MULTIMODULE EPROM
iSBC 416
16K EPROM EXPANSION BOARD

- Allows iSBC 80 EPROM/ROM expansion through the MULTIBUS interface
- Sockets for up to 16K bytes of Intel 2708 programmable and erasable PROM
- Switches enable or disable each memory block
- Jumper selectable addresses for each 8K block
- Buffered address and data lines

The iSBC 416 16K EPROM Expansion Board is a member of Intel's complete line of iSBC memory and I/O expansion boards. The iSBC 416 interfaces directly to any iSBC 80 single board computer via the system bus to expand EPROM memory capacity. The board contains 16 sockets that can house Intel 2708 programmable and erasable EPROMs. EPROM memory can be added in 1K-byte increments. The iSBC 416 contains a set of jumpers allowing the selection of the base address of independent 8K memory blocks, to begin on any 8K boundary. Switches are used to enable on-board memory in 1K block increments.
SPECIFICATIONS

Word Size
8 bits

Memory Size
Sockets for up to 16K bytes. Memory may be added in 1K-byte increments.

Compatible Intel Memory
EPROM — 2708

Interface
All address, data, and command signals are TTL compatible and iSBC 80 bus compatible.

Address Selection
Switches and jumpers allowing the selection of a base address for each independent 8K block of memory, on any 8K boundaries

Connectors
Edge Connector — 86-pin double-sided PC edge connector with 0.156-in. (0.40 cm) contact centers.
Mating Connector — Viking 3KH43/9AMK12

Physical Characteristics
Width — 12.00 in. (30.40 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 12 oz (340.5 gm)

Electrical Characteristics
DC Power Requirements

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<thead>
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<th></th>
<th>Without Memory</th>
<th>With 2508</th>
<th>With 2708</th>
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</thead>
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<tr>
<td></td>
<td>Typ</td>
<td>Max</td>
<td>Typ</td>
</tr>
<tr>
<td>+5V</td>
<td>0.75A</td>
<td>0.77A</td>
<td>0.79A</td>
</tr>
<tr>
<td>-5V</td>
<td>—</td>
<td>0.010A</td>
<td>0.010A</td>
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<tr>
<td>+12V</td>
<td>0.58A</td>
<td>0.96A</td>
<td>0.80A</td>
</tr>
</tbody>
</table>

Environmental Characteristics
Operating Temperature — 0°C to 55°C

Reference Manuals
9800265A — iSBC 416 Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

Part Number Description
SBC 416 16K EPROM Expansion Board
iSBC™ 464
64K BYTE EPROM EXPANSION BOARD

- Provides EPROM/ROM expansion of iSBC™ 80, iSBC™ 86 and iSBC™ 88 systems via direct MULTIBUS interface
- Sockets for up to 64K bytes of EPROM
- Compatible with Intel® 2758, 2716 or 2732/2732A erasable PROMs
- Switch selectable base address on 4K byte boundaries for each memory bank
- Assignable anywhere within a 1 megabyte address space
- EPROM components which are not enabled are placed in standby power mode
- Requires a single +5V power supply

The iSBC 464 is a member of Intel's complete line of iSBC memory and I/O expansion boards. The iSBC 464 board interfaces directly to the iSBC 80, iSBC 86 or iSBC 88 single board computers via the MULTIBUS system bus, to expand system EPROM memory capacity.
FUNCTIONAL DESCRIPTION

Memory Configuration
The ISBC 464 board contains sixteen sockets which provide a maximum of 64K bytes of memory expansion. The actual capacity of the board is determined by the type and quantity of EPROM components installed by the user. The board is compatible with three different sizes of Intel EPROM devices. These are the 1K byte 2758 EPROM, the 2K byte 2716 EPROM, and the 4K byte 2732 EPROM.

Mode of Operation — The ISBC 464 board can operate in one of two modes: the 8 bit only mode or the 16/8 bit mode. The 8 bit mode provides the most efficient memory configuration for systems handling 8 bit data. The 16/8 bit mode allows 16 bit words to be accessed by 16 bit processors. In the 16/8 bit mode, 16 bit and 8 bit microprocessors may also access either the high order byte or the low order byte of a 16 bit word. The mode of operation is selected by placing two option jumper blocks in the appropriate sockets.

Memory Banks — When used in the 8 bit mode, the ISBC 464 board is organized into four banks (labeled A-D) of four sockets each. Depending on the type of memory components used, each bank may contain a maximum of 4K, 8K or 16K bytes of memory. Unused memory sockets may be deselected by bank or individually in bank D. Deselecting a bank or individual socket frees that address space for use elsewhere in the system. In the 16/8 bit mode, banks A & B and C & D are paired together to form two banks (labeled AB, CD) which are 16 bits wide. Each of these banks has four socket pairs. Bank AB may be deselected as a single unit. Socket pairs in bank CD may be deselected individually. Thus, board configurations using fewer than 16 memory components do not fill memory address space with unused sockets. Selection/deselection is accomplished by setting switches on the board.

Memory Access Time — The ISBC 464 board operates with one of 15 switch selectable memory access times ranging from 35 to 1435 nanoseconds. This feature allows the board to be tailored to the performance of the installed components and the system CPU.

Figure 1. ISBC 464 Block Diagram
Memory Addresses
Switch selectable options on the ISBC 464 board allow the board to be assigned anywhere within a 1 megabyte address space. In either operating mode, the base address of each memory bank may be set to any 4K byte boundary within a 64K byte memory page. There is one exception. If the 4K byte devices are used in the 16/8 bit mode, then base addresses are restricted to 8K byte boundaries. If the board is used in a system with an address range greater than 64K bytes, memory on the ISBC 464 board may reside in one or two 64K byte memory pages. Any two pages out of a possible 16 may be chosen by setting switches on the board.

Standby Power Operation
The ISBC 464 board takes advantage of the standby modes of the Intel 2758, 2716 and 2732. When they are not enabled, these components draw as little as 25% of their active level power with no degradation in access time. The ISBC 464 board is designed so that only two memory components are enabled during a read operation.

RAM Overlap
Memory banks of the ISBC 464 board can be overlapped with the addresses of system RAM by setting on-board switches. The process of addressing a memory bank will drive the Inhibit RAM (INH1/) signal true. This signal is issued to the MULTIBUS system bus in order to prevent any MULTIBUS accessible RAM in the system from responding to the current address. If an EPROM is addressed which has its corresponding RAM overlap switch on, an access time of 15 clock cycles is imposed. This allows overlapped dynamic RAM to refresh before the address on the MULTIBUS is changed. The RAM overlap feature does not apply to RAM which is not on the MULTIBUS system bus.

SPECIFICATIONS

Word Size
8 bits or 16 and 8 bits

Memory Size
Sockets are provided for up to 16K bytes in 1K increments or 32K bytes in 2K increments or 64K bytes in 4K increments

Compatible Intel® Memory
EPROM — 2758 or 2716 or 2732
INTERFACE — All 20 address, 16 data, and 6 control signals are TTL compatible and Intel MULTIBUS compatible

Electrical Characteristics
DC Power (max)
VCC: +5V DC ± 5%
ICC: 1.1 amps without EPROMs
ICC: 1.6 amps with (16) 2716s or 2758s
ICC: 1.3 amps with (16) 2732s or 2732As

Connectors
Bus — 86-pin double-sided PC edge connector with 0.40 cm (0.156 in.) contact centers

Mating Connector — Viking 3KH43/9AMK12 or compatible connector

Physical Characteristics
Length — 30.48 cm (12 in.)
Height — 17.15 cm (6.75 in.)
Depth — 1.27 cm (0.5 in.)
Weight — 294 gm (10.5 oz) without EPROM

Environment
Operating Temperature — 0°C to +55°C
Relative Humidity Limits — < 90% non-condensing

Reference Manual
9800643A — ISBC 464 Memory Expansion Board Hardware Reference Manual (NOT SUPPLIED)
Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

Part Number Description
SBC 464 64K EPROM Expansion Board
Digital I/O Expansion and Signal Conditioning Boards
The Intel iSBC 337 MULTIMODULE Numeric Data Processor offers high performance numerics support for iSBC 86 and iSBC 88 Single Board Computer users, for applications including simulation, instrument automation, graphics, signal processing and business systems. The coprocessor interface between the 8087 and the host CPU provides a simple means of extending the instruction set with over 60 additional numeric instructions supporting six additional data types. The data formats conform to the proposed IEEE Floating Point Standard insuring highly accurate results. The MULTIMODULE implementation allows the iSBC 337 module to be used on all iSBC 86 and iSBC 88 Microcomputers and can be added as an option to custom iAPX 86 and iAPX 88 board designs.
OVERVIEW

The iSBC 337 MULTIMODULE Numeric Data Processor provides arithmetic and logical instruction extensions to the 8086 and 8088 CPU's of the iAPX 86 and iAPX 88 families, to provide iAPX 86/20 and iAPX 88/20 Numeric Data Processors. The instruction set consists of arithmetic, transcendental, logical, trigonometric and exponential instructions which can all operate on seven different data types. The data types are 16, 32, and 64 bit integer, 32 and 64 bit floating point, 18 digit packed BCD and 80 bit temporary.

Coprocessor Interface

The coprocessor interface between the host CPU (8086 and 8088) and the iSBC 337 processor provides easy to use and high performance math processing. Installation of the iSBC 337 processor is simply a matter of removing the host CPU from its socket, installing the iSBC 337 processor into the host's CPU socket, and reinstalling the host CPU chip into the socket provided for it on the iSBC 337 processor (see Figure 1). All synchronization and timing signals are provided via the coprocessor interface with the host CPU. The two processors also share a common address/data bus. (See Figure 2.) The 8087 Numeric Data Processor (NDP) component is capable of recognizing and executing 8087 numeric instructions as they are fetched by the host CPU. This interface allows concurrent processing by the host CPU and the 8087. It also allows 8087 and host CPU instructions to be intermixed in any fashion to provide the maximum overlapped operation and the highest aggregate performance.

High Performance and Accuracy

The 80-bit wide internal registers and data paths contribute significantly to high performance and
minimizes the execution time difference between single and double precision floating point formats. This 80-bit architecture, in conjunction with the use of the proposed IEEE Floating Point Standard provides very high resolution and accuracy. This precision is complemented by extensive exception detection and handling. Six different types of exceptions can be reported and handled by the 8087. The user also has control over internal precision, infinity control and rounding control.

SYstem Configuration

As a coprocessor to an 8086 or 8088, the 8087 is wired in parallel with the CPU as shown in Figure 2. The CPU's status and queue status lines enable the NDP to monitor and decode instructions in synchronization with the CPU and without any CPU overhead. Once started, the 8087 can process in parallel with and independent of the host CPU. For resynchronization, the NDP's BUSY signal informs the CPU that the NDP is executing an instruction and the CPU WAIT instruction tests this signal to insure that the NDP is ready to execute subsequent instructions. The NDP can interrupt the CPU when it detects an error or exception. The interrupt request line is routed to the CPU through an 8259A Programmable Interrupt Controller. This interrupt request signal is brought down from the iSBC 337 module to the iSBC 86, 88 Single Board Computer through a single pin connector (see Figure 1). The signal is then routed to the interrupt matrix for jumper connection to the 8259A Interrupt Controller. Other iAPX 86 and 88 designs may use a similar arrangement, or by masking off the 8086's "READ" pin from the iSBC 337 socket, provisions are made to allow the now vacated pin of the host's CPU socket to be used to bring down

Figure 2. iSBC 337 System Configuration
The interrupt request signal for connection to the base board and then to the 8259A. Another alternative is to use a wire to establish this connection.

**PROGRAMMING INTERFACE**

Table 1 lists the seven data types the 8087 supports and presents the format for each type. Internally, the 8087 holds all numbers in the temporary real format. Load and store instructions automatically convert operands represented in memory as 16-, 32-, or 64-bit integers, 32- or 64-bit floating point numbers or 18-digit packed BCD numbers into temporary real format and vice versa.

Computations in the 8087 use the processor’s register stack. These eight 80-bit registers provide the equivalent capacity of 40 16-bit registers. The 8087 register set can be accessed as a stack, with instructions operating on the top stack element, or as a fixed register set, with instructions operating on explicitly designated registers.

Table 3 lists the 8087’s instructions by class. Assembly language programs are written in ASM 86/88, the iAPX 86, 88 assembly language. Table 2 gives the execution times of some typical numeric instructions and their equivalent time on a 5 MHz 8086.

<table>
<thead>
<tr>
<th>Data Formats</th>
<th>Range</th>
<th>Precision</th>
<th>Most Significant Byte</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Integer</td>
<td>$10^4$</td>
<td>16 Bits</td>
<td>$I_{15}$ $I_0$</td>
</tr>
<tr>
<td>Short Integer</td>
<td>$10^6$</td>
<td>32 Bits</td>
<td>$I_{31}$ $I_0$</td>
</tr>
<tr>
<td>Long Integer</td>
<td>$10^{19}$</td>
<td>64 Bits</td>
<td>$I_{63}$ $I_0$</td>
</tr>
<tr>
<td>Packed BCD</td>
<td>$10^{18}$</td>
<td>18 Digits</td>
<td>$S$ $D_{17}$ $D_{16}$</td>
</tr>
<tr>
<td>Short Real</td>
<td>$10^{±38}$</td>
<td>24 Bits</td>
<td>$S$ $E_7$ $E_0$ $F_1$ $F_{23}$</td>
</tr>
<tr>
<td>Long Real</td>
<td>$10^{±308}$</td>
<td>53 Bits</td>
<td>$S$ $E_{10}$ $E_0$ $F_1$ $F_{62}$</td>
</tr>
<tr>
<td>Temporary Real</td>
<td>$10^{±4932}$</td>
<td>64 Bits</td>
<td>$S$ $E_{14}$ $E_0$ $F_0$ $F_{63}$</td>
</tr>
</tbody>
</table>

**FUNCTIONAL DESCRIPTION**

The NDP is internally divided into two processing elements, the control unit (CU) and the numeric execution unit (NEU), providing concurrent operation of the two units. The NEU executes all numeric instructions, while the CU receives and decodes instructions, reads and writes memory operands and executes processor control instructions.

**Control Unit**

The CU keeps the 8087 operating in synchronization with its host CPU. 8087 instructions are intermixed with CPU instructions in a single instruc-
tion stream. The CPU fetches all instructions from memory; by monitoring the status signals emitted by the CPU, the NDP control unit determines when an 8086 instruction is being fetched. The CU taps the bus in parallel with the CPU and obtains that portion of the data stream.

After decoding the instruction, the host executes all opcodes but ESCAPE (ESC), while the 8087 executes only the ESCAPE class instructions. (The first five bits of all ESCAPE instructions are identical.) The CPU does provide addressing for ESC instructions, however.

An 8087 instruction either will not reference memory, will require loading one or more operands from memory into the 8087, or will require storing one or more operands from the 8087 into memory. In the first case a non-memory reference escape is used to start 8087 operation. In the last two cases, the CU makes use of a “dummy read” cycle initiated by the CPU, in which the CPU calculates the operand address and initiates a bus cycle, but does not capture the data. Instead, the CPU captures and saves the address which the CPU places on the bus. If the instruction is a load, the CU additionally captures the data word when it becomes available on the local data bus. If data required is longer than one word, the CU immediately obtains the bus from the CPU using the request/grant protocol and reads the rest of the information in consecutive bus cycles. In a store operation, the CU captures and saves the store address as in a load, and ignores the data word that follows in the “dummy read” cycle. When the 8087 is ready to perform the store, the CU obtains the bus from the CPU and writes the operand starting at the specified address.

**Numeric Execution Unit**

The NEU executes all instructions that involve the register stack; these include arithmetic, logical, transcendental, constant and data transfer instructions. The data path in the NEU is 80 bits wide (64 fraction bits, 15 exponent bits and a sign bit) which allows internal operand transfers to be performed at very high speeds.

When the NEU begins executing an instruction, it activates the 8087 BUSY signal. This signal is
used in conjunction with the CPU WAIT instruction to resynchronize both processors when the NEU has completed its current instruction.

Register Set

The 8087 register set is shown in Figure 3. Each of the eight data registers in the 8087's register stack is 80 bits wide and is divided into "fields" corresponding to the NDP's temporary real data type.

The register set may be addressed as a push down stack, through a top of stack pointer or any register may be addressed explicitly relative to the top of stack.

<table>
<thead>
<tr>
<th>DATA FIELD</th>
<th>TAG FIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGN EXPONENT SIGNIFICAND</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>15</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL REGISTER</td>
<td>STATUS REGISTER</td>
</tr>
<tr>
<td>INSTRUCTION POINTER</td>
<td>DATA POINTER</td>
</tr>
</tbody>
</table>

Figure 3. 8087 Register Set

Status Word

The status word shown in Figure 4 reflects the overall state of the 8087; it may be stored in memory and then inspected by CPU code. The status word is a 16-bit register divided into fields as shown in Figure 4. The busy bit (bit 15) indicates whether the NEU is executing an instruction (B = 1) or is idle (B = 0).

Several instructions which store and manipulate the status word are executed exclusively by the CU, and these do not set the busy bit themselves.

The four numeric condition code bits \((C_0-C_3)\) are similar to the flags in a CPU: various instructions update these bits to reflect the outcome of NDP operations.

Bits 14-12 of the status word point to the 8087 register that is the current top-of-stack (TOP).

Bit 7 is the interrupt request bit. This bit is set if any unmasked exception bit is set and cleared otherwise.

Bits 5-0 are set to indicate that the NEU has detected an exception while executing an instruction.

Tag Word

The tag word marks the content of each register as shown in Figure 5. The principal function of the tag word is to optimize the NDP's performance. The tag word can be used, however, to interpret the contents of 8087 registers.

<table>
<thead>
<tr>
<th>EXCEPTION FLAGS (1 = EXCEPTION HAS OCCURRED)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INVALID OPERATION</td>
</tr>
<tr>
<td>DENORMALIZED OPERAND</td>
</tr>
<tr>
<td>ZERO DIVIDE</td>
</tr>
<tr>
<td>OVERFLOW</td>
</tr>
<tr>
<td>UNDERFLOW</td>
</tr>
<tr>
<td>PRECISION</td>
</tr>
<tr>
<td>(RESERVED)</td>
</tr>
<tr>
<td>INTERRUPT REQUEST (^\text{(\text{(1)})})</td>
</tr>
<tr>
<td>CONDITION CODE</td>
</tr>
<tr>
<td>TOP OF STACK POINTER (^\text{(\text{(2)})})</td>
</tr>
<tr>
<td>NEU BUSY</td>
</tr>
</tbody>
</table>

\(^\text{(1)}\) IR is set if any unmasked exception bit is set, cleared otherwise.

\(^\text{(2)}\) Top Values:

- 000 = Register 0 is Top of Stack.
- 001 = Register 1 is Top of Stack.
- ...
- 111 = Register 7 is Top of Stack.

Figure 4. 8087 Status Word
Instruction and Data Pointers

The instruction and data pointers (see Figure 6) are provided for user-written error handlers. Whenever the 8087 executes an NEU instruction, the CU saves the instruction address, the operand address (if present) and the instruction opcode. The 8087 can then store this data in memory.

1. INVALID OPERATION: Stack overflow, stack underflow, indeterminate form (0/0, --, etc.) or the use of a Non-Number (NAN) as an operand. An exponent value is reserved and any bit pattern with this value in the exponent field is termed a Non-Number and causes this exception. If this exception is masked, the 8087’s default response is to generate a specific NAN called INDEFINITE, or to propagate already existing NANs as the calculation result.

2. OVERFLOW: The result is too large in magnitude to fit the specified format. The 8087 will generate the code for infinity if this exception is masked.

Exception Handling

The 8087 detects six different exception conditions that can occur during instruction execution. Any or all exceptions will cause an interrupt if unmasked and interrupts are enabled.

If interrupts are disabled the 8087 will simply suspend execution until the host clears the exception. If a specific exception class is masked and that exception occurs, however, the 8087 will post the exception in the status register and perform an on-chip default exception handling procedure, thereby allowing processing to continue. The exceptions that the 8087 detects are the following:

- **INVALID OPERATION**
- **OVERFLOW**
- **UNDERFLOW**
- **ZERO DIVIDE**
- **DENORMALIZED OPERAND**
- **PRECISION**

### Figure 5. 8087 Tag Word

<table>
<thead>
<tr>
<th>TAG (7)</th>
<th>TAG (6)</th>
<th>TAG (5)</th>
<th>TAG (4)</th>
<th>TAG (3)</th>
<th>TAG (2)</th>
<th>TAG (1)</th>
<th>TAG (0)</th>
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<tbody>
<tr>
<td>TAG VALUES:</td>
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<tr>
<td>00 = VALID</td>
<td>01 = ZERO</td>
<td>10 = SPECIAL</td>
<td>11 = EMPTY</td>
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</table>

### Figure 6. 8087 Instruction and Data Pointers

Control Word

The NDP provides several processing options which are selected by loading a word from memory into the control word. Figure 7 shows the format and encoding of the fields in the control word.

### Figure 7. 8087 Control Word

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<tr>
<th>X</th>
<th>X</th>
<th>X</th>
<th>I</th>
<th>C</th>
<th>R</th>
<th>C</th>
<th>P</th>
<th>C</th>
<th>M</th>
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<th>OM</th>
<th>ZM</th>
<th>DM</th>
<th>IM</th>
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<td>EXCEPTION MASKS (1 = EXCEPTION IS MASKED)</td>
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<td>INTERRUPT_MASK (1 = INTERRUPTS ARE MASKED)</td>
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<td>00 = Round Down (toward -)</td>
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<td>10 = 53 bits</td>
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<td>00 = 64 bits</td>
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</table>
3. **ZERO DIVISOR:** The divisor is zero while the dividend is a non-infinite, non-zero number. Again, the 8087 will generate the code for infinity if this exception is masked.

4. **UNDERFLOW:** The result is non-zero but too small in magnitude to fit in the specified format. If this exception is masked the 8087 will denormalize (shift right) the fraction until the exponent is in range. This process is called gradual underflow.

5. **DENORMALIZED OPERAND:** At least one of the operands or the result is denormalized; it has the smallest exponent but a non-zero significand. Normal processing continues if this exception is masked off.

6. **INEXACT RESULT:** If the true result is not exactly representable in the specified format, the result is rounded according to the rounding mode, and this flag is set. If this exception is masked, processing will simply continue.

**SOFTWARE SUPPORT**

The iSBC 337 module is supported by Intel's ASM-86/88 Assembly Language and PL/M-86/88 Systems Implementation Language. In addition to the instructions provided in the languages to support the additional math functions, a software emulator is also available to allow the execution of iAPX 86/20 instructions without the need for the iSBC 337 module. This allows for the development of software in an environment without the iAPX 86/20 processor and then transporting the code to its final run time environment with no change in mathematical results.

**SPECIFICATIONS**

**Physical Characteristics**

Width — 5.33 cm (2.100")
Length — 5.08 cm (2.000")
Height — 1.82 cm (.718")
   iSBC 337 board + host board
Weight — 17.33 grams (.576 oz.)

**Electrical Characteristics**

DC Power Requirements (8087 only)

\[ V_{cc} = 5V \pm 5\% \quad I_{cc} = 475 \text{ mA max.} \]

**Environmental Characteristics**

Operating Temperature — 0°C to 55°C
Free air moving across base board and iSBC 337 module.
Relative Humidity — Up to 90% R.H. without condensation.

**Reference Manual**

142887-001 — iSBC 337 MULTIMODULE Numeric Data Processor Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office, or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 337</td>
<td>MULTIMODULE Numeric Data Processor</td>
</tr>
</tbody>
</table>
iSBX 488™
GPIB MULTIMODULE BOARD

- Complete IEEE 488-1978 talker/listener functions including:
  - Addressing, handshake protocol, service request, serial and parallel polling schemes
- Complete IEEE 488-1978 controller functions including:
  - Transfer control, service requests and remote enable
- Simple read/write programming
- Software functions built into VLSI hardware for high performance, low cost and small size
- Standard iSBX™ Bus interface for easy connection to Intel iSBC™ boards
- IEEE 488-1978 standard electrical interface transceivers
- Five volt only operation

The Intel iSBX 488 GPIB Talker/Listener/Controller Multimodule board provides a standard interface from any Intel iSBC board equipped with an iSBX connector to over 600 instruments and computer peripherals that employ the use of the IEEE 488-1978 standard (General Purpose Interface Bus). The single-wide iSBX 488 Multimodule board implements the complete IEEE 488-1978 Standard Digital Interface for Programmable Instrumentation by taking full advantage of Intel's VLSI technology. The iSBX 488 Multimodule board incorporates the 8291A GPIB Talker/Listener, 8292 GPIB Controller and two 8293 GPIB Transceiver devices on a single low cost 3.7" by 2.85" iSBX Multimodule board. The iSBX 488 board represents a significant step forward in joining microcomputers and instrumentation using industry standards such as the Multibus system bus, iSBX bus and IEEE 488-1978. The high performance iSBX 488 Multimodule board mounts easily on Intel iSBX bus compatible single board computers and provides functions which previously required a board eight times its size.

The iSBX 488 board provides a simple programming interface to the user for easy reading, writing and monitoring of all GPIB functions. The intelligent interface provided by the iSBX 488 board minimizes the impact of the host processor bandwidth.
FUNCTIONAL DESCRIPTION

The iSBX 488 Multimodule board is a single-wide iSBX bus compatible I/O expansion board that provides a complete implementation of the IEEE 488-1978 Standard Digital Interface for Programmable Instrumentation. The iSBX 488 Multimodule board may be configured to be a GPIB controller, talker, listener or talker/listener. The hardware implementation of the iSBX 488 board takes full advantage of Intel's VLSI capability by using the Intel 8292 GPIB controller, 8291A talker/listener and two (2) 8293 bus transceivers. All communication between the host ISBC board and the iSBX 488 Multimodule board is executed via the Intel standard iSBX connector. Many of the functions that previously were performed by user software have been incorporated into VLSI hardware for high performance and simple programming. Both the Intel 8291A GPIB Talker/Listener device and the 8292 device can each communicate independently with the host processor on the ISBC board depending on configuration. Communication from the host ISBC board to either device on the iSBX 488 board is flexible and may be either interrupt or poll driven depending on user requirements. Data transfers to or from the GPIB may be executed by the host processor's I/O Read and I/O Write commands or with DMA handshaking techniques for very high speed transfers.

GPIB Talker/Listener Capabilities

The Intel 8291A device on the iSBX 488 Multimodule board handles all talker/listener communications between the host ISBC processor board and the GPIB. Its capabilities include data transfer, bus handshake protocol, talker/listener addressing procedures, device clearing and triggering, service requests, and both serial and parallel polling schemes. In executing most procedures the iSBX 488 board does not interrupt the microprocessor on the ISBC processor board unless a byte of data is waiting on input or a byte is sent to an empty output buffer, thus offloading the host CPU of GPIB overhead chores.

SIMPLE PROGRAMMING INTERFACE — The GPIB talker/listener functions can be easily programmed using the high level commands made available by the Intel 8291A on the ISBX 488 Multimodule board. The 8291A device architecture includes eight registers for input and eight registers for output. One each of these read and write registers is used for direct data transfers. The remaining write registers are used by the pro-

![Figure 1. iSBX 488™ Multimodule Board Block Diagram](8-10)
grammer to control the various interface features of the Intel 8291A device. The remaining read registers provide the user with a monitor of GPIB states, bus conditions and device status.

SOFTWARE FUNCTIONS BUILT INTO VLSI HARDWARE — Additional features that have migrated from discrete logic and software into Intel VLSI include programmable data transfer rate and three addressing modes that allow the iSBX board to be addressed as either a major or a minor talker/listener with primary or secondary addressing. The iSBX 488 Multimodule board can be programmatically configured into almost any bus talker, listener, or talker/listener configuration. Writing software to control these and other iSBX 488 board functions is simply a matter of reading or writing the control registers.

IEEE 488-1978 Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>iSBX 488™ Supported IEEE Subsets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Handshake (SH)</td>
<td>SH0, SH1</td>
</tr>
<tr>
<td>Acceptor Handshake (AH)</td>
<td>AH0, AH1</td>
</tr>
<tr>
<td>Talker (T)</td>
<td>T0 through T8</td>
</tr>
<tr>
<td>Extended Talker (TE)</td>
<td>TE0 through TE8</td>
</tr>
<tr>
<td>Listener (L)</td>
<td>L0 through L4</td>
</tr>
<tr>
<td>Extended Listener (LE)</td>
<td>LE0 through LE4</td>
</tr>
<tr>
<td>Service Request (SR)</td>
<td>SR0, SR1</td>
</tr>
<tr>
<td>Remote Local (RL)</td>
<td>RL0, RL1</td>
</tr>
<tr>
<td>Parallel Poll (PP)</td>
<td>PP0, PP1, PP2</td>
</tr>
<tr>
<td>Device Clear (DC)</td>
<td>DC0 through DC2</td>
</tr>
<tr>
<td>Device Trigger (DT)</td>
<td>DTO, DT1</td>
</tr>
<tr>
<td>Controller (C)</td>
<td>C0 through C28</td>
</tr>
</tbody>
</table>

1 For detailed information refer to IEEE Standard Digital Interface for Programmable Instrumentation published by The Institute of Electrical and Electronics Engineers, Inc., 1978.

Controller Capabilities

The GPIB controller functions supplied by the iSBX 488 board are provided by the Intel 8292 GPIB controller device. The 8292 is actually an Intel 8041A eight bit microcomputer that has been preprogrammed to implement all IEEE 488-1978 controller functions. The internal RAM in the 8041A is used as a special purpose register bank for the 8292 GPIB Controller. Just as with the 8291A GPIB Talker/Listener device, these registers are used by the programmer to implement controller monitor, read and write commands on the GPIB.

When configured as a bus controller the iSBX 488 board will respond to Service Requests (SRQ) and will issue Serial Polls. Parallel Polls are also issued to multiple GPIB instrument devices for receiving simultaneous responses. In applications requiring multiple bus controllers, several iSBX 488 boards may each be configured as a controller and pass the active control amongst each other. An iSBX 488 board configured for a System Controller has the capability to send Remote Enable (REN) and Interface Clear (IFC) for initializing the bus to a known state.

GPIB Physical Interface

The iSBX 488 Multimodule board interfaces to the GPIB using two Intel 8293 bidirectional transceivers. The iSBX 488 board meets or exceeds all of the electrical specifications defined in IEEE 488-1978 including the required bus termination specifications. In addition, for direct connection to the GPIB, the iSBX 988 cable, a 26 conductor 0.5 meter GPIB interface cable is also available from Intel. The cable is terminated with a 26-pin edge connector at the iSBX end and a 24-pin GPIB connector at the other. The cable is also supplied with shield lines for simple grounding in electrically noisy environments.

Installation

The iSBX 488 Multimodule board plugs directly onto the female iSBX connector available on many Intel iSBC boards. The Multimodule board is then secured at one additional point with nylon hardware (supplied) to insure the mechanical security of the assembly.

SPECIFICATIONS

Interface Information

iSBX™ Bus — All signals TTL compatible
26-pin edge connector — Electrical levels compatible with IEEE 488-1978.

Physical Characteristics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>3.70 in (.94 cm)</td>
</tr>
<tr>
<td>Length</td>
<td>2.85 in (7.24 cm)</td>
</tr>
<tr>
<td>Height</td>
<td>0.8 in (2.04 cm)</td>
</tr>
<tr>
<td>Weight</td>
<td>3.1 oz (87.8 gm)</td>
</tr>
</tbody>
</table>
GPIB Data Rate*
300K bytes/sec transfer rate with DMA host iSBC board
50K bytes/sec transfer rate using programmed I/O
730 nsec Data Accept Time
* Data rates are iSBX board maximum. Data rates will vary and can be slower depending on host iSBC board and user software driver.

Electrical Characteristics
DC power requirements —
\[ V_{CC} = +5 \text{ Vdc} \pm 5\% \]
\[ I_{CC} = 600 \text{ milliamps maximum} \]

GPIB Electrical and Mechanical Specifications
Conforms to IEEE 488-1978 standard electrical levels and mechanical connector standard when purchased with the iSBC 988 GPIB cable.

Environmental Characteristics
Operating Temperature — 0° to 60°C (32° to 140°F)
Relative Humidity — Up to 90% R.H. without condensation.

Reference Manual
143154-001 — iSBX 488 GPIB Talker/Listener/Controller Multimodule Board Hardware Reference Manual (not supplied).

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBX 488</td>
<td>GPIB Multimodule</td>
</tr>
<tr>
<td>SBC 988</td>
<td>0.5 meter GPIB cable for iSBX 488 Multimodule Board</td>
</tr>
</tbody>
</table>
The iSBC 517 Combination I/O Expansion Board is a member of Intel's complete line of iSBC memory and I/O expansion boards. The board interfaces directly with any iSBC single board computer via the system bus to expand serial and parallel I/O capacity. The combination I/O board contains 48 programmable parallel I/O lines. The system software is used to configure the I/O lines to meet a wide variety of system peripheral requirements. The flexibility of the I/O interface is significantly enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. A programmable RS232C communications interface is provided on the iSBC 517. This interface may be programmed by the system software to provide virtually any asynchronous or synchronous serial data transmission technique (including IBM Bi-Sync). A comprehensive RS232C interface to CRTs, RS232C compatible cassettes, and asynchronous and synchronous modems is thus on the board. An on-board register contains the status of eight interrupt request lines which may be interrogated from the system bus, and each interrupt request line is maskable under program control. The iSBC 517 also contains a jumper selectable 1 ms interval timer and interface logic for eight interrupt request lines.
FUNCTIONAL DESCRIPTION

Programming Flexibility
The 48 programmable I/O lines on the iSBC 517 are implemented utilizing two Intel 8255 programmable peripheral interfaces. The system software is used to configure these programmable I/O lines in any of the combinations of unidirectional input/output, and bidirectional ports indicated in Table 1. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. The 48 programmable I/O lines and signal ground lines are brought out to two 50-pin edge connectors that mate with flat, round, or woven cable. Typical I/O read access time is 280 nanoseconds. Typical I/O read cycle time is 600 nanoseconds.

Communications Interface
The programmable communications interface on the iSBC 517 is provided by an Intel 8251 Universal Synchronous/Asynchronous Receiver/Transmitter (USART). The USART can be programmed by the system software to select the desired asynchronous or synchronous serial data transmission technique (including IBM BISync). The mode of operation (i.e., synchronous or asynchronous), data format, control character format, parity, and asynchronous serial transmission rate are all under program control. The 8251 provides full duplex, double-buffered transmit and receive capability, and parity, overrun, and framing error detection are all incorporated in the USART. The comprehensive RS232C interface on the board provides a direct interface to RS232C compatible equipment. The RS232C serial data lines and signal ground lines are brought out to a 26-pin edge connector that mates with RS232C compatible flat or round cables.

Interrupt Request Lines
Interrupt requests may originate from eight sources. Four jumper selectable interrupt requests can be automatically generated by the programmable peripheral interface when a byte of information is ready to be transferred to the CPU (i.e., input buffer is full) or a character has been transmitted (i.e., output data buffer is empty). Two jumper selectable interrupt requests can be automatically generated by the USART when a character is ready to be transferred to the CPU (i.e., receive buffer is full) or a character has been transmitted (transmit buffer is empty). These six interrupt request lines are all maskable under program control. Two interrupt request lines may be interfaced directly from user designated peripheral devices via the I/O edge connector. An on-board register contains the status of all eight interrupt request lines, and may be interrogated by the CPU. Each interrupt request line is

![Figure 1. iSBC 517 Combination I/O Expansion Board Block Diagram](http://example.com/figure1.png)
Table 1. Input/Output Port Modes of Operation

<table>
<thead>
<tr>
<th>Ports</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
<th>Bidirectional</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unidirectional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input</td>
<td>Output</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unlatched Latched &amp; Strobed</td>
<td>Latched &amp; Strobed</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>X</td>
<td></td>
<td>X1</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>X</td>
<td>X1</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>X</td>
<td></td>
<td>X2</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td>X</td>
<td>X2</td>
</tr>
</tbody>
</table>

Notes
1. Part of port 3 must be used as control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
2. Part of port 6 must be used as a control port when either port 4 or port 5 are used as a latched and strobed input or a latched and strobed output port or port 4 is used as a bidirectional port.

maskable under program control. Routing for the eight interrupt request lines is jumper selectable. They may be ORed to provide a single interrupt request line for the iSBC 80/10B, or they may be individually provided to the system bus for use by other iSBC single board computers.

Interval Timer
Each board contains a jumper selectable 1 ms interval timer. The timer is enabled by jumpering one of the interrupt request lines from the I/O edge connector to a 1 ms interval interrupt request signal originating from the baud rate generator.

Serial Communications Characteristics
Synchronous — 5-8 bit characters; internal or external character synchronization; automatic sync insertion.
Asynchronous — 5-8 bit characters; peak characters generation; 1, 1½, or 2 stop bits; false start bit detectors.

Interrupts
Eight interrupt request lines may originate from the programmable peripheral interface (4 lines), the USART (2 lines), or user specified devices via the I/O edge connector (2 lines) or interval timer.

Interrupt Register Address
X1 Interrupt mask register
X0 Interrupt status register

Note
X is any hex digit assigned by jumper selection.

Timer Interval
1.003 ms ± 0.1% when 110 baud rate is selected
1.042 ms ± 0.1% for all other baud rates
Interfaces
Bus — All signals TTL compatible
Parallel I/O — All signals TTL compatible
Serial I/O — RS232C
Interrupt Requests — All TTL compatible

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (qty)</th>
<th>Centers (in.)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>86</td>
<td>0.156</td>
<td>CDC VPB01E43A00A1</td>
</tr>
<tr>
<td>Parallel I/O</td>
<td>50</td>
<td>0.1</td>
<td>3M 3415-000 or TI H312125</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>26</td>
<td>0.1</td>
<td>3M 3462-000 or TI H312113</td>
</tr>
<tr>
<td>Auxiliary¹</td>
<td>60</td>
<td>0.1</td>
<td>AMP PE5-14559 or TI H311130</td>
</tr>
</tbody>
</table>

Note 1. Connector heights and wire-wrap pin lengths are not guaranteed to conform to Intel OEM or system packaging. Auxiliary connector is used for test purposes only.

Line Drivers and Terminators
I/O Drivers — The following line drivers and terminators are compatible with all the I/O driver sockets on the iSBC 517:

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I, OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I, OC</td>
<td>16</td>
</tr>
<tr>
<td>7429</td>
<td>NI, OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I, OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

Note 1 = inverting; NI = non-inverting; OC = open-collector.

Ports 1 and 4 have 25 mA totem-pole drivers and 1 kΩ terminators.

I/O Terminators — 220Ω/330Ω divider or 1 kΩ pullup

```
+5V          2200
      3300    | ISBC 901 OPTION
2200/3300          

1 kΩ +5V          1 kΩ    | ISBC 902 OPTION
```

Bus Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-state</td>
<td>50</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-state</td>
<td>25</td>
</tr>
</tbody>
</table>

Physical Characteristics
Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 14 oz (397.3 gm)

Electrical Characteristics
Average DC Current
\( V_{CC} = +5V \pm 5\% \)
\( V_{DD} = +12V \pm 5\% \)
\( V_{AA} = -12V \pm 5\% \)
\( I_{CC} = 2.4 \text{ mA max} \)
\( I_{DD} = 40 \text{ mA max} \)
\( I_{AA} = 60 \text{ mA max} \)

Note
Does not include power required for optional I/O drivers and I/O terminators. With eight 220Ω/330Ω input terminators installed, all terminator inputs low.

Environmental Characteristics
Operating Temperature — 0 °C to +55 °C

Reference Manual

9800388B — iSBC 517 hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.
iSBC 519 (or pSBC 519*)
PROGRAMMABLE I/O EXPANSION BOARD

- iSBC I/O expansion via direct MULTIBUS interface
- 72 programmable I/O lines with sockets for interchangeable line drivers and terminators
- Jumper selectable I/O port addresses
- Jumper selectable 0.5, 1.0, 2.0, or 4.0 ms interval timer
- Eight maskable interrupt request lines with priority encoded and programmable interrupt algorithms

The iSBC 519 Programmable I/O Expansion Board is a member of Intel's complete line of iSBC memory and I/O expansion boards. The iSBC 519 interfaces directly to any iSBC single board computer via the system bus to expand input and output port capacity. The iSBC 519 provides 72 programmable I/O lines. The system software is used to configure the I/O lines to meet a wide variety of peripheral requirements. The flexibility of the I/O interface is further enhanced by the capability of selecting the appropriate combination of optional line drivers and terminators to provide the required sink current, polarity, and drive/termination characteristics for each application. Address selection is accomplished by using wire-wrap jumpers to select one of 16 unique base addresses for the input and output ports. The board operates with a single +5V power supply.

*Same product, manufactured by Intel Puerto Rico, Inc.
FUNCTIONAL DESCRIPTION

The 72 programmable I/O lines on the iSBC 519 are implemented utilizing three Intel 8255 programmable peripheral interfaces. The system software is used to configure the I/O lines in any combination of unidirectional input/output and bidirectional ports indicated in Table 1. In order to take full advantage of the large number of possible I/O configurations, sockets are provided for interchangeable I/O line drivers and terminators. The 72 programmable I/O lines and signal ground lines are brought out to three 50-pin edge connectors that mate with flat, round, or woven cable.

Interval Timer

Typical I/O read access time is 350 nanoseconds.

Table 1. Input/Output Port Modes of Operation

<table>
<thead>
<tr>
<th>Ports</th>
<th>Lines (qty)</th>
<th>Mode of Operation</th>
<th>Unidirectional</th>
<th>Bidirectional</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Input</td>
<td>Output</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unlatched</td>
<td>Latched &amp;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Strobed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Latched</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&amp; Strobed</td>
<td></td>
</tr>
<tr>
<td>1,4,7</td>
<td>8</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2,5,8</td>
<td>8</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3,6,9</td>
<td>4</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>1,2,3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes
1. Part of port 3 must be used as a control port when either port 1 or port 2 are used as a latched and strobed input or a latched and strobed output port or port 1 is used as a bidirectional port.
2. Part of port 6 must be used as a control port when either port 4 or port 5 are used as a latched and strobed input or a latched and strobed output port or port 4 is used as a bidirectional port.
3. Part of port 9 must be used as a control port when either port 7 or port 8 are used as a latched and strobed input or a latched and strobed output port or port 7 is used as a bidirectional port.

Figure 1. iSBC 519 Programmable I/O Expansion Board Block Diagram
Table 2. Interrupt Priority Options

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully nested</td>
<td>Interrupt request line priorities fixed at 0 as highest, 7 as lowest.</td>
</tr>
<tr>
<td>Auto-rotating</td>
<td>Equal priority. Each level, after receiving service, becomes the lowest priority level until next interrupt occurs.</td>
</tr>
<tr>
<td>Specific priority</td>
<td>System software assigns lowest priority level. Priority of all other levels are based in sequence numerically on this assignment.</td>
</tr>
</tbody>
</table>

The incoming requests are of the highest priority, determines whether this request is of higher priority than the level currently being serviced, and if appropriate, issues an interrupt to the system master. Any combination of interrupt levels may be masked through storage, via software, of a single byte to the interrupt mask register of the PIC.

**Interrupt Request Generation** — Interrupt requests may originate from 10 sources. Six jumper selectable interrupt requests can be automatically generated by the programmable peripheral interfaces when a byte of information is read to be transferred to the system master (i.e., input buffer is full) or a character has been transmitted (i.e., output data buffer is empty). Three interrupt request lines may be interfaced to the PIC directly from user designated peripheral devices via the I/O edge connectors. One interrupt request may be generated by the interval timer.

**Bus Line Drivers** — The PIC interrupt request output line may be jumper selected to drive any of the nine interrupt lines on the MULTIBUS. Any of the on-board request lines may also drive any interface interrupt line directly via jumpers and buffers on the board.

**SPECIFICATIONS**

**Addressing**

<table>
<thead>
<tr>
<th>Port</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>8255 No. 1 Control</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8255 No. 2 Control</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>8255 No. 3 Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>X0</td>
<td>X1</td>
<td>X2</td>
<td>X3</td>
<td>X4</td>
<td>X5</td>
<td>X6</td>
<td>X7</td>
<td>X8</td>
<td>X9</td>
<td>XA</td>
<td>XB</td>
</tr>
</tbody>
</table>

**Interrupts**

Register Addresses (hex notation, I/O address space)
- XD: Interrupt request register
- XC: In-service register
- XD: Mask register
- XC: Command register
- XD: Block address register
- XC: Status (polling register)

**Interfaces**

- **Bus** — All signals TTL compatible
- **Parallel I/O** — All signals TTL compatible
- **Interrupt Requests** — All TTL compatible

**Connectors**

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (qty)</th>
<th>Centers (in.)</th>
<th>Matting Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>86</td>
<td>0.156</td>
<td>Viking 3KH43/9AMK12</td>
</tr>
<tr>
<td>Parallel I/O</td>
<td>50</td>
<td>0.1</td>
<td>3M 3415-000 or Ti H312125</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>26</td>
<td>0.1</td>
<td>3M 3462-000 or Ti H312113</td>
</tr>
<tr>
<td>Auxiliary</td>
<td>60</td>
<td>0.1</td>
<td>AMP PE6-14559 or Ti H311120</td>
</tr>
</tbody>
</table>

**Note**

1. Connector heights and wire-wrap pin lengths are not guaranteed to conform to Intel OEM or System packaging.

**Line Drivers and Terminators**

**I/O Drivers** — The following line drivers and terminators are compatible with all the I/O driver sockets on the ISBC 519:

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>I,OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7432</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

**Note**

1 = inverting; NI = non-inverting; OC = open-collector.
I/O Terminators — 220Ω/330Ω divider or 1 kΩ pullup

Ports 1, 4, and 7 may use any of the drivers or terminators shown above for unidirectional (input or output) port configurations. Either terminator and the following bidirectional drivers and terminators may be used for ports 1, 4, and 7 when these ports are used as bidirectional ports.

Bidirectional Drivers

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel 8216</td>
<td>NI, TS</td>
<td>25</td>
</tr>
<tr>
<td>Intel 8226</td>
<td>I, TS</td>
<td>50</td>
</tr>
</tbody>
</table>

Note
I = inverting; NI = non-inverting; TS = three-state.

Terminators (for ports 1, 4, and 7 when used as bidirectional ports)

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Product Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTS</td>
<td>760-</td>
</tr>
<tr>
<td>Dale</td>
<td>LDP14k-02</td>
</tr>
<tr>
<td>Beckman</td>
<td>899-1</td>
</tr>
</tbody>
</table>

Bus Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-state</td>
<td>50</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-state</td>
<td>25</td>
</tr>
</tbody>
</table>

Physical Characteristics

Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 14 oz (397.3 gm)

Electrical Characteristics

Average DC Current

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Without Termination</th>
<th>With Termination</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CC} = +5V ±5%$</td>
<td>$I_{CC} = 1.5A$ max</td>
<td>3.5A max</td>
</tr>
</tbody>
</table>

Note
1. Does not include power required for optional I/O drivers and I/O terminators.
2. With 18 220Ω/330Ω input terminators installed, all terminator inputs low.

Environmental Characteristics

Operating Temperature — 0°C to +55°C

Reference Manual

9800385B — ISBC 519 hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.
The iSBC 556 Optically Isolated I/O Board provides 48 digital input/output lines with isolation between process application or peripheral device and the iSBC 80 series single board computers. The iSBC 556 contains two 8255A programmable interface devices, and sockets for user supplied optically isolated drivers, receivers, and input resistor terminators, together with common interrupt logic and iSBC 80 bus interface logic. Input signals can be single-ended or differential types with user defined input range (resistor terminator and opto-isolated receiver selection), allowing flexibility in design of voltage and threshold levels. The output allows user selection of Opto-Isolated Darlington Pair which can be used as an output driver either as an open collector or current switch.
Table 1. I/O Ports Opto-Isolator Receivers, Drivers, and Terminators

<table>
<thead>
<tr>
<th>Port No.</th>
<th>Type of I/O</th>
<th>Lines (qty)</th>
<th>Resistor Terminator Pac Rp 16-Pin DIP Bourns 4116R-00 or Equivalent</th>
<th>Dual Opto-Isolator 8-Pin Dip Monsanto MC T66 or Equivalent</th>
<th>Dual Opto-Isolator Darlington Pair 6-Pin DIP Monsanto 4N29, 30 31, 32 or Equivalent</th>
<th>Driver 7438 or Equivalent</th>
<th>Pull-Up Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>X+0</td>
<td>Input</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>X+1</td>
<td>Output</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>X+2</td>
<td>Input/Control</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>X+4</td>
<td>Input</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>X+5</td>
<td>Output</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>X+6</td>
<td>Input/Control</td>
<td>8</td>
<td>1 if input</td>
<td>8</td>
<td>2 if output</td>
<td>2 if input</td>
<td>—</td>
</tr>
</tbody>
</table>

SPECIFICATIONS

Number of Lines

- 24 input lines
- 16 output lines
- 8 programmable lines: 4 input — 4 output

I/O Interface Characteristics

- Line-to-Line Isolation — 235V DC or peak AC
- Input/Output Isolation — 500V DC or peak AC

![Diagram of bus interface characteristics]

Bus Interface Characteristics

All data address and control commands are ISBC 80 bus compatible.

I/O Addressing

<table>
<thead>
<tr>
<th>Address</th>
<th>8255 #1</th>
<th>Control</th>
<th>8255 #2</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>X+0</td>
<td>X+1</td>
<td>X+2</td>
<td>X+3</td>
<td>X+4</td>
</tr>
</tbody>
</table>

Where: base address is from 00H to 1FH (jumper selectable)

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 556</td>
<td>Optically Isolated I/O Board</td>
</tr>
</tbody>
</table>
iSBC 569
INTELLIGENT DIGITAL CONTROLLER

- Single board digital I/O controller with up to four microprocessors to share the digital input/output signal processing
- 3 MHz 8085A central control processor
- Three sockets for 8041/8741A Universal Peripheral Interface (UPI-41A) for distributed digital I/O processing, such as:
  - Industrial signal processor (iSBC 941)
  - Custom programmed 8041A/8741A
- Three operational modes
  - Stand-alone digital controller
  - MULTIBUS master
  - Intelligent slave (slave to MULTIBUS master)
- 2K bytes of dual port static read/write memory
- Sockets for up to 8K bytes of Intel 2758, 2716, 2732 erasable programmable read only memory
- 48 programmable parallel I/O lines with sockets for interchangeable line drivers or terminators
- Three programmable counters
- 12 levels of programmable interrupt control
- Single +5V supply
- MULTIBUS standard control logic compatible with optional iSBC 80 and iSBC 86 CPU, memory, and I/O expansion boards

The Intel iSBC 569 Intelligent Digital Controller is a single board computer (8085A based) with sockets for three 8041A/8741A Universal Peripheral Interface chips (UPI-41A). The I/O processing algorithm may be tailored to application requirements using designer selected combinations of standard Intel industrial signal processors (e.g., iSBC 941) or user programmed UPI-41A processors. These devices may be used to offload the 8085A processor from time consuming tasks such as pulse counting, event sensing, and parallel or serial digital I/O data formatting with error checking and handshaking. The iSBC 569 board is a complete digital controller with up to four processors on a single 6.75 inches x 12.00 inches (17.15cm x 30.48cm) printed circuit board. The 8085A CPU, system clock, read/write memory, non-volatile memory, priority interrupt logic, programmable timers, MULTIBUS control and interface logic, optional UPI processors and optional line driver and terminators all reside on one board.
FUNCTIONAL DESCRIPTION

Intelligent Digital Controller

Three modes of operation — the iSBC 569 Intelligent Digital Controller is capable of operating in one of three modes; stand alone controller, bus master, or intelligent slave.

Stand alone controller — the iSBC 569 board may function as a stand alone, single board controller with CPU, memory, and I/O elements on a single board. Five volt (+5VDC) only operation allows configuration of low cost controllers with only a single power supply voltage. The on-board 2K bytes RAM and up to 16K bytes ROM/EPROM, as well as the assistance of three UPI-41A processors, allow significant digital I/O control from a single board.

Bus master — in this mode of operation, the iSBC 569 controller may interface with and control iSBC expansion memory and I/O boards, or even other iSBC 569 Intelligent Digital Controllers configured as intelligent slaves (but no additional bus masters).

Intelligent slave — the iSBC 569 controller can perform as an intelligent slave to any 8- or 16-bit MULTIBUS master CPU by offloading the master of digital control related tasks. Preprocessing of data for the master is controlled by the on-board 8085A CPU which coordinates up to three UPI-41A processors. Using the iSBC 569 board as an intelligent slave, multi-channel digital control can be managed entirely on-board, freeing a system master to perform other system functions. The dual port RAM memory allows the iSBC 569 controller to process and store data without MULTIBUS memory contention.

Simplified Programming

By using Intel UPI-41A processors for common tasks such as counting, sensing change of state, printer control and keyboard scanning/debouncing, the user frees up time to work on the more important application programming of machine or process optimization. Controlling the Intel UPI-41A processors becomes a simple task of reading or writing command and data bytes to or from the data bus buffer register on the UPI device. Programming the iSBC 941 Industrial Digital Processor to produce a pulse output, for example, is as simple as sending command and parameter bytes indicating initialization, pulse output selection, period and delay parameters, followed by a command to begin execution.

Central Processing Unit

A powerful Intel 8085A 8-bit CPU, fabricated on a single LSI chip, is the central processor for the iSBC 569™ controller. The six general purpose 8-bit registers may be addressed individually or in pairs, providing both single and double precision operations. The program counter can address up to 64K bytes of memory using iSBC expansion boards. The 16-bit stack pointer controls the addressing of an external stack. This stack provides sub-routine nesting bounded only by memory size. The minimum instruction execution time is 1.30 microseconds. The 8085A CPU is software compatible with the Intel 8080A CPU.

Bus Structure

The iSBC 569 Intelligent Digital Controller utilizes a triple bus architecture concept. An internal bus is used for on-board memory and I/O operations. A MULTIBUS interface is available to provide access for all external memory and I/O operations. A dual port bus with controller enables access via the third bus to 2K bytes of static RAM from either the on-board CPU or a system master. Hence, common data may be stored in on-board memory and may be accessed either by the on-board CPU or by system masters. A block diagram of the iSBC 569 functional components is shown in Figure 1.

![Figure 1. iSBC 569 Intelligent Digital Controller Block Diagram](image-url)
RAM Capacity
The iSBC 569 board contains 2K bytes of read/write memory using Intel 2114 static RAMs. RAM accesses may occur from either the iSBC 569 controller or from any other bus master interfaced via the MULTIBUS system bus. The iSBC 569 board provides addressing jumpers to allow the on-board RAM to reside within a one megabyte address space when accessed via the system bus. In addition, a switch is provided which allows the user to reserve a 1K byte segment of on-board RAM for use by the 8085A CPU. This reserved RAM space is not accessible via the system bus and does not occupy any system address space.

EPROM/ROM Capacity
Two sockets for up to 16K bytes of nonvolatile read only memory are provided on the iSBC 569 board. Nonvolatile memory may be added in 1K-byte increments up to a maximum of 2K bytes using Intel 2758 erasable and electrically reprogrammable ROMs (EPROMs); in 2K-byte increments up to a maximum of 4K bytes using Intel 2316 ROMs or 2716 EPROMs; in 4K byte increments up to 8K bytes maximum using Intel 2732 EPROMs; or in 8K-byte increments up to 16K bytes maximum using Intel 2364 ROMs (both sockets must contain same type ROM/EPROM). All on-board ROM/EPROM operations are performed at maximum processor speed.

Universal Peripheral Interfaces (UPI-41A)
The iSBC 569 Intelligent Digital Controller board provides three sockets for user supplied Intel 8041A/8741A Universal Peripheral Interface (UPI-41A) chips. Sockets are also provided for the associated line drivers and terminators for the UPI I/O ports. The UPI-41A processor is a single chip microcomputer containing a CPU, 1K bytes of ROM (8041A) or EPROM (8741A), 64 bytes of RAM, 16 programmable I/O lines, and an 8-bit timer/event counter. Special interface registers included in the chip allow the UPI-41A processor to function as a slave processor to the iSBC 569 controller board’s 8085A CPU. The UPI processor allows the user to specify algorithms for controlling peripherals directly thereby freeing the 8085A for other system functions. For additional information, including UPI-41A instructions, refer to the UPI-41 User’s Manual (Manual No. 9800504).

Industrial Digital Processor (iSBC 941)
The iSBC 941 Industrial Digital Processor is a 40-pin DIP device which provides the user with easy-to-use processing of digital input and output signals desired in many industrial automation environments. One of nine digital I/O functions can be selected at any one time for measuring, counting, or controlling up to 16 separate I/O lines. An additional eight utility commands allow reading or setting the condition of unused I/O lines. Simplex serial input and output modes can assemble or disassemble bytes transmitted asynchronously over TTL lines, including insertion and deletion of start/stop bits. The iSBC 941 processor plugs into any of the three UPI-41A sockets on the iSBC 569 board. Simple programming commands from the master 8085A processor can thus implement up to 48 lines of preprocessed digital I/O signals. For specific commands and further information, refer to the iSBC 941 Data Sheet in this document.

Programmable Timers
The iSBC 569 Intelligent Digital Controller board provides three independently programmable interval timer/counters utilizing one Intel 8253 Programmable Interval Timer (PIT). The Intel 8253 PIT provides three 16-bit BCD or binary interval timer/counters. Each timer may be used to provide a time reference for each UPI™ processor or for a group of UPI processors. The output of each timer also connects to the 8259A Programmable Interrupt Controller (PIC) providing the capability of timed interrupts. All gate inputs, clock inputs, and timer outputs of the 8253 PIT are available at the I/O ports for external access.

Timer Functions — In utilizing the iSBC 569 controller, the systems designer simply configures, via software, each timer to meet systems requirements. The 8253 PIT modes are listed in Table 1. The contents of each counter may be read at any time during system operation with simple read operations for event counting applications. The contents of each counter can be read “on-the-fly” for time stamping events or time clock referenced program initiations.

Table 1. 8253 Programmable Timer Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal count</td>
<td>When terminal count is reached, an interrupt request is generated.</td>
</tr>
<tr>
<td>Programmable one-shot</td>
<td>Output goes low upon receipt of an external trigger edge or software command and returns high when terminal count is reached. This function is retriggerable.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle, and the period from one low-going pulse to the next is N times the input clock period.</td>
</tr>
<tr>
<td>Square-wave rate generator</td>
<td>Output will remain high until one-half the count has been completed, and go low for the other half of the count.</td>
</tr>
<tr>
<td>Software triggered strobe</td>
<td>Output remains high until software loads count (N). N counts after count is loaded, output goes low for one input clock period.</td>
</tr>
<tr>
<td>Hardware triggered strobe</td>
<td>Output goes low for one clock period N counts after rising edge on counter trigger input. The counter is retriggerable.</td>
</tr>
<tr>
<td>Event counter</td>
<td>On a jumper selectable basis, the clock input becomes an input from the external system. CPU may read the number of events occurring after the counting “window” has been enabled or an interrupt may be generated after N counts occur in the system.</td>
</tr>
</tbody>
</table>
Interrupt Capability

The iSBC 569 Intelligent Digital Controller provides interrupt service for up to 12 interrupt sources. Any of the 12 sources may interrupt the on-board processor. Four interrupt levels are handled directly by the 8085A CPU and eight levels are serviced from an Intel 8259A Programmable Interrupt Controller (PIC) routing an interrupt request output to the INTR input of the 8085A.

8085A Interrupt — Each of four direct 8085A interrupt inputs has a unique vector memory address. An 8085A jump instruction at each of these addresses then provides software linkage to interrupt service routines located independently anywhere in the memory.

8259A Interrupts — The eight interrupt sources originate from both on-board controller functions and the system bus:

- UPI-41A Processors — one interrupt from each of three UPI processor sockets.
- 8253 PIT — one interrupt from each of three timer outputs.
- MULTIBUS System Bus — one of eight MULTIBUS interrupt lines may be jumpered to either of two 8259A PIC interrupt inputs.

Programmable Reset — The iSBC 569 Intelligent Digital Controller board has a programmable output latch used to control on-board functions. Three of the outputs are connected to separate UPI-41A RESET inputs. Thus, the user can reset any or all of the UPI-41A processors under software control. A fourth latch output may be used to generate an interrupt request onto the MULTIBUS interrupt lines. A fifth latch output is connected to a light-emitting diode which may be used for diagnostic purposes.

Expansion Capabilities

When the iSBC 569 controller is used as a single board digital controller, memory and I/O capacity may be expanded using Intel MULTIBUS compatible expansion boards. In this mode, no other bus masters may be in the system. Memory may be expanded to a 64K byte capacity by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capacity may be increased by adding I/O expansion boards. Multiple iSBC 569 boards may be included in an expanded system using one iSBC 569 Intelligent Digital Controller as the system master and additional controllers as intelligent slaves.

Intelligent Slave Programming

When used as an intelligent slave, the iSBC 569 controller appears as an additional RAM memory module. System bus masters communicate with the iSBC 569 board as if it were just an extension of system memory. To simplify this communication, the user has been given some specific tools:

Flag Interrupt — The Flag Interrupt is generated any time a write command is performed by an off-board CPU to the first location of ISBC 569 RAM. This interrupt provides a means for the master CPU to notify the iSBC 569 controller that it wished to establish a communications sequence. The flag interrupt is cleared when the on-board processor reads the first location of its RAM. In systems with more than one intelligent slave, the flag interrupt provides a unique interrupt to each slave outside the normal MULTIBUS interrupt lines (IN/0~INT7/).

RAM — The on-board 2K byte RAM area that is accessible to both an off-board CPU and the on-board 8085A may be configured for system access on any 2K boundary.

MULTIBUS Interrupts — The third tool to improve system operation as an intelligent slave is access to the MULTIBUS interrupt lines. The iSBC 569 controller can both respond to interrupt signals from an off-board CPU, and generate an interrupt to the off-board CPU via the system bus.

System Development Capability

Software development for the iSBC 569 Intelligent Digital Controller board is supported by the Intellec® Microcomputer Development System including a resident macroassembler, text editor, system monitor, a linker, object code locator, and Library Manager. In addition, both PL/M and FORTRAN language programs can be compiled to run on the iSBC 569 board. A unique in-circuit emulator (ICE-85™) option provides the capability of developing and debugging software directly on the iSBC 569 board. This greatly simplifies the design, development, and debug of iSBC 569 system software.

SPECIFICATIONS

8085A CPU

Word Size — 8, 16 or 24 bits
Cycle Time — 1.30 μsec ± .1% for fastest executable instruction; i.e., four clock cycles.
Clock Rate — 3.07 MHz ± .1%
System Access Time
Dual port memory — 725 nsec
Memory Capacity
On-board ROM/EPROM — 2K, 4K, 8K, or 16K bytes of user installed ROM or EPROM
On-board RAM — 2K bytes of static RAM. Fully accessible from on-board 8085A. Separately addressable from system bus.
Off-board expansion — up to 64K bytes of EPROM/ROM or RAM capacity.

I/O Capacity

Parallel-Timers — Three timers, with independent gate input, clock input, and timer output user-accessible. Clock inputs can be strapped to an external source or to an on-board 1.3824 MHz reference. Each timer is connected to a 8259A Programmable Interrupt Controller and may also be optionally connected to UPI processors.

UPI-I/O — Three UPI-41A interfaces, each with two 8-bit I/O ports plus the two UPI Test Inputs. The 8-bit ports are user-configurable (as inputs or outputs) in groups of four.
Serial — 1 TTL compatible serial channel utilizing SID and SOD lines of on-board 8085A CPU

On-Board Addressing
All communications to the UPI-41A processors, to the programmable reset latch, to the timers, and to the interrupt controller are via read and write commands from the on-board 8085A CPU.

Memory Addressing
On-board ROM/EPROM — 0-07FF (using 2758 EPROMs); 0-OFF (using 2716 EPROMs or 2316 ROMs); 0-1FFF (using 2732 EPROMs); 0-3FFF (using the 2364 ROMs)
On-board RAM — 8000-87FF System access — any 2K increment 0000-FF800 (switch selectable); 1 K bytes may be disabled from bus access by switch selection.

I/O Addressing

<table>
<thead>
<tr>
<th>Source</th>
<th>Addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td>8253</td>
<td>0EH-0EH</td>
</tr>
<tr>
<td>UPI0</td>
<td>0E4H-0E5H</td>
</tr>
<tr>
<td>UPI1</td>
<td>0E6H-0E7H</td>
</tr>
<tr>
<td>UPI2</td>
<td>0E8H-0E9H</td>
</tr>
<tr>
<td>PROGRAMMABLE RESET</td>
<td>0EAH-0EBH</td>
</tr>
<tr>
<td>8259A</td>
<td>0ECH-0EDH</td>
</tr>
</tbody>
</table>

Timer Specifications
Input frequencies — jumper selectable reference
- Internal: 1.3824 MHz ± .1% (.723 μsec, nominal)
- External: User supplied (2 MHz maximum)

Output Frequencies (at 1.3824 MHz)

<table>
<thead>
<tr>
<th>Function</th>
<th>Min¹</th>
<th>Max¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-time interrupt interval</td>
<td>1.45 μsec</td>
<td>47.4 msec</td>
</tr>
<tr>
<td>Rate Generator (frequency)</td>
<td>21.09 Hz</td>
<td>691.2 KHz</td>
</tr>
</tbody>
</table>

¹ Single 16-bit binary count

Interfaces
MULTIBUS™ Interface — All signals compatible with iSBC and MULTIBUS architecture
Parallel I/O — All signals TTL compatible
Interrupt Requests — All TTL compatible
Timer — All signals TTL compatible
Serial I/O — All signals TTL compatible

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (q/t)</th>
<th>Centers (in.)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>86</td>
<td>0.156</td>
<td>Viking®3KH43/6AM12</td>
</tr>
<tr>
<td>Parallel I/O</td>
<td>50</td>
<td>0.1</td>
<td>3M 3415-000 or TI H31212S</td>
</tr>
</tbody>
</table>

Physical Characteristics
Width — 30.48 cm (12.00 inches)

Depth — 17.15 cm (6.75 inches)
Thickness — 1.27 cm (0.50 inch)
Weight — 3.97 gm (14 ounces)

Electrical Characteristics
DC Power Requirements — +5V @ 2.58A with no optional devices installed. For each 8741A add 135 mA. For each 220/330 resistor network, add 60 mA. Add the following for each EPROM/ROM installed.

<table>
<thead>
<tr>
<th>Type</th>
<th>1ROM</th>
<th>2ROMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2758</td>
<td>100 mA</td>
<td>125 mA</td>
</tr>
<tr>
<td>2716</td>
<td>100 mA</td>
<td>125 mA</td>
</tr>
<tr>
<td>2316E</td>
<td>120 mA</td>
<td>240 mA</td>
</tr>
<tr>
<td>2732</td>
<td>40 mA</td>
<td>55 mA</td>
</tr>
<tr>
<td>2364</td>
<td>40 mA</td>
<td>55 mA</td>
</tr>
</tbody>
</table>

Line Drivers and Terminators
I/O Drivers — The following line drivers are all compatible with the I/O driver sockets on the iSBC 569 Intelligent Digital Controller.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7438</td>
<td>OC</td>
<td>48</td>
</tr>
<tr>
<td>7437</td>
<td>I</td>
<td>48</td>
</tr>
<tr>
<td>7426</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7409</td>
<td>NI,OC</td>
<td>16</td>
</tr>
<tr>
<td>7408</td>
<td>NI</td>
<td>16</td>
</tr>
<tr>
<td>7403</td>
<td>I,OC</td>
<td>16</td>
</tr>
<tr>
<td>7400</td>
<td>I</td>
<td>16</td>
</tr>
</tbody>
</table>

Note  I = inverting; NI = non-inverting; OC = open collector.

I/O Terminators — 220Ω/330Ω divider or 1 kΩ pullup

Environmental Characteristics
Operating Temperature — 0°C to 55°C (32°F to 131°F)
Relative Humidity — To 90% without condensation

Reference Manuals
9800445-01 — iSBC 569 Intelligent Digital Controller Board Hardware Reference Manual (NOT SUPPLIED)
9803077 — iSSC 941 Digital Signal Processor User's Guide (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.
Communication
Controllers
iSBC™ 534 (or pSBC 534*)
FOUR CHANNEL COMMUNICATION EXPANSION BOARD

- Serial I/O expansion through four programmable synchronous and asynchronous communications channels
- Individual software programmable baud rate generation for each serial I/O channel
- Two independent programmable 16-bit interval timers
- Sixteen maskable interrupt request lines with priority encoded and programmable interrupt algorithms
- Jumper selectable interface register addresses
- 16-bit parallel I/O interface compatible with Bell 801 automatic calling unit
- RS232C/CCITT V.24 interfaces plus 20 mA optically isolated current loop interfaces (sockets)
- Programmable digital loopback for diagnostics
- Interface control for auto answer and auto originate modems

The iSBC 534 Four Channel Communication Expansion Board is a member of Intel's complete line of memory and I/O expansion boards. The iSBC 534 interfaces directly to any single board computer via the MULTIBUS to provide expansion of system serial communications capability. Four fully programmable synchronous and asynchronous serial channels with RS232C buffering and provision for 20 mA optically isolated current loop buffering are provided. Baud rates, data formats, and interrupt priorities for each channel are individually software selectable. In addition to the extensive complement of EIA Standard RS232C signals provided, the iSBC 534 provides 16 lines of RS232C buffered programmable parallel I/O. This interface is configured to be directly compatible with the Bell Model 801 automatic calling unit. These capabilities provide a flexible and easy means for interfacing Intel iSBC based systems to RS232C and optically isolated current loop compatible terminals, cassettes, asynchronous and synchronous modems, and distributed processing networks.
FUNCTIONAL DESCRIPTION
Communications Interface

Four programmable communications interfaces using Intel's 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) are contained on the board. Each USART can be programmed by the system software to individually select the desired asynchronous or synchronous serial data transmission technique (including IBM Bisync). The mode of operation (i.e., synchronous or asynchronous), data format, control character format, parity, and baud rate are all under program control. Each 8251A provides full duplex, double buffered transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in each USART. Each set of RS232C command lines, serial data lines, and signal ground lines are brought out to 26-pin edge connectors that mate with RS232C flat or round cables.

16-Bit Interval Timers
The iSBC 534 provides six fully programmable and independent BCD and binary 16-bit interval timers utilizing two Intel 8253 programmable interval timers. Four timers are available to the systems designer to generate baud rates for the USARTs under software control. Routing for the outputs from the other two counters is jumper selectable. Each may be independently routed to the programmable interrupt controller to provide real time clocking or to the USARTs (for applications requiring different transmit and receive baud rates). In utilizing the iSBC 534, the systems designer simply figures, via software, each timer independently to meet system requirements. Whenever a given baud rate or time delay is needed, software commands to the programmable timers select the desired function. Three functions of these timers are supported on the iSBC 534, as shown in Table 1. The contents of each counter may be read at any time during system operation.

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on terminal count</td>
<td>When terminal count is reached an interrupt request is generated. This function is used for the generation of real-time clocks.</td>
</tr>
<tr>
<td>Rate generator</td>
<td>Divide by N counter. The output will go low for one input clock cycle and high for N – 1 input clock periods.</td>
</tr>
<tr>
<td>Square wave rate generator</td>
<td>Output will remain high for one-half the count and low for the other half of the count.</td>
</tr>
</tbody>
</table>

Interrupt Request Lines
Two independent Intel 8259A programmable interrupt controllers (PIC's) provide vectoring for 16 interrupt levels. As shown in Table 2, a selection of three priority processing algorithms is available to the system designer. The manner in which requests are serviced may thus be configured to match system requirements. Priority assignments may be reconfigured dynamically via software at any time during system operation. Any combination of interrupt levels may be masked through storage, via software, of a single byte to the interrupt mask register of each PIC. Each PIC's interrupt request

Figure 1. iSBC 534 Four Channel Communications Expansion Board Block Diagram
output line may be jumper selected to drive any of the nine interrupt lines on the MULTIBUS.

### Table 2. Interrupt Priority Options

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully nested</td>
<td>Interrupt request line priorities fixed at 0 as highest, 7 as lowest.</td>
</tr>
<tr>
<td>Auto-rotating</td>
<td>Equal priority. Each level, after receiving service, becomes the lowest priority level until next interrupt occurs.</td>
</tr>
<tr>
<td>Specific priority</td>
<td>System software assigns lowest priority level. Priority of all other levels based in sequence numerically on this assignment.</td>
</tr>
</tbody>
</table>

**Interrupt Request Generation** — As shown in Table 3, interrupt requests may originate from 16 sources. Two jumper selectable interrupt requests (8 total) can be automatically generated by each USART when a character is ready to be transferred to the MULTIBUS system bus (i.e., receive buffer is full) or a character has been transmitted (transmit buffer is empty). Jumper selectable requests can be generated by two of the programmable timers (PITs), and six lines are routed directly from peripherals to accept carrier detect (4 lines), ring indicator, and the Bell 801 present next digit request lines.

**Systems Compatibility**
The isBC 534 provides 16 RS232C buffered parallel I/O lines implemented utilizing an Intel 8255A programmable peripheral interface (PPI) configured to operate in mode 0.* These lines are configured to be directly compatible with the Bell 801 automatic calling unit (ACU). This capability allows the ISBC 534 to interface to Bell 801 type ACUs and up to four modems or other serial communications devices. For systems not requiring interface to an ACU, the parallel I/O lines may also be used as general purpose RS232C compatible control lines in system implementation.

**SPECIFICATIONS**

**Serial Communications Characteristics**

- **Synchronous** — 5-8 bit characters; internal or external character synchronization; automatic sync insertion.
- **Asynchronous** — 5-8 bit characters; break character generation; 1, 1½, or 2 stop bits; false start bit detection.

**Sample Baud Rates**¹

<table>
<thead>
<tr>
<th>Frequency (kHz, Software Selectable)</th>
<th>Baud Rate (Hz)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Synchronous</td>
<td>Asynchronous</td>
<td></td>
</tr>
<tr>
<td>153.6</td>
<td>-</td>
<td>16</td>
<td>64</td>
</tr>
<tr>
<td>76.8</td>
<td>-</td>
<td>960</td>
<td>2400</td>
</tr>
<tr>
<td>38.4</td>
<td>38400</td>
<td>480</td>
<td>1200</td>
</tr>
<tr>
<td>19.2</td>
<td>19200</td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>9.6</td>
<td>9600</td>
<td>600</td>
<td>150</td>
</tr>
<tr>
<td>4.8</td>
<td>4800</td>
<td>300</td>
<td>75</td>
</tr>
<tr>
<td>6.98</td>
<td>6980</td>
<td>-</td>
<td>110</td>
</tr>
</tbody>
</table>

**Notes:**

1. Baud rates shown here are only a sample subset of possible software-programmable rates available. Any frequency from 18.75 Hz to 614.4 kHz may be generated utilizing on-board crystal oscillator and 16-bit programmable interval timer (used here as frequency divider).

2. Frequency selected by I/O writes of appropriate 16-bit frequency factor to Baud Rate Register.

**Interval Timer and Baud Rate Generator Frequencies**

**Input Frequency** (On-Board Crystal Oscillator) — 1.2288 MHz ± 0.1% (0.813 μs period, nominal)

<table>
<thead>
<tr>
<th>Function</th>
<th>Single Timer</th>
<th>Dual/Timer Counter (Two Timers Cascaded)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Real-Time Interval Interrupt</td>
<td>1.63μs</td>
<td>53.3 ms</td>
</tr>
<tr>
<td>Rate Generator (Frequency)</td>
<td>18.75 Hz</td>
<td>614.4 kHz</td>
</tr>
</tbody>
</table>

**Interfaces** — RS232C Interfaces
- EIA Standard RS232C Signals provided and supported:
  - Carrier detect: Receive data
  - Clear to send: Ring indicator
  - Data set ready: Secondary receive data
  - Data terminal ready: Secondary transmit data
  - Request to send: Transmit clock
  - Receive clock: Transmit data

**Parallel I/O** — 8 input lines, 8 output lines, all signals RS232C compatible
**Bus** — All signals MULTIBUS system bus compatible

I/O Addressing
The USART, interval timer, interrupt controller, and parallel interface registers of the ISBC 534 are configured as a block of 16 I/O address locations. The location of this block is jumper selectable to begin at any 16-byte I/O address boundary (i.e., 00H, 10H, 20H, etc.).

I/O Access Time
400 ns USART registers
400 ns Parallel I/O registers
400 ns Interval timer registers
400 ns Interrupt controller registers

Compatible Connectors/Cable

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (qty)</th>
<th>Centers (in.)</th>
<th>Mating Connectors</th>
<th>Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>86</td>
<td>0.156</td>
<td>Viking 2KH43/9AMK12</td>
<td>N/A</td>
</tr>
<tr>
<td>Serial and parallel I/O</td>
<td>26</td>
<td>0.1</td>
<td>3M 3462-0001 or</td>
<td>Intel iSBC955</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TI H312113</td>
<td></td>
</tr>
</tbody>
</table>

Compatible Opto-Isolators

<table>
<thead>
<tr>
<th>Function</th>
<th>Supplier</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>Fairchild</td>
<td>4N33</td>
</tr>
<tr>
<td></td>
<td>General Electric</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monsanto</td>
<td></td>
</tr>
<tr>
<td>Receiver</td>
<td>Fairchild</td>
<td>4N37</td>
</tr>
<tr>
<td></td>
<td>General Electric</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monsanto</td>
<td></td>
</tr>
</tbody>
</table>

Physical Characteristics
Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 14 oz (398 gm)

Electrical Characteristics
Average DC Current

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Without Opto-Isolators</th>
<th>With Opto-Isolators</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC = +5V</td>
<td>1.9 A, max</td>
<td>1.9 A, max</td>
</tr>
<tr>
<td>VDD = +12V</td>
<td>275 mA, max</td>
<td>420 mA, max</td>
</tr>
<tr>
<td>VAA = −12V</td>
<td>250 mA, max</td>
<td>400 mA, max</td>
</tr>
</tbody>
</table>

Note
1. With four 4N33 and four 4N37 opto-isolator packages installed in sockets provided to implement four 20 mA current loop interfaces.

Environmental Characteristics
Operating Temperature — 0 °C to +55 °C

Reference Manual
9800450-02 — ISBC 534 Hardware Reference Manual (NOT SUPPLIED)
Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 534</td>
<td>Four Channel Communication Expansion Board</td>
</tr>
</tbody>
</table>
iSBC 544
INTELLIGENT COMMUNICATIONS CONTROLLER

- iSBC Communications Controller acting as a single board communications computer or an intelligent slave for communications expansion
- On-board dedicated 8085A Microprocessor providing communications control and buffer management for four programmable synchronous/asynchronous channels
- Sockets for up to 8K bytes of read only memory
- 16K bytes of dual port dynamic read/write memory with on-board refresh
- Extended MULTIBUS addressing permits iSBC 544 board partitioning into 16K-byte segments in a 1-megabyte address space
- Ten programmable parallel I/O lines compatible with Bell 801 Automatic Calling Unit
- Twelve levels of programmable interrupt control
- Individual software programmable baud rate generation for each serial I/O channel
- Three independent programmable interval timer/counters
- Interface control for auto answer and auto originate modem

The iSBC 544 Intelligent Communications Controller is a member of Intel's family of single-board computers, memory, I/O, and peripheral controller boards. The iSBC 544 board is a complete communications controller on a single 6.75 x 12.00 inch printed circuit card. The on-board 8085A CPU may perform local communications processing by directly interfacing with on-board read/write memory, nonvolatile read only memory, four synchronous/asynchronous serial I/O ports, RS232/RS366 compatible parallel I/O, programmable timers, and programmable interrupts.
isBC 544

FUNCTIONAL DESCRIPTION

Intelligent Communications Controller

Two Mode Operation — The isBC 544 board is capable of operating in one of two modes: 1) as a single board communications computer with all computer and communications interface hardware on a single board; 2) as an "intelligent bus slave" that can perform communications related tasks as a peripheral processor to one or more bus masters. The isBC 544 may be configured to operate as a stand-alone single board communications computer with all MPU, memory and I/O elements on a single board. In this mode of operation, the isBC 544 may also interface with expansion memory and I/O boards (but no additional bus masters). The isBC 544 performs as an intelligent slave to the bus master by performing all communications related tasks. Complete synchronous and asynchronous I/O and data management are controlled by the on-board 8085A CPU to coordinate up to four serial channels. Using the isBC 544 as an intelligent slave, multichannel serial transfers can be managed entirely on-board, freeing the bus master to perform other system functions.

Architecture — The isBC 544 board is functionally partitioned into three major sections: I/O, central computer, and shared dual port RAM memory (Figure 1). The I/O hardware is centered around the four Intel 8251A USART devices providing fully programmable serial interfacing. Included here as well is a 10-bit parallel interface compatible with the Bell 801 automatic calling unit, or equivalent. The I/O is under full control of the on-board CPU and is protected from access by system bus masters. The second major segment of the intelligent communications controller is a central computer, with an 8085A CPU providing powerful processing capability. The 8085A together with on-board EPROM / ROM, static RAM, programmable timers/counters, and program-

---

Figure 1. isBC 544 Intelligent Communications Controller Block Diagram
mable interrupt control provide the intelligence to manage sophisticated communications operations on-board the iSBC 544 board. The timer/counters and interrupt control are also common to the I/O area providing programmable baud rates to the USARTs and prioritizing interrupts generated from the USARTs. The central computer functions are protected for access only by the on-board 8085A. Likewise, the on-board 8085A may not gain access to the system bus when being used as an intelligent slave. When the iSBC 544 is used as a bus master, the on-board 8085A CPU controls complete system operation accessing on-board functions as well as memory and I/O expansion. The third major segment, dual port RAM memory, is the key link between the iSBC 544 intelligent slave and bus masters managing the system functions. The dual port concept allows a common block of dynamic memory to be accessed by the on-board 8085A CPU and off-board bus masters. The system program can, therefore, utilize the shared dual port RAM to pass command and status information between the bus masters and on-board CPU. In addition, the dual port concept permits blocks of data transmitted or received to accumulate in the on-board shared RAM, minimizing the need for a dedicated memory board.

Serial I/O
Four programmable communications interfaces using Intel's 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART) are contained on the board and controlled by the on-board CPU in combination with the on-board interval timer/counter to provide all common communication frequencies. Each USART can be programmed by the system software to individually select the desired asynchronous or synchronous serial data transmission technique (including IBM Bisync). The mode of operation (i.e., synchronous or asynchronous), data format, control character format, parity, and baud rate are all under program control. Each 8251A provides full duplex, double-buffered, transmit and receive capability. Parity, overrun, and framing error detection are all incorporated in each USART. Each channel is fully buffered to provide a direct interface to RS232C compatible terminals, peripherals, or synchronous/asynchronous modems. Each channel of RS232C command lines, serial data lines, and signal ground lines are brought out to 26-pin edge connectors that mate with RS232C flat or round cable.

Parallel I/O Port
The iSBC 544 provides a 10-bit parallel I/O interface controlled by an Intel 8155 Programmable Interface (PPI) chip. The parallel I/O port is directly compatible with an Automatic Calling Unit (ACU) such as the Bell Model 801, or equivalent, and can also be used for auxiliary functions. All signals are RS232C compatible, and the interface cable signal assignments meet RS366 specifications. For systems not requiring an ACU interface, the parallel I/O port can be used for any general purpose interface requiring RS232C compatibility.

Central Processing Unit
Intel's powerful 8-bit n-channel 8085A CPU, fabricated on a single LSI chip, is the central processor for the iSBC 544. The 8085A CPU is directly software compatible with the Intel 8080A CPU. The 8085A contains six 8-bit general purpose registers and an accumulator. The six general purpose registers may be addressed individually or in pairs, providing both single and double precision operators. The minimum instruction execution time is 1.45 microseconds. The 8085A CPU has a 16-bit program counter. An external stack, located within any portion of iSBC 544 read/write memory, may be used as a last-in/first-out storage area for the contents of the program counter, flags, accumulator, and all of the six general purpose registers. A 16-bit stack pointer controls the addressing of this external stack. This stack provides subroutine nesting bounded only by memory size.

EPROM/ROM Capacity
Sockets for up to 8K bytes of nonvolatile read only memory are provided on the iSBC 544 board. Read only memory may be added in 2K-byte increments up to a maximum of 4K bytes using Intel 2716 EPROMs or masked ROMs; or in 4K-byte increments up to 8K bytes maximum using Intel 2732 EPROMs. All on-board EPROM/ROM operations are performed at maximum processor speed.

RAM Capacity
The iSBC 544 contains 16K bytes of dynamic read/write memory using Intel 2117 RAMs. Power for the on-board RAM may be provided on an auxiliary power bus, and memory protect logic is included for RAM battery back-up requirements. The iSBC 544 contains a dual port controller, which provides dual port capability for the on-board RAM memory. RAM accesses may occur from either the on-board 8085A CPU or from another bus master, when used as an intelligent slave. Since on-board RAM accesses do not require the MULTI BUS, the bus is available for concurrent bus master use. Dynamic RAM refresh is accomplished automatically by the iSBC 544 for accesses originating from either the CPU or from the MULTI BUS.

Addressing — On board RAM, as seen by the on-board 8085A CPU, resides at address 8000-BFFF. On-board RAM, as seen by an off-board CPU, may be placed on any 4K-byte address boundary. The iSBC 544 provides extended addressing jumpers to allow the on-board RAM to reside within one megabyte address space when accessed via the MULTI BUS. In addition, jumper options are provided which allow the user to protect 8K- or 12K-bytes of on-board RAM for use by the on-board 8085 CPU only. This reserved RAM space is not accessible via the MULTI BUS and does not occupy any system address space.

Static RAM — The iSBC 544 board also has 256 bytes of static RAM located on the Intel 8155 PPI. This memory is only accessible to the on-board 8085A CPU and is located at address 7F00H-7FFFH.
Programmable Timers

The ISBC 544 board provides seven fully programmable and independent interval timer/counters utilizing two Intel 8253 Programmable Interval Timers (PIT), and the Intel 8155. The two Intel 8253 PITs provide six independent BCD or binary 16-bit interval timer/counters and the 8155 provides one 14-bit binary timer/counter. Four of the PIT timers (BDGO-3) are dedicated to the USARTs providing fully independent programmable baud rates.

Three General Use Timers — The fifth timer (BDG4) may be used as an auxiliary baud rate to any of the four USARTs or may alternatively be cascaded with timer six to provide extended interrupt intervals. The sixth PIT timer/counter (TINT1) can be used to generate interrupt intervals to the on-board 8085A. In addition to the timer/counters on the 8253 PITs, the ISBC 544 has a 14-bit timer available on the 8155 PPI providing a third general use timer/counter (TINT0). This timer output is jumper selectable to the interrupt structure of the on-board 8085A CPU to provide additional timer/counter capability.

Timer Functions — In utilizing the ISBC 544 board, the systems designer simply configures, via software, each timer independently to meet systems requirements. Whenever a given baud rate or interrupt interval is needed, software commands to the programmable timers select the desired function. The on-board PITs together with the 8155 provide a total of seven timer/counters and six operating modes. Mode 3 of the 8253 is the primary operating mode of the four dedicated USART baud rate generators. The timer/counters and useful modes of operation for the general use timer/counters are shown in Table 1.

Interrupt Capability

The ISBC 544 board provides interrupt service for up to 21 interrupt sources. Any of the 21 sources may interrupt the intelligent controller, and all are brought through the interrupt logic to 12 interrupt levels. Four interrupt levels are handled directly by the interrupt processing capability of the 8085A CPU and eight levels are serviced from an Intel 8259A Programmable Interrupt Controller (PIO) routing an interrupt request output to the INTR input of the 8085A (see Table 2).

Interrupt Sources — The 21 interrupt sources originate from both on-board communications functions and the Multibus. Two interrupts are routed from each of the four USARTs (8 interrupts total) to indicate that the transmitter and receiver are ready to move a data byte to or from the on-board CPU. The PIC is dedicated to accepting these 8 interrupts to optimize USART service request. One of eight interrupt request lines is jumper selectable for direct interface from a bus master via the system bus. Two auxiliary timers (TINT0 from 8155 and TINT1 from 8253) are jumper selectable to provide general purpose counter/timer interrupts. A jumper selectable Flag Interrupt is generated to allow any bus master to interrupt the ISBC 544 by writing into the base address of the shared dual port memory accessible to the system. The Flag Interrupt is then cleared by the ISBC 544 when the on-board processor reads the base address. This interrupt provides an interrupt link between

Table 1. Programmable Timer Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
<th>Counter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrupt on Terminal Count (Mode 0)</td>
<td>When terminal count is reached, an interrupt request is generated. This function is useful for generation of real-time clocks.</td>
<td>8253 TINT1</td>
</tr>
<tr>
<td>Rate Generator (Mode 2)</td>
<td>Divide by N counter. The output will go low for one input clock cycle and high for N-1 input clock periods.</td>
<td>8253 BDGO-4 TINT1</td>
</tr>
<tr>
<td>Square-Wave Rate Generator (Mode 3)</td>
<td>Output will remain high until one-half the TC has been completed, and go low for the other half of the count. This is the primary operating mode used for generating a Baud rate clocked to the USARTs.</td>
<td>8155 TINT0</td>
</tr>
<tr>
<td>Software Triggered Strobe (Mode 4)</td>
<td>When the TC is loaded, the counter will begin. On TC the output will go low for one input clock period.</td>
<td>8253 BDGO-4 TINT1</td>
</tr>
<tr>
<td>Single Pulse</td>
<td>Single pulse when TC reached.</td>
<td>8155 TINT0</td>
</tr>
<tr>
<td>Repetitive Single Pulse</td>
<td>Repetitive single pulse: each time TC is reached until a new command is loaded.</td>
<td>8155 TINT0</td>
</tr>
</tbody>
</table>

* BDG4 is jumper selectable as an auxiliary baud rate generator to the USARTs or as a cascaded output to TINT1. BDG4 may be used in modes 2 and 4 only when configured as a cascaded output.

Table 2. Interrupt Vector Memory Locations

<table>
<thead>
<tr>
<th>Interrupt Source</th>
<th>Vector Location</th>
<th>Interrupt Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Fail</td>
<td>TRAP</td>
<td>24 H</td>
</tr>
<tr>
<td>8253 TINT1</td>
<td>RST 7.5</td>
<td>3C H</td>
</tr>
<tr>
<td>8255 TINT0</td>
<td>RST 6.5</td>
<td>34 H</td>
</tr>
<tr>
<td>Ring Indicator (1)</td>
<td>RST 5.5</td>
<td>2C H</td>
</tr>
<tr>
<td>Carrier Detect</td>
<td></td>
<td>Programable</td>
</tr>
<tr>
<td>Flag Interrupt</td>
<td>INTR</td>
<td></td>
</tr>
<tr>
<td>INTO/INT7/(1 of 8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RXRDY0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TXRDY0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RXRDY1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TXRDY1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RXRDY2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TXRDY2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RXRDY3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TXRDY3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Four ring indicator interrupts and four carrier detect interrupts are summed to the RST 6.5 input. The 8155 may be interrogated to inspect any one of the eight signals.
a bus master and intelligent slave (See System Programming). Eight inputs from the serial ports are monitored to detect a ring indicator and carrier detect from each of the four channels. These eight interrupt sources are summed to a single interrupt level of the 8085A CPU. If one of these eight interrupts occurs, the 8155 PPI can then be interrogated to determine which port caused the interrupt. Finally, a jumper selectable Power Fail Interrupt is available from the Multibus to detect a power down condition.

8085 Interrupt — Thirteen of the twenty-one interrupt sources are available directly to four interrupt inputs of the on-board 8085A CPU. Requests routed to the 8085A interrupt inputs, TRAP, RST 7.5, RST 6.5 and RST 5.5 have a unique vector memory address. An 8085A jump instruction at each of these addresses then provides software linkage to interrupt service routines located independently anywhere in the Memory. All interrupt inputs with the exception of the TRAP may be masked via software.

8259A Interrupts — Eight interrupt sources signaling transmitter and receiver ready from the four USARTs are channeled directly to the Intel 8259A PIC. The PIC then provides vectoring for the next eight interrupt levels. Operating mode and priority assignments may be reconfigured dynamically via software at any time during system operation. The PIC accepts transmitter and receiver interrupts from the four USARTs. It then determines which of the incoming requests is of highest priority, determines whether this request is of higher priority than the level currently being serviced, and, if appropriate, issues an interrupt to the CPU. The output of the PIC is applied directly to the INTR input of the 8085A. Any combination of interrupt levels may be masked, via software, by storing a single byte in the interrupt mask register of the PIC. When the 8085A responds to a PIC interrupt, the PIC will generate a CALL instruction for each interrupt level. These addresses are equally spaced at intervals of 4 or 8 (software selectable) bytes. Interrupt response to the PIC is software programmable to a 32- or 64-byte block of memory. Interrupt sequences may be expanded from this block with a single 8085A jump instruction at each of these addresses.

Interrupt Output — In addition, the ISBC 544 board may be jumper selected to generate an interrupt from the on-board serial output data (SOD) of the 8085A. The SOD signal may be jumpered to any one of the 8 MULTIBUS interrupt lines (INT0/INT7) to provide an interrupt signal directly to a bus master.

Power-Fail Control
Control logic is also included to accept a power-fail interrupt in conjunction with the AC-low signal from the ISBC 635 Power Supply or equivalent.

Expansion Capabilities
When the ISBC 544 board is used as a single board communications controller, memory and I/O capacity may be expanded and additional functions added using Intel MULTIBUS™ compatible expansion boards. In this mode, no other bus masters may be configured in the system. Memory may be expanded to a 65K byte capacity by adding user specified combinations of RAM boards, EPROM boards, or combination boards. Input/output capacity may be increased by adding digital I/O and analog I/O expansion boards. Furthermore, multiple ISBC 544 boards may be included in an expanded system using one ISBC 544 board as a single board communications computer and additional controllers as intelligent slaves.

System Programming
In the system programming environment, the ISBC 544 board appears as an additional RAM memory module when used as an intelligent slave. The master CPU communicates with the ISBC 544 board as if it were just an extension of system memory. Because the ISBC 544 board is treated as memory by the system, the user is able to program into it a command structure which will allow the ISBC 544 board to control its own I/O and memory operation. To enhance the programming of the ISBC 544 board, the user has been given some specific tools. The tools are: 1) the flag interrupt, 2) an on-board RAM memory area that is accessible to both an off-board CPU and the on-board 8085A through which a communications path can exist, and 3) access to the bus interrupt line.

Flag Interrupt — The Flag Interrupt is generated anytime a write command is performed by an off-board CPU to the base address of the ISBC 544 board's RAM. This interrupt provides a means for the master CPU to notify the ISBC 544 board that it wishes to establish a communications sequence. In systems with more than one intelligent slave, the flag interrupt provides a unique interrupt to each slave outside the normal eight MULTIBUS interrupt lines (INT0/INT7).

On-Board RAM — The on-board 16K byte RAM area that is accessible to both an off-board CPU and the on-board 8085A can be located on any 4K boundary in the system. The selected base address of the ISBC 544 RAM will cause a flag interrupt when written into by an off-board CPU.

Bus Access — The third tool to improve system operation as an intelligent slave is access to the Multibus interrupt lines. The ISBC 544 board can both respond to interrupt signals from an off-board CPU, and generate an interrupt to the off-board CPU via the MULTIBUS.

System Development Capability
The development cycle of ISBC 544 board based products may be significantly reduced using the Intellec series microcomputer development systems. The Intellec resident macroassembler, text editor, and system monitor greatly simplify the design, development and debug of ISBC 544 system software. An optional ISIS-II diskette operating system provides a linker, object code locator, and library manager. A unique in-circuit emulator (ICE-85) option provides the capability of developing and debugging software directly on the ISBC 544 board.
SPECIFICATIONS

Serial Communications Characteristics

Synchronous — 5-8 bit characters; automatic sync insertion; parity.
Asynchronous — 5-8 bit characters; break character generation; 1, 1½, or 2 stop bits; false start bit detection; break character detection.

Baud Rates

<table>
<thead>
<tr>
<th>Frequency (KHz)</th>
<th>Baud Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Synchronous</td>
</tr>
<tr>
<td>307.2</td>
<td>16</td>
</tr>
<tr>
<td>153.6</td>
<td>9600</td>
</tr>
<tr>
<td>76.8</td>
<td>4800</td>
</tr>
<tr>
<td>55.8</td>
<td>3500</td>
</tr>
<tr>
<td>38.4</td>
<td>2400</td>
</tr>
<tr>
<td>19.2</td>
<td>1200</td>
</tr>
<tr>
<td>9.6</td>
<td>600</td>
</tr>
<tr>
<td>4.8</td>
<td>300</td>
</tr>
<tr>
<td>6.98</td>
<td>110</td>
</tr>
</tbody>
</table>

Notes:
1) Frequency selected by I/O writes of appropriate 16-bit frequency factor to Baud Rate Register.
2) Baud rates shown here are only a sample subset of possible software programmable rates available. Any frequency from 18.75 Hz to 614.4 KHz may be generated utilizing on-board crystal oscillator and 16-bit Programmable Interval Timer (used here as a frequency divider).

8085A CPU

Word Size — 8, 16 or 24 bits/instruction; 8 bits of data
Cycle Time — 1.45/usec ± 0.1% for fastest executable instruction; i.e. four clock cycles.
Clock Rate — 2.76 MHz ± 0.1%

System Access Time
Dual port memory — 740 nsec
Note: Assumes no refresh contention

Memory Capacity
On-Board ROM/PROM — 4K, or 8K bytes of user installed ROM or EPROM.
On-Board Static RAM — 256 bytes on 8155.
On-Board Dynamic RAM (on-board access) — 16K bytes. Integrity maintained during power failure with user-furnished batteries (optional).
On-Board Dynamic RAM (MULTIBUS access) — 4K, 8K, or 16K-bytes available to bus by switch selection.

Memory Addressing
On-Board ROM/PROM — 0:0FFF (using 2716 EPROMs or masked ROMs); 0:1FFF (using 2732 EPROMs)
On-Board Static Ram — 256 bytes: 7F00-7FFF
On-Board Dynamic RAM (on-board access) — 16K bytes: 8000-BFFF.

On-Board Dynamic RAM (MULTIBUS access) — any 4K increment 00000-FF000 which is switch and jumper selectable. 4K: 8K- or 16K-bytes can be made available to the bus by switch selection.

I/O Capacity
Serial — 4 programmable channels using four 8251A USARTs.
Parallel — 10 programmable lines available for Bell 801 ACU, or equivalent use. Two auxiliary jumper selectable signals.

I/O Addressing

On-Board Programmable I/O

<table>
<thead>
<tr>
<th>Port</th>
<th>Data</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>USART0</td>
<td>D0</td>
<td>D1</td>
</tr>
<tr>
<td>USART1</td>
<td>D2</td>
<td>D3</td>
</tr>
<tr>
<td>USART2</td>
<td>D4</td>
<td>D5</td>
</tr>
<tr>
<td>USART3</td>
<td>D6</td>
<td>D7</td>
</tr>
<tr>
<td>8155 PPI</td>
<td>E9 (Port A)</td>
<td>E8</td>
</tr>
<tr>
<td></td>
<td>EA (Port B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EB (Port C)</td>
<td></td>
</tr>
</tbody>
</table>

Interrupts

Addresses for 8259A Registers (Hex notation, I/O address space)

Address 6: Interrupt request register
Address 6: In-service register
Address 7: Mask register
Address 6: Command register
Address 7: Block address register
Address 6: Status (polling register)

Note: Several registers have the same physical address: Sequence of access and one data bit of the control word determines which register will respond.

Interrupt levels routed to the 8085 CPU automatically vector the processor to unique memory locations:

<table>
<thead>
<tr>
<th>Hex</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>TRAP</td>
</tr>
<tr>
<td>3C</td>
<td>RST 7.5</td>
</tr>
<tr>
<td>34</td>
<td>RST 6.5</td>
</tr>
<tr>
<td>2C</td>
<td>RST 5.5</td>
</tr>
</tbody>
</table>

Timers

Addresses for 8253 Registers (Hex notation, I/O address space)

Programmable Interrupt Timer One

<table>
<thead>
<tr>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D8</td>
<td>Timer 0</td>
</tr>
<tr>
<td>D9</td>
<td>Timer 1</td>
</tr>
<tr>
<td>DA</td>
<td>Timer 2</td>
</tr>
<tr>
<td>DB</td>
<td>Control register</td>
</tr>
</tbody>
</table>

Programmable Interrupt Timer Two

<table>
<thead>
<tr>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>Timer 0</td>
</tr>
<tr>
<td>DD</td>
<td>Timer 1</td>
</tr>
<tr>
<td>DE</td>
<td>Timer 2</td>
</tr>
<tr>
<td>DF</td>
<td>Control register</td>
</tr>
</tbody>
</table>

Address for 8155 Programmable Timer

<table>
<thead>
<tr>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E8</td>
<td>Control</td>
</tr>
<tr>
<td>EC</td>
<td>Timer (LSB)</td>
</tr>
<tr>
<td>ED</td>
<td>Timer (MSB)</td>
</tr>
</tbody>
</table>
iSBC 544

Input frequencies — Jumper selectable reference 1.2288 MHz±.1% (.814 usec period nominal) or 1.843 MHz±.1% crystal (0.542 usec period, nominal)

Output Frequencies (at 1.2288 MHz)

<table>
<thead>
<tr>
<th>Function</th>
<th>Single timer/counter</th>
<th>Dual timer/counter (two timers cascaded)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Real-time interrupt interval</td>
<td>1.63 usec</td>
<td>53.3 usec</td>
</tr>
<tr>
<td>Rate Generator (frequency)</td>
<td>18.75 Hz</td>
<td>614.4 Hz</td>
</tr>
</tbody>
</table>

Interfaces

Serial I/O — EIA Standard RS232C signals provided and supported:
- Carrier Detect
- Clear to Send
- Data Set Ready
- Data Terminal Ready
- Request to Send
- Receive Clock

Parallel I/O — Four inputs and eight outputs (includes two jumper selectable auxiliary outputs). All signals compatible with EIA Standard RS232C. Directly compatible with Bell Model 801 Automatic Calling Unit, or equivalent.

MULTIBUS — Compatible with iSBC MULTIBUS.

On-Board Addressing

All communications to the parallel and serial I/O ports, to the timers, and to the interrupt controller, are via read and write commands from the on-board 8085A CPU.

Auxiliary Power

An auxiliary power bus is provided to allow separate power to RAM for systems requiring battery backup of read/write memory. Selection of this auxiliary RAM power bus is made via jumpers on the board.

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (qty)</th>
<th>Centers (in.)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>86</td>
<td>0.156</td>
<td>Viking 2KH43/9AMK12</td>
</tr>
<tr>
<td>Parallel I/O</td>
<td>50</td>
<td>0.1</td>
<td>3M 3415-000 or AMP 88083-1</td>
</tr>
<tr>
<td>Serial I/O</td>
<td>26</td>
<td>0.1</td>
<td>3M 3462-000 or AMP 88573-5</td>
</tr>
</tbody>
</table>

Memory Protect

An active-low TTL compatible memory protect signal is brought out on the auxiliary connector which, when asserted, disables read/write access to RAM memory on the board. This input is provided for the protection of RAM contents during the system power-down sequences.

Bus Drivers

<table>
<thead>
<tr>
<th>Function</th>
<th>Characteristic</th>
<th>Sink Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Tri-state</td>
<td>50</td>
</tr>
<tr>
<td>Address</td>
<td>Tri-state</td>
<td>15</td>
</tr>
<tr>
<td>Commands</td>
<td>Tri-state</td>
<td>32</td>
</tr>
</tbody>
</table>

Note: Used as a master in the single board communications computer mode.

Physical Characteristics

| Width: 30.48 cm (12.00 inches) |
| Depth: 17.15 cm (6.75 inches) |
| Thickness: 1.27 cm (0.50 inch) |
| Weight: 3.97 gm (14 ounces) |

Electrical Characteristics

DC Power Requirements

<table>
<thead>
<tr>
<th>Current Requirements</th>
<th>Configuration</th>
<th>( V_{CC} = +5V \pm 5% ) (max)</th>
<th>( V_{DD} = +12V \pm 5% ) (max)</th>
<th>( V_{BB} = -5V(3) \pm 5% ) (max)</th>
<th>( V_{AA} = -12V \pm 5% ) (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With 4K EPROM (using 2716)</td>
<td>( I_{CC} = 3.4 mA ) max</td>
<td>( I_{DD} = 350 mA ) max</td>
<td>( I_{BB} = 5mA ) max</td>
<td>( I_{AA} = 200 mA ) max</td>
<td></td>
</tr>
<tr>
<td>Without EPROM</td>
<td>( 3.3A ) max</td>
<td>( 350 mA ) max</td>
<td>( 5 mA ) max</td>
<td>( 200 mA ) max</td>
<td></td>
</tr>
<tr>
<td>RAM only(1)</td>
<td>( 390 mA ) max</td>
<td>( 176 mA ) max</td>
<td>( 5 mA ) max</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>RAM(2) refresh only</td>
<td>( 390 mA ) max</td>
<td>( 20 mA ) max</td>
<td>( 5 mA ) max</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1. For operational RAM only; for AUX power supply rating.
2. For RAM refresh only. Used for battery backup requirements. No RAM accessed.
3. \( V_{BB} \) is normally derived on-board from \( V_{AA} \) eliminating the need for a \( V_{BB} \) supply. If it is desired to supply \( V_{BB} \) from the bus, the current requirement is as shown.

Environmental Characteristics

Operating Temperature: 0°C to 55°C (32°F to 131°F)
Relative Humidity: To 90% without condensation

Reference Manual

9800616B — iSBC 544 Intelligent Communication Controller Board Hardware Reference Manual (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>iSBC 544</td>
<td>Intelligent Communications Controller</td>
</tr>
</tbody>
</table>

9-11
The iSBC 550 Ethernet Communications Controller meets the tri-corporate (DEC, Xerox, Intel) specification for Ethernet local area networks. All the functions of the Ethernet data link layer and physical link layer are provided on two 6.75 x 12" circuits boards and associated firmware. The MULTIBUS compatible controller can be utilized as the foundation for a single board computer (iSBC)-based Ethernet local area network or as a prototype for Intel® 8085, IAPX™ 88, or IAPX 86 component-based Ethernet applications. The iSBC 550 controller's firmware (supplying the Ethernet and system interface) has an easy-to-use MULTIBUS Interprocessor Protocol (MIP) facility, which is readily accessed from another iSBC Board using a custom run-time software system or Intel's iRMX™ 80/88/86 Real-Time Executive software and the iMMX™ 800 (MULTIBUS Message Exchange) software package. The Ethernet data link functions are divided between the processor board which provides the data link layer's software to control the data encapsulation and the link management, and the serial/deserialization (SerDes) board which provides the 10-MBit per second serial interface to the Ethernet transceiver.
FUNCTIONAL DESCRIPTION

The ISBC 550 Ethernet Communications Controller is a two-board MULTIBUS-compatible set that offers high-speed Ethernet-compatible data transfer between digital devices operating at a 10-Mbit per sec data rate. The ISBC 550 controller can effectively support the needs of local area network applications, such as office automation, distributed data processing, factory data collection, research data collection, intelligent terminal and other EDP-related products.

Ethernet Specification

The Ethernet network is a local area network concept that is jointly being supported by Intel Corporation, Digital Equipment Corporation, and Xerox Corporation. The network is designed to link systems over a distance of up to 2500 meters using an available 50-ohm coaxial cable. Several hundred stations may be connected to the cable which supports a data rate of 10 Megabits per second. The data is encapsulated in a packet message format. The data signal is a base-band, Manchester-encoded type that is self-synchronizing.

The jointly developed Ethernet specification, "The Ethernet, A Local Area Network Data Link Layer and Physical Link Layer Specification, Version 1.0, September 30, 1980", precisely defines the two lower layers of a local area network architecture where the system is a series of independent layers. The lowest layer, the physical link layer, is concerned with coaxial cable interface. The data link layer supports the peer protocol's statistical contention resolution (CSMA/CD) and link management functions. All additional network layers are defined by the user during the implementation of the application-specific layers.

Ethernet Data Link Layer Support

The ISBC 550 processor board provides the data link layer's software to control the data encapsulation and the link management, including frame delimitation, address handling, error detection, and collision handling. After the ISBC 550 processor board is initialized upon system start-up or reset, the data link firmware is ready to service the local area network commands. An example of a command structure sent the ISBC controller to receive a packet of data from the Ethernet link is shown in Figure 1. The message passed via the MIP (MULTIBUS Interprocessor Protocol) interface is composed of two parts, the ISBC 550 controller information (including the command and associated data), and the required Ethernet information.

<table>
<thead>
<tr>
<th>ISBC 550 CONTROLLER INFORMATION</th>
<th>RESERVED DATA COMMAND</th>
<th>(14 bytes)</th>
<th>RESERVED DATA</th>
<th>(7 bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETHERNET INFORMATION</td>
<td>DESTINATION SOURCE</td>
<td>(6 bytes)</td>
<td>TYPE DATA</td>
<td>(46-1500 bytes)</td>
</tr>
</tbody>
</table>

Figure 1. Data Link for SUPPLYBUF Command Format

Shown in Table 1 are eight external Ethernet controller commands available to a user's application via the MIP interface. The commands manage the Ethernet multicast address recognition, message type connection, message flow, and overall network statistics.

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONNECT</td>
<td>Indicates the data link message TYPE to be connected to user program.</td>
</tr>
<tr>
<td>DISCONNECT</td>
<td>Disconnects the data link TYPE from the user's application.</td>
</tr>
<tr>
<td>ADDMCID</td>
<td>Adds a multicast ID for recognition.</td>
</tr>
<tr>
<td>DELETEmCID</td>
<td>Delete the specified multicast ID.</td>
</tr>
<tr>
<td>TRANSMIT</td>
<td>Transmit a data packet to the Ethernet link.</td>
</tr>
<tr>
<td>SUPPLYBUF</td>
<td>Supplies a buffer for packet reception from the Ethernet link (&quot;receive&quot; function).</td>
</tr>
<tr>
<td>READ</td>
<td>Read the statistical variables maintained by data link layer.</td>
</tr>
<tr>
<td>READC</td>
<td>Read and clear the statistical variables.</td>
</tr>
</tbody>
</table>

Table 1. External Controller Commands

Ethernet Physical Link Layer Support

The Serialization/Deserialization (SerDes) board provides the required electrical characteristics of the physical link layer of the Ethernet architecture for a transceiver interface. The transceiver is a device physically attached to the coax cable which does signal conditioning for transmitting and receiving.

Many major functions are controlled by the SerDes board. These functions include serialization/deserialization, packet framing, Manchester encoding/decoding, transmit data flow control, receive data flow control, destination address decoding for received message, CRC generation and
checking, and diagnostics for CRC error, loopback, transmit timeout, and CSMA/CD (Carrier-Sense Multiple-Access with Collision-Detection).

**Easy-To-Use Interface**

One of the iSBC 550 controller boards is an iAPX 88-based processor board which has firmware support for the user's application interface. The programmatic interface utilizes the MULTIBUS Interprocessor Protocol (MIP) interface to the processor board. This interface is concerned with the message-passing protocol between multiple-processors. The iMMX 800 (MULTIBUS Message Exchange) software supports the MIP interface and offers a convenient quick-start method for users of Intel's iRMX 80, iRMX 88 executives and iRMX 86 operating system products for an Ethernet-based application.

**Confidence Test**

An effective diagnostic function is implemented in firmware on the processor board. This function is invoked at system initialization during both power-up and system reset time. These functions include: packet CRC checking, memory test, controller loopback, and other error tests. The tests provide a fundamental level of controller integrity.

**Network Statistics**

Statistics maintained by the data link firmware include packet traffic counts, collision information and error totals. This information can be effectively utilized by the user's application to understand the network's operation.

**End-To-End Networking Foundation**

The iSBC 550 controller provides the foundation data link layer and the physical link layer for a local area network architecture. Typically, the higher levels are user-defined and include the transport and the session control layers. The transport control layer is concerned with the end-to-end communications and the virtual channel connection via a port-to-port address. The session control layer provides the process-to-process control function which includes symbolic name binding and the establishment of the virtual connection via the transport control layer. In addition, the session control provides the specific error and recovery control responsible for message delivery.

The higher levels of the local area network architecture (see Figure 2) which use the data link layer are outside of the Ethernet standard, but can be implemented quickly on companion iSBC boards (e.g., iSBC 80/24, iSBC 88/25, iSBC 86/12A) running under the iRMX 80/88/86 Real-Time Multitasking Executives, respectively, and associated iMMX MULTIBUS Message Exchange (iMMX 800) software. Special iSBC 550 device driver software compatible with the iRMX 86 and iRMX 88 file systems is provided in the iMMX 800 package.
SPECIFICATIONS

Memory Addressing Capability
MULTIBUS System Bus — (00000–EFFFF)

Ethernet I/O Channels
One Ethernet electrically-compatible transceiver line on the SerDes board.

Interface Specifications
MULTIBUS System Bus — All signals TTL compatible.
Transceiver — All signals Ethernet specifications transceiver compatible.

Serial Communications Characteristics
Bit Serial Frame — Provides 64-bit preamble, 48-bit destination address, 48-bit source address, 16-bit type, 46-1500 bytes for data, and a frame check sequence of 32 bits.

Ethernet Network Specifications Supported
Coax Cable Length — 500-meter max.
Transceiver Cable Length — 50-meter max.
Number of Stations — 100 max.
Baud Rate — 10-Mbit/sec

System Clock
5.00 MHz, ± 0.1%

Physical Characteristics (Both Boards)
Width — 12.00 in. (30.48 cm) (each board)
Height — 6.75 in. (17.15 cm) (each board)
Depth — 0.5 in. (1.27 cm) (each board)
Weight — 3.5 lb (1.6 kg) (both boards)

SerDes to Transceiver Cable
Length — 0.55 meter (22 in.). Four pair twisted-wire cable with SerDes connector and transceiver interface connector.

Electrical Characteristics
Power requirements for both boards
+ 5 VDC @ 9.0A max.
+ 12 VDC @ 0.5A max.

Environmental Characteristics
Operating Temperature — 0°C to 55°C
Relative Humidity — To 90% (without condensation)

Connectors

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (qty)</th>
<th>Centers (in.)</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTIBUS System</td>
<td>86</td>
<td>0.156</td>
<td>Viking 2KH43/9AMK12</td>
</tr>
<tr>
<td>SerDes Connector</td>
<td>10</td>
<td>0.1</td>
<td>AMP 87631-5 Housing</td>
</tr>
<tr>
<td>Transceiver</td>
<td>15</td>
<td>0.1</td>
<td>Cinch Type DA51220-1</td>
</tr>
</tbody>
</table>

Reference Manuals
121746 — iSBC 550 Ethernet Communications Controller Hardware Reference Manual (NOT SUPPLIED)
121769 — The Ethernet Communications Controller Programmer’s Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051.

ORDERING INFORMATION

Part Number Description
SBC 550 Ethernet Communications Controller for 10 Mbit/sec coaxial transmission. Includes Ethernet data link control software and cable to transceiver.
iSBX™ 352
BIT SERIAL COMMUNICATIONS
MULTIMODULE™ BOARD

- Provides an HDLC/SDLC half/full-duplex communications channel for iSBX™ bus compatible microcomputers
- Supports RS232C (including modem support) or RS449/422A interface
- Single +5V when configured for RS449/422A interface
- Software programmable baud rate generation up to 64K baud synchronous and 9.6K baud self-clocking
- Supports synchronous or self-clocking NRZI point-to-point, multidrop and self-clocking NRZI SDLC loop data link interfaces

The Intel iSBX 352 Bit Serial Communications MULTIMODULE board offers incremental on-board I/O expansion support for ISO/CCITT's HDLC or IBM's SDLC communication. Plugging directly into any iSBX bus compatible host board, the iSBX 352 module provides one RS232C or RS449/422A programmable bit serial communications channel with software selectable baud rates (up to 64K baud for half-duplex synchronous operations). Data link interfaces supported are: synchronous point-to-point, multidrop and SDLC loop. The phase lock loop feature provides NRZI self-clocking 9.6K baud operation.
FUNCTIONAL DESCRIPTION

Communications Interface

The iSBX 352 module uses the Intel 8273 Programmable HDLC/SDLC Protocol Controller. The iSBX 352 module provides one bit-serial communications channel for iSBX bus compatible host microcomputers. (See Figure 1.) An iSBC microcomputer or MULTIBUS-based application is easily connected to an HDLC/SDLC point-to-point, multidrop, or an SDLC loop configuration.

The High-Level Data Link Control (HDLC) is the International Standards Organization (ISO) standard discipline used to implement X.25 packet switching communications. The Synchronous Data Link Control (SDLC) is an IBM communication protocol used to implement the System Network Architecture (SNA). Both protocols, HDLC and SDLC, are bit oriented, code independent, and support full-duplex operations.

Data Link Interface

The control lines, serial data lines and signal ground lines are brought out to the double edge connector of the iSBX 352 module and are configurable for RS232C or RS449/422A interface (see Figure 2).

Addressing an iSBX 352 board by using a port address, the program performs the 8-bit data transfer required, using buffered or non-buffered transmit/receive and abort sequences.

Serial data transfer control is provided by the 8273 controller of the iSBX 352 module which interfaces the parallel iSBX bus to the serial channel. During a transmit sequence, the iSBX 352 module accepts data and commands from the iSBX bus interface, translates and formats the data into HDLC/SDLC protocol formats, provides the proper RS232C or RS422A interface control signals, and passes data onto the serial channel. The receive operation is the inverse of the previous sequence.

Data Link Configurations

The supported data link configurations are shown in Table 1. The following example configurations provide an overview and a figure for five typical data link configurations:

<table>
<thead>
<tr>
<th>Connection</th>
<th>Synchronous Modem Direct</th>
<th>Asynchronous Modem* Direct</th>
</tr>
</thead>
<tbody>
<tr>
<td>point-to-point</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>multidrop</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>loop</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

* Modem should not respond to a break.
SYNCHRONOUS POINT-TO-POINT INTERFACE

Figure 3 shows a synchronous point-to-point mode of operation for the iSBX 352 module. This RS232C example uses a modem for generation of the receive clock for coordination of the data transfer. The iSBX 352 module generates the transmit synchronizing clock for synchronous transmission.

SELF-CLOCKING POINT-TO-POINT INTERFACE

The iSBX 352 module is used in an asynchronous mode interface when configured as shown in Figure 4. The point-to-point RS232C example uses the self-clocking mode interface for NRZI encoding/decoding of data. The digital phase lock loop allows operation of the interface in either half-duplex or full-duplex implementation with or without modems.
SYNCHRONOUS MULTIDROP
The iSBX 352 MULTIMODULE is used as both a master and a slave node in the RS449/422A example shown in Figure 5. This synchronous multidrop application is effective for high-speed data transfers between slave stations and a central master station.

ASYNCHRONOUS SELF-CLOCKING MULTIDROP
The iSBX 352 MULTIMODULE example in Figure 6 shows a master and multiple slaves in a multidrop configuration. This self-clocking example uses the 8273 digital phase lock loop and NRZI data encoding.

SDLC Loop
The SDLC self-clocking loop configuration shown in Figure 7 permits longer networks since each secondary slave station is a repeater set in one-bit delay mode. The data sent out by the primary station (the loop controller) are relayed bit-for-bit through each secondary station and finally back to the master station.

---

**NOTE:**
The last slave device in the system must contain termination resistors on all signal lines received by the slave board. The master device must contain resistors on all received signal lines.

---

Figure 5. Synchronous Multidrop Network Configuration Example - RS422A

Figure 6. Self-Clocking Multidrop Configuration Example - RS422A

Figure 7. Self-Clocking SDLC Loop Network Configuration Example
## SPECIFICATIONS

### Data Size

8 Bits

### I/O Port Addresses

<table>
<thead>
<tr>
<th>Port Address</th>
<th>Device Selected</th>
<th>Function Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>X0 X0</td>
<td>8254-2 PIT</td>
<td>Read Counter 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Write Counter 0</td>
</tr>
<tr>
<td>X1 X2</td>
<td>8254-2 PIT</td>
<td>Read Counter 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Write Counter 1</td>
</tr>
<tr>
<td>X2 X4</td>
<td>8254-2 PIT</td>
<td>Read Counter 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Write Counter 2</td>
</tr>
<tr>
<td>X3 X6</td>
<td></td>
<td>Write Control</td>
</tr>
<tr>
<td>X4 X8</td>
<td></td>
<td>Read Status</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Write Command</td>
</tr>
<tr>
<td>X5 XA</td>
<td></td>
<td>Read Result</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Write Parameter</td>
</tr>
<tr>
<td>X6 XC</td>
<td>8273 HDLC/SDLC CONTROLLER</td>
<td>Read Transmit Interrupt</td>
</tr>
<tr>
<td>X7 XE</td>
<td></td>
<td>Read Receive Interrupt</td>
</tr>
<tr>
<td>Y0 Y0</td>
<td></td>
<td>Read Receive Data</td>
</tr>
<tr>
<td>Y4 Y8</td>
<td></td>
<td>Write Transmit Data</td>
</tr>
</tbody>
</table>

**NOTE:** Refer to the Hardware Reference Manual for your host iSBX™ microcomputer to determine the upper digit (either X or Y) of the MULTIMODULE™ port address.

### Interfaces

**iSBX™ BUS** — All signals TTL compatible

### SERIAL RS232C SIGNALS

- **CTS** Clear to Send
- **DSR** Data Set Ready
- **DTE TXC** Transmit Clock
- **DTR** Data Terminal Ready
- **FG** Frame Ground
- **RTS** Request to Send
- **RXC** Receive Clock
- **RXD** Receive Data
- **SG** Signal Ground
- **TXD** Transmit Data

### RATE GENERATOR FREQUENCIES

<table>
<thead>
<tr>
<th>Baud Rate (bits/sec)</th>
<th>8254-2 Divide Count</th>
<th>Synchronous</th>
<th>Self-Clocking</th>
</tr>
</thead>
<tbody>
<tr>
<td>64K</td>
<td>125</td>
<td>TX Clock</td>
<td>32X Clock</td>
</tr>
<tr>
<td>56K</td>
<td>143</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>48K</td>
<td>167</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>19.2K</td>
<td>417</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>9.6K</td>
<td>833</td>
<td>833</td>
<td>26</td>
</tr>
<tr>
<td>4.8K</td>
<td>1,667</td>
<td>1,667</td>
<td>52</td>
</tr>
<tr>
<td>2.4K</td>
<td>3,333</td>
<td>3,333</td>
<td>104</td>
</tr>
<tr>
<td>1.2K</td>
<td>6,667</td>
<td>6,667</td>
<td>208</td>
</tr>
<tr>
<td>0.6K</td>
<td>13,333</td>
<td>13,333</td>
<td>417</td>
</tr>
<tr>
<td>0.3K</td>
<td>26,667</td>
<td>26,667</td>
<td>833</td>
</tr>
</tbody>
</table>

**NOTE:** All numbers are in decimal notation.

### SERIAL RS449/422A SIGNALS

- **CS** Clear to Send
- **DM** Data Mode
- **RC** Receive Common
- **RD** Receive Data
- **RS** Request to Send
- **RT** Receive Timing
- **SC** Send Common
- **SD** Send Data
- **SG** Signal Ground
- **TR** Terminal Ready
- **TT** Terminal Timing

### OPERATING SPEEDS

- 24 MHz on-board crystal
- 8 MHz clocking of the 8254-2 PIT
- 4 MHz clocking of the 8273 Device

### DATA THROUGHPUT SPEED

- 64K baud maximum for half-duplex operation
- 48K baud for full-duplex operation issuing commands during transmit operations
SERIAL INTERFACE CONNECTORS

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Mode²</th>
<th>MULTIMODULE™ Edge Connector</th>
<th>Cable</th>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS232C</td>
<td>DTE</td>
<td>26-pin³, 3M-3462-0001</td>
<td>3M³-3349/25</td>
<td>25-pin³, 3M-3482-1000</td>
</tr>
<tr>
<td>RS232C</td>
<td>DCE</td>
<td>26-pin³, 3M-3462-0001</td>
<td>3M³-3349/25</td>
<td>25-pin³, 3M-3483-1000</td>
</tr>
<tr>
<td>RS449</td>
<td>DTE</td>
<td>40-pin⁶, 3M-3464-0001</td>
<td>3M³-3349/37</td>
<td>37-pin¹, 3M-3502-1000</td>
</tr>
<tr>
<td>RS449</td>
<td>DCE</td>
<td>40-pin⁶, 3M-3464-0001</td>
<td>3M³-3349/37</td>
<td>37-pin¹, 3M-3503-1000</td>
</tr>
</tbody>
</table>

NOTES:
1. Cable housing 3M-3485-4000 may be used with the connector.
2. DTE – Data Terminal Equipment mode (male connector); DCE – Data Set Equipment mode (female connector).
3. Cable is tapered at one end to fit the 3M-3462 connector.
4. Cable is tapered to fit 3M-3464 connector.
5. Pin 26 of the edge connector is not connected to the flat cable.
6. Pins 38, 39, and 40 of the edge connector are not connected to the flat cable.
7. May be used with the cable housing 3M-3485-1000.

Electrical Characteristics

DC POWER REQUIREMENTS

<table>
<thead>
<tr>
<th>Interface</th>
<th>Voltage</th>
<th>Current (max)</th>
<th>Total Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS 232C</td>
<td>+5 ± 0.25V</td>
<td>595 mA</td>
<td>3.8 watts</td>
</tr>
<tr>
<td></td>
<td>-12 ± 0.6V</td>
<td>30 mA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+12 ± 0.6V</td>
<td>30 mA</td>
<td></td>
</tr>
<tr>
<td>RS 449/422A</td>
<td>+5 ± 0.25V</td>
<td>775 mA</td>
<td>4.1 watts</td>
</tr>
</tbody>
</table>

Physical Characteristics

Width — 7.27 cm (2.85 inches)
Length — 9.40 cm (3.70 inches)
Height — 1.40 cm (0.56 inches)
Weight — 72 gm (2.53 ounces)

Reference Manual (Not Supplied)

143983 — iSBX 352 Bit Serial Communications MULTIMODULE Board Hardware Reference Manual.

Reference manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Ave., Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBX 352</td>
<td>HDLC/SDLC Serial I/O</td>
</tr>
<tr>
<td></td>
<td>MULTIMODULE Board</td>
</tr>
</tbody>
</table>
Analog I/O Expansion and Signal Conditioning Boards
iSBX 311
ANALOG INPUT MULTIMODULE BOARD

- Low cost analog input for iSBX MULTI-MODULE compatible iSBC boards
- 8 differential/16 single-ended, fault protected inputs
- 20 mV to 5V full scale input range, resistor gain selectable
- Unipolar (0 to +5V) or bipolar (-5V to +5V) input, jumper selectable
- 12-bit resolution analog-to-digital converter
- 0.035% full scale accuracy (11 bits) at 25°C
- 18 kHz samples per second throughput to memory
- Connector compatible with iCS 910 Analog Termination Panel

The Intel iSBX 311 Analog Input MULTIMODULE board provides simple interfacing of non-isolated analog signals to any iSBC board which has an iSBX compatible bus and connectors. The single-wide iSBX 311 plugs directly onto the iSBC board, providing data acquisition of analog signals from eight differential or sixteen single-ended voltage inputs, jumper selectable. The iSBX 311 MULTIMODULE is connector and pinout compatible with the Intel iCS 910 Analog Signal Conditioning/Termination panel so that field wiring can easily be terminated and current loop-to-voltage conversion resistors can be mounted for current loop analog signal monitoring. Resistor gain selection is provided for both low level (20mv full scale range) and high level (5 volt FSR) signals. Incorporating the latest high quality IC components, the iSBX 311 MULTIMODULE board provides 12 bit resolution, 11 bit accuracy, and a simple programming interface, all on a low cost iSBX MULTIMODULE board.
iSBX 311

FUNCTIONAL DESCRIPTION

The iSBX 311 Analog Input MULTIMODULE board is a member of Intel's growing family of MULTIMODULE expansion boards, designed to allow quick, easy, and inexpensive expansion for the Intel single board computer product line. The iSBX 311 Analog Input MULTIMODULE Board shown in figure 1, is designed to plug onto any host iSBC microcomputer that contains an iSBX bus connector (P1). The board provides 8 differential or 16 single-ended analog input channels that may be jumper-selected as the application requires. The MULTIMODULE board includes a user-configurable gain, and a user-selectable voltage input range (0 to +5 volts, or -5 to +5 volts). The MULTIMODULE board receives all power and control signals through the iSBX bus connector to initiate channel selection, sample and hold operation, and analog-to-digital conversion.

Input Capacity

Sixteen separate analog signals may be randomly or sequentially sampled in single-ended mode with the sixteen input multiplexers and a common ground. For noisier environments, differential input mode can be configured to achieve 8 separate differential signal inputs, or 16 pseudo-differential inputs.

Resolution

The iSBX 311 MULTIMODULES provide 12-bit resolution with a successive approximation analog-to-digital converter. For bipolar operation (-5 to +5 volts) it provides 11 bits plus sign.

Speed

The A-to-D converter conversion speed is 35 microseconds (28KHZ samples per second). Combined with the sample and hold, settling times and the programming interface, maximum throughput via the iSBX bus and into memory will be 54 microseconds per sample, or 18 KHZ samples per second, for a single channel, a random channel, or a sequential channel scan. A-to-D conversion is initiated via the iSBX connector and programmed command from the iSBC base board. Interrupt on end-of-conversion is a standard feature to ease programming and timing constraints.

Figure 1. iSBX 311 Analog Input MULTIMODULE Board
Accuracy

High quality components are used to achieve 12 bits resolution and accuracy of ±0.035% full scale range ±½ LSB. Offset and gain are adjustable to ±0.024% FSR ±½ LSB accuracy at any fixed temperature between 0°C (gain = 1). See specifications for other gain accuracies.

Gain

To allow sampling of millivolt level signals such as strain gauges and thermocouples, gain is made configurable via user inserted gain resistors up to 250 x (20 millivolts, full scale input range). User can select any other gain range from 1 to 250 to match his application.

OPERATIONAL DESCRIPTION

The host iSBC microcomputer addresses the iSBX 311 MULTIMODULE board by executing IN or OUT instructions to the iSBX 311 MULTIMODULE as one of the legal port addresses. Analog-to-digital conversions can be programmed in either of two modes: 1. start conversion and poll for end-of-conversion (EOG), or 2. start conversion and wait for interrupt (INTRO/) at end of conversion. When conversion is complete as signaled by one of the above techniques, INput instructions read two bytes (low and high bytes) containing the 12 bit data word plus status information as shown below.

SPECIFICATIONS


Full Scale Input Voltage Range — -5 to +5 volts (bipolar). 0 to +5 volts (unipolar). Jumper selectable.

Gain — User-configurable through installation of two resistors. Factory-configured for gain of X1; gains above 250 not recommended.

Resolution — 12 bits over full scale range (1.22 mv at 0-5 v, 5 µv at 0-20 mv)

Accuracy

<table>
<thead>
<tr>
<th>Gain</th>
<th>Accuracy at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>±0.035% ±½ LSB</td>
</tr>
<tr>
<td>5</td>
<td>±0.035% ±½ LSB</td>
</tr>
<tr>
<td>50</td>
<td>±0.035% ±½ LSB</td>
</tr>
<tr>
<td>250</td>
<td>±0.035% ±½ LSB</td>
</tr>
</tbody>
</table>

NOTE:

Figures are in percent of full scale reading. At any fixed temperature between 0° and 60°C, the accuracy is adjustable to ±0.035% of full scale.

Dynamic Error — ±0.015% FSR for transitions

Gain TC (at Gain = 1): 30 PPM per degree centigrade (typical); 56 PPM per degree centigrade (max).
iSBX 311

Offset TC (in percent of FSR/°C):

<table>
<thead>
<tr>
<th>Gain</th>
<th>Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.0018</td>
</tr>
<tr>
<td>5</td>
<td>.0036</td>
</tr>
<tr>
<td>50</td>
<td>.024</td>
</tr>
<tr>
<td>250</td>
<td>.116</td>
</tr>
</tbody>
</table>

Offset is measured with user-supplied 10 PPM/°C gain resistors installed.

Input Protection — ± 30 volts.

Input Impedance — 20 megohms (minimum).

Conversion Speed — 50 microseconds (nominal).

Common Mode Rejection Ratio — 60 db (minimum).

Sample and hold — sample time 15 microseconds.

Aperature — hold aperature time: 120 nanoseconds.

Connectors —

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (Qty)</th>
<th>Centers in cm</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 ISBX Bus</td>
<td>36</td>
<td>0.1 0.254</td>
<td>iSBC ISBX connector</td>
</tr>
<tr>
<td>J1 8/16 channels analog</td>
<td>50</td>
<td>0.1 0.254</td>
<td>3m 3415-000 or T1 H312125 or iCS 910 cable</td>
</tr>
</tbody>
</table>

Physical Characteristics

Width — 9.40 cm (3.7 inches)
Length — 6.35 cm (2.5 inches)
Height — 2.03 cm (0.80 inch) MULTIMODULE board only
2.82 cm (1.13 inches) MULTIMODULE and iSBC board
Weight — 68.05 gm (2.4 ounces)

Electrical Characteristics (from iSBX connector)

Vcc = ± 5 volts (± 0.25V), Icc = 250 mAmax
Vdd = + 12 volts (± 0.6V), ldd = 50 mAmax
Vss = − 12 volts (± 0.6V), Iss = 55 mAmax

Environmental Characteristics

Operating Temperature — 0° to 60°C (32° to 140°C)
Relative Humidity — to 90% (without condensation)
Shock Tested At — Class B Specification

Reference Manuals

142913-001 — iSBX 311 Analog Input MULTIMODULE Board Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

Part Number  Description
SBX 311     Analog Input MULTIMODULE Board
The Intel iSBX 328 MULTIMODULE board provides analog signal output for any iSBC board which has an iSBX compatible bus and connectors. The single-wide iSBX 328 plugs directly onto the iSBC board, providing eight independent output channels of analog voltage for meters, CRT control, programmable power supplies, etc. Voltage output can be mixed with current loop output for control of popular 4-20mA industrial control elements. By using an Intel single chip computer LSI (8041) for refreshing separate sample-hold amplifiers through a single 12 bit DAC, eight channels can be contained on a single MULTIMODULE board, for high density and low cost per channel. High quality analog components provide 12 bit resolution, 11 bit accuracy, and slew rates per channel of 0.1 volt per microsecond. Programming the iSBX 328 MULTIMODULE board is done via a simple two byte protocol over the iSBX bus. Maximum channel update rates are 5KHZ on a single channel to 1 KHZ on all eight channels. Outputs are compatible for screw termination of field wiring on the iCS 910 Analog Signal Conditioning/Termination Panel.
FUNCTIONAL DESCRIPTION

The iSBX 328 MULTIMODULE board, shown in figure 1 is designed to plug onto any host iSBX microcomputer that contains an iSBX bus connector. The board uses an 8041 UPI device to control eight analog output channels that may be user-configured through jumpers to operate in either bipolar voltage output mode (-5 to +5 volts), unipolar voltage output mode (0 to +5 volts), or current loop output mode (4 to 20 mA) applications. Channels may be individually wired for simultaneous operation in both current loop output and voltage output applications. The outputs from 50-pin edge connector J1 on the MULTIMODULE board are pin-compatible with the iCS 910 Signal Conditioning/Termination Panel.

Interfacing Through the Intel iSBX Bus

All data to be output through the MULTIMODULE board is transferred from the host iSBX microcomputer to the MULTIMODULE board via the iSBX bus connector. The UPI device on the MULTIMODULE board accepts the binary digital data and generates a 12-bit data word for the Digital-to-Analog Converter (DAC) and a four bit channel decode/enable for selecting the output channel. The DAC transforms the data into analog signal outputs for either voltage output mode or current loop output mode. Offsetting of the DAC voltage in current output mode may be performed by the UPI software offset routine or by the hardware offset adjustments included on the board. The MULTIMODULE board status is available via the iSBX bus connector, to determine if the UPI is ready to receive updates to analog output channels.

OPERATIONAL DESCRIPTION

The host iSBX microcomputer addresses the MULTIMODULE board by executing IN or OUT instructions specifying the iSBX 328 MULTIMODULE as a port address. The UPI on the iSBX 328 is initialized to select whether software or hardware offset is to be used and how many channels will be active. Then a 2 byte transfer to each active channel sets the 12 bit output value, the channel selected and the current or voltage mode.

Commands

OUTput Command — Initialization of UPI/iSBX 328

<table>
<thead>
<tr>
<th>7</th>
<th>N</th>
<th>N</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
</tr>
</thead>
<tbody>
<tr>
<td>NN</td>
<td>0,0 = unipolar configuration software current offset</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0,1 = no mixing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,0 = bipolar configuration software current offset</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OUTput Command — Data Bytes

<table>
<thead>
<tr>
<th>7</th>
<th>0 Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>contention for buffer</td>
</tr>
<tr>
<td>1</td>
<td>SBC generates offset in current loop mode</td>
</tr>
</tbody>
</table>

Figure 1. iSBX 328 Analog Output MULTIMODULE Board Block Diagram
iSBX 328

SPECIFICATIONS

Outputs — 8 non-isolated channels, each independently jumpered for voltage output or current loop output mode.

Voltage Ranges — 0 to +5 volts (unipolar operation)
-5 to +5 volts (bipolar operation)

Current Loop Range — 4 to 20 mA (unipolar operation only)

Output Current — ±5 mA maximum (voltage mode-bipolar operation)

Load Resistance — 0 to 250 ohms with on-board iSBX power. 1000 ohms minimum with 30 VDC max. external supply

Compliance Voltage — 12 V using on-board iSBX power. If supplied by user, up to 30 VDC max

Resolution — 12 bits bipolar or unipolar

Slew Rate — 0.1 volt per microsecond minimum

Single Channel Update Rate — 5KHz

Eight Channel Update Rate — 1KHz

Accuracy —

<table>
<thead>
<tr>
<th>Mode</th>
<th>Accuracy</th>
<th>Ambient Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage-Unipolar, typical</td>
<td>±0.025% FSR</td>
<td>@ 25°C</td>
</tr>
<tr>
<td>Voltage-Unipolar, maximum</td>
<td>±0.035% FSR</td>
<td>@ 25°C</td>
</tr>
<tr>
<td>Voltage-Unipolar, typical</td>
<td>±0.08% FSR</td>
<td>@ 0° to 60°C</td>
</tr>
<tr>
<td>Voltage-Unipolar, maximum</td>
<td>±0.19% FSR</td>
<td>@ 0° to 60°C</td>
</tr>
<tr>
<td>Voltage-Bipolar, typical</td>
<td>±0.025% FSR</td>
<td>@ 25°C</td>
</tr>
<tr>
<td>Voltage-Bipolar, maximum</td>
<td>±0.035% FSR</td>
<td>@ 25°C</td>
</tr>
<tr>
<td>Voltage-Bipolar, typical</td>
<td>±0.09% FSR</td>
<td>@ 0° to 60°C</td>
</tr>
<tr>
<td>Voltage-Bipolar, maximum</td>
<td>±0.17% FSR</td>
<td>@ 0° to 60°C</td>
</tr>
<tr>
<td>Current Loop, typical</td>
<td>±0.07% FSR</td>
<td>@ 25°C</td>
</tr>
<tr>
<td>Current Loop, maximum</td>
<td>±0.06% FSR</td>
<td>@ 25°C</td>
</tr>
<tr>
<td>Current Loop, typical</td>
<td>±0.17% FSR</td>
<td>@ 0° to 60°C</td>
</tr>
<tr>
<td>Current Loop, maximum</td>
<td>±0.37% FSR</td>
<td>@ 0° to 60°C</td>
</tr>
</tbody>
</table>

Interrupts

No interrupts are issued from the iSBX 328 to the host iSBC microcomputer. Data coordination is handled via iSBC software polls of the status buffer.

Output Impedance — 0.1 ohm. Drives capacitive loads up to 0.05 microfarads. (approx. 1000 foot cable)

Temperature Coefficient — 0.005%/°C

Connectors —

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pins (Qty)</th>
<th>Centers in</th>
<th>Centers cm</th>
<th>Mating Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 iSBX Bus</td>
<td>36</td>
<td>0.1</td>
<td>0.254</td>
<td>iSBC iSBX connector</td>
</tr>
<tr>
<td>J1 8/16 channels analog</td>
<td>50</td>
<td>0.1</td>
<td>0.254</td>
<td>3m 3415-000 or T1 H312125 or ICS 910 cable</td>
</tr>
</tbody>
</table>

Physical Characteristics

Width — 9.40 cm (3.7 inches)

Length — 6.35 cm (2.5 inches)

Height — 1.4 cm (0.56 inch) MULTIMODULE board only
2.82 cm (1.13 inches) MULTIMODULE and iSBC board.

Weight — 85.06 gm (3.0 ounces)

Electrical Characteristics

Vcc = ±5 volts (±0.25V), Icc = 140 ma max

Vdd = ±12 volts (±0.6V), Idd = 45 ma max (voltage mode) = 200 ma max (current loop mode)

Vss = -12 volts (±0.6V), Iss = 55 ma max
Environmental Characteristics

Operating Temperature — 0°C to 60°C (32°F to 140°F)

Relative Humidity — to 90% (without condensation)

Shock Tested At — Class B specifications

Reference Manuals

142914-001 — iSBX 328 Analog Output MULTI-MODULE Board Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBX 328</td>
<td>Analog Output MULTIMODULE Board</td>
</tr>
</tbody>
</table>
System Packaging and Power Supplies and Service
iSBC 604/614 or (pSBC 604/614*)
MODULAR CARDCA GAGE/BACKPLANE

- Interconnection on MULTIBUS system bus and housing for up to four Intel iSBC boards
- Cardcage mounting holes facilitate interconnection of units
- Strong cardcage structure helps protect installed iSBC single board computers and expansion boards against warping and physical damage
- Connectors allow interconnection of two or more cardcage/backplane assemblies
- Dual backplane power supply connectors and signal line termination circuits on iSBC 604 Cardcage/Backplane

The iSBC 604 and iSBC 614 Modular Cardcage/Backplane units provide low-cost, off-the-shelf housing for OEM products using two or more Intel single board computers. Each unit interconnects and houses up to four boards. The base unit, the iSBC 604 Cardcage/Backplane, contains a male backplane PC edge connector and bus signal termination circuits, plus power supply connectors. It is suitable for applications requiring a single unit, or may be interconnected with the iSBC 614 Cardcage/Backplane when more than one cardcage/backplane unit is needed. The iSBC 614 Cardcage/Backplane contains both male and female backplane connectors, and may be interconnected with iSBC 604/614 Cardcage/Backplane units. Both units are identical, with the exception of the power connectors and bus signal terminator features. A single unit may be packaged in a 3.5-inch RETMA rack enclosure, and two interconnected units may be packaged in a 7-Inch enclosure. The units are mountable in any of three planes.

*Same product, manufactured by Intel Puerto Rico, Inc.
SPECIFICATIONS

Backplane Characteristics

Bus Lines — All MULTIBUS system bus address, data, and command bus lines are bussed to all four connectors on the printed circuit backplane.

Power Connectors — for ground, +5V, -5V, +12V, -12V, -10V power supply lines.

ISBC 604 — Bus signal terminators, backplane male PC edge connector only, and power supply headers.

ISBC 614 — Backplane male and female connectors.

Mating Power Connectors:

<table>
<thead>
<tr>
<th>AMP</th>
<th>Connector</th>
<th>87159-7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pin</td>
<td>87023-1</td>
</tr>
<tr>
<td></td>
<td>Polarizing key</td>
<td>87116-2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Molex</th>
<th>Connector</th>
<th>09-50-7071</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pin</td>
<td>08-50-0106</td>
</tr>
<tr>
<td></td>
<td>Polarizing key</td>
<td>15-04-0219</td>
</tr>
</tbody>
</table>

Physical Dimensions

Height — 8.5 in. (21.59 cm)
Width — 14.2 in. (36.07 cm)
Depth — 3.34 in. (8.48 cm)
Weight — 35 oz (992.23 gm)

Environmental Characteristics

Operating Temperature — 0°C to 55°C

Reference Manual

9800708 — iSBC 604/614 Cardcage Hardware Reference Manual (NOT SUPPLIED)

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 604</td>
<td>Modular Cardcage/Backplane (Base Unit)</td>
<td>SBC 614</td>
<td>Modular Cardcage/Backplane (Expansion Unit)</td>
</tr>
</tbody>
</table>
iSBC 660
SYSTEM CHASSIS

- Eight-slot cardcage and backplane for iSBC computers and expansion boards
- Heavy duty power supply with all standard iSBC voltages
- Compatible with all Intel single board computers
- Forced-air cooling
- Attractive, versatile pop-off front panel
- 19-inch wide rack mountable chassis
- Horizontal board mounting for compactness
- 110/220V, 50/60 Hz operation

The iSBC 660 System Chassis is an attractive, 7-inch high system chassis designed for use with Intel OEM computers. It has eight slots for single board computers, memory, I/O, or other expansion modules. The iSBC 660 is ideal for applications requiring multiple board solutions. DC power output is provided at +12V, +5V, −12V, and −5V levels. The current capabilities of each of these output levels have been chosen to provide power over a 0°C to 50°C temperature range for the majority of applications requiring combinations of computers, memories, peripherals, and other I/O capabilities. Current limiting and over-voltage protection is provided at all outputs. Standard logic recognizes a system AC power failure and generates a TTL signal for use in power-down control. For user convenience, a reset switch is provided on the front panel. The reset signal generated and sent to the system bus can be used for external system control.
SPECIFICATIONS

Electrical Characteristics

Input Power
Frequency: 50 Hz ± 5%, 60 Hz ± 5%
Voltage: 115V ± 10%, 230V ± 10%, 215 VAC ± 10%, 100 VAC ± 10% via user configured wiring options

Output Power

<table>
<thead>
<tr>
<th>Power</th>
<th>Output Current (Max)</th>
<th>Current Limit (Amps)</th>
<th>Over-Voltage Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>+12V</td>
<td>4.5A</td>
<td>5.4</td>
<td>15V ± 1V</td>
</tr>
<tr>
<td>+5V</td>
<td>30A</td>
<td>3.6</td>
<td>6.2V ± 0.4V</td>
</tr>
<tr>
<td>-5V</td>
<td>1.75A</td>
<td>2.1</td>
<td>-6.2V ± 0.4V</td>
</tr>
<tr>
<td>-12V</td>
<td>1.75A</td>
<td>2.1</td>
<td>-15V ± 1V</td>
</tr>
</tbody>
</table>

Combined Line/Load Regulation — ±1% at ±10% static line change and ±50% static load change, measured at the output connector (±0.2% measured at the power supply under the same conditions).

Remote Sensing — Provided for +5 VDC output line regulation.

Output Ripple and Noise — 10 mV peak-to-peak maximum (DC to 500 kHz).

Output Transient Response — Less than 50 μs for ±50% load change.

Output Transient Deviation — Less than ±5% of initial voltage for ±50% load change.

Power Failure Indication (AC Low) — A TTL open collector high signal is provided when the input voltage drops below 90% of its nominal value. DC voltages will remain within 5% of their nominal values for 3.0 milliseconds (minimum) after AC low goes true. The “AC Low” signal will reset to a TTL low level when the AC input voltage is restored and after all output voltages are within specified regulation. The “AC Low” threshold is adjustable for optimum power-down performance at other input combinations (i.e. 100 VAC, 215 VAC, 50 Hz).
iSBC 660

Humidity — Up to 90% relative, non-condensing

Physical Characteristics
Height — 7 in. (17.8 cm)
Width
At Front Panel: 19 in. (48.3 cm)
Behind Front Panel: 17 in. (43.2 cm)
Depth — 20 in. (50.8 cm) with all protrusions

Environmental Characteristics
Temperature
Operating: 0°C to 50°C
Non-Operating: -40°C to +85°C

Equipment Supplied
iSBC 660 System Chassis with iSBC 640 Power Supply,
iSBC 604/614 Cardcage/Backplane, dual fans, pop-off
front panel
Connector pack with RS232C cable (terminal/modem in-
terface to single board computers), two 50-pin parallel

I/O connectors for single board computers
Schematics for cardcage/backplane, chassis
Outline drawing

Reference Manuals
9800505A — iSBC 660 Hardware Reference Manual (NOT SUPPLIED)
9800505 — iSBC 660 System Chassis Hardware Reference Manual (NOT SUPPLIED)
9800803 — iSBC 640 Power Supply Hardware Reference Manual (NOT SUPPLIED)
9800708 — iSBC 604/614 Cardcage Hardware Reference Manual (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 660</td>
<td>System Chassis</td>
</tr>
</tbody>
</table>
iSBC™ 680/iSBC 681
MULTISTORE™ USER SYSTEM PACKAGE

- Complete system package for user-selected Intel® iSBC boards and up to two 8" peripheral drives
- Available in table-top (iSBC 680 package) or rack-mount (iSBC 681 package) configurations
- Holds up to six iSBC boards compatible with the MULTIBUS® system bus
- Designed to meet UL safety requirements and FCC/VDE EMI limits
- Supplies ±5, ±12, ±24 VDC to power boards and peripheral drives
- Power supply provides 8 ms of power-fail warning, plus a real-time clock

The iSBC 680/iSBC 681 Multistore User System Package products make available to the OEM a new way to assemble his systems for those applications requiring rotating memory or other peripherals built in the 8" industry-standard form factor. The Multistore package allows the OEM to select the iSBC boards required for the job, and to independently choose from a wide variety of peripherals to complete the system. The switching power supply provides sufficient current at all voltage levels to power most manufacturers' drives, as well as furnishing the standard MULTIBUS system bus voltages to the iSBC boards in the package's cardcage. The appearance of the packages provides an attractive addition to the OEM's system, while the construction allows easy access to the interior for service.
FUNCTIONAL DESCRIPTION

Physical Packaging

PACKAGE CONSTRUCTION — The Multistore package is constructed entirely of metal, and all cover pieces are gasketed to completely contain high-frequency noise from the power supply and the system boards within the package.

MOUNTING OPTIONS — The iSBC 680 package is a table-top structure; the iSBC 681 package is the rack-mount version with slides attached to the side panels and a wider trim bezel to cover the mounting rails.

COOLING — The boards and peripherals installed in the package are cooled by air brought in at the bottom of the front panel and drawn through the power supply, with the heated air discharged to the rear of the package.

CARD CAGE/BACKPLANE — The cardcage/backplane accepts up to six iSBC boards compatible with the Intel MULTIBUS system bus (Figure 1).

PARALLEL PRIORITY — Up to six bus masters may be installed in the package because of the parallel priority logic which is an integral part of the backplane.

ENHANCED NOISE IMMUNITY — The integrity of the package is enhanced by a new backplane for the system boards, which offers improved noise immunity through advanced design techniques.

PERIPHERAL MOUNTING — Two positions are provided for mounting of peripheral drives conforming to the de facto industry standard for size and mounting points on 8” peripherals. The mounting system provides slides for the bases of the drives, allowing the drives to be installed/removed from the front of the package (Figure 2).

Blank covers with ventilation slots are provided with the package for the unused peripheral positions and for those peripherals not furnished with a cosmetic cover.

System Power

BASIC POWER SUPPLY — The supply provided with the package is an advanced-technology switching power supply, offering large current capabilities over the six DC voltages supported. Sockets for drive power are located on the power supply bulkhead at the rear of the peripheral cavity (Figure 3).

Figure 1. Boards Mounted in the Cardcage of the iSBC 680 Package

Figure 2. iSBC 680 Package with Winchester Drive Pulled Out for Servicing

Figure 3. Power Supply Showing Three Power Connectors (Two for Peripherals, One for the Cardcage/Backplane)
INTERNATIONAL ACCEPTANCE — The package is a UL-recognized component, and it has been designed to meet the safety requirements of CSA and VDE.

MEETS EMI STANDARDS — The FCC standards for conducted and radiated EMI (electromagnetic interference), as well as the VDE requirements (0871/0875), are met by the package.

POWER-FAIL/AUTO-RESTART SYSTEM — The package gives the user a set of logic signals providing advanced warning of power failures and protection for battery backed-up memory as the DC voltages fall. It also furnishes a real-time clock derived from the line frequency, thus ensuring long-term stability in user time-keeping.

User Interface

USER CONTROLS — At the front of the package the user has access to both the AC power switch (with integral circuit breaker) and controls and indicators for the microcomputer system itself. “RESET” and “INTERRUPT” switches are provided, along with “RUN” and “HALT” LED indicators.

DEVICE INTERFACE — With the package designed for maximum suppression of both EMI and ESD (electrostatic discharge) the preferred interface between the installed boards and external devices is with shielded cables isolated through user-supplied connectors installed in the panel provided at the rear of the package (Figure 4). The six cut-outs, sized for 50-pin connectors, are furnished with individual cover plates.

Figure 4. ISBC 680 Package Showing External Device Connection Panel

SPECIFICATIONS

Input Power

Frequency — 47–66 Hz
Voltage — 90–126 VAC/180–252 VAC, single phase (user-selectable).

Periodic and Random Deviation (PARD) — 50 mV peak-to-peak, all outputs.

Output Regulation (Combined Line and Load) — ± 1% under any conditions of AC input voltage variation (within operational range) and output load change.

Line Transient Tolerance — A signal of up to 1000 VDC, with a pulse width of up to 50 μs, will have no affect on system operation.

Output Power

Power Fail Indication — PFIN/ is generated approximately 8 ms after the input drops below 90/160 VAC. PFIN/ is available on the P2 connector of the cardcage/backplane for generation of an interrupt. The ± 24 VDC outputs will go to zero within 1 ms of issuance of PFIN/; the ± 5 and ± 12 VDC outputs will remain within specification for at least 8 ms, after which MPRO/ will go true to protect non-volatile memories from being written into as DC power fails.

System Clock — The power supply provides a 2 x line frequency clock output, available on the P2 connector of the cardcage/backplane.

<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Current¹ (Max Amps)</th>
<th>Typical Peripheral Power Requirements²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8&quot; Winchester</td>
<td>Diskette Drive</td>
</tr>
<tr>
<td>+5</td>
<td>30.0</td>
<td>5.1</td>
</tr>
<tr>
<td>-5</td>
<td>2.0</td>
<td>0.25</td>
</tr>
<tr>
<td>+12</td>
<td>2.9</td>
<td>—</td>
</tr>
<tr>
<td>-12</td>
<td>3.0</td>
<td>0.7</td>
</tr>
<tr>
<td>+24</td>
<td>7.8</td>
<td>4.0</td>
</tr>
<tr>
<td>-24</td>
<td>1.6</td>
<td>1.8</td>
</tr>
</tbody>
</table>

NOTES:
1. The maximum power available from the supply, from all outputs, is 300 watts.
2. These are worst-case data, drawn from manufacturers’ data sheets.
Physical Characteristics (Figure 5)

Width — 16.8/19.0 in. (42.5/48.3 cm)
Length — 21.5 in. (54.6 cm)
Height — 12.2 in. (31.1 cm)
Weight — 40 lb (18.2 kg) (approximate)

Board Slots — Six @0.665 in. on centers between boards. The board in the top slot may contain any ISBX and/or ISBC MULTIMODULE boards.

Peripheral Size — The drives must fit within an envelope 8.55 in. high by 14.25 in. deep by 4.65 in. wide.

Data Separator Board Location — A space is provided within the package to secure a Winchester drive data separator board, if required.

Environmental Characteristics

Ambient (Inlet) Air Temperature — The inlet air temperature, with peripheral drives installed, may not exceed 35°C. This is for the protection of the peripherals, as both diskette and Winchester drives have ambient maximums of 40°C in most instances.

Humidity — 20% to 80% RH, non-condensing for the chassis and typical peripheral content.

NOTE: The photos of the Multistore packages in this data sheet show boards, an 8" Winchester hard disk drive, and an 8" flexible disk drive installed. The packages do not include these boards and peripherals; they are shown in the photographs to illustrate physical arrangements in the Multistore package.

Equipment Supplied

iSBC 680 Chassis — Includes table-top package with aluminum sheet metal, 6-slot cardcage/backplane, combination On/Off switch and circuit breaker, peripheral mounting hardware (user must supply power and signal cabling for peripherals), and power supply with AC power cord.

iSBC 681 Chassis — Same as iSBC 680 chassis, plus rack-mount chassis slides and wider bezel.

Reference Manual

162432 — ISBC™ 680/681 Multistore™ Chassis Hardware Reference Manual (NOT SUPPLIED)

Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 680</td>
<td>Multistore User System Package (Table-Top)</td>
</tr>
<tr>
<td>SBC 681</td>
<td>Multistore User System Package (Rack-Mount)</td>
</tr>
</tbody>
</table>
ISBC 635
POWER SUPPLY

- Compact single chassis
- ± 5V and ± 12V ISBC 80 and ISBC 86 system power
- Sufficient power for one fully loaded Intel single board computer plus residual power for up to three Intel ISBC expansion boards
- Current limiting and overvoltage protection on all outputs
- DC power cables and connectors mate directly to ISBC 604 Modular Cardcage/Backplane assembly
- “AC low” power failure TTL logic level output provided for system power-down control
- 100V, 115V, 215V, and 230V AC operation
- 50 Hz or 60 Hz input

The ISBC 635 Power Supply provides low cost, off-the-shelf, single chassis power generation for OEM products using Intel single board computers. The ISBC 635 supply provides regulated DC output power at +12V, +5V, -12V, and -12V levels. The current capabilities of each of these output levels have been chosen to provide power over a 0°C to +55°C temperature range for one Intel single board computer fully loaded with I/O line terminators and drivers and EPROMs, plus residual capability for most combinations of up to three ISBC memory, I/O or combination expansion boards. Current limiting and overvoltage protection is provided on all outputs. Access for AC input is provided via a standard 4-pin keyed connector. DC output power levels are provided on cables with keyed connectors directly compatible with the ISBC 604 Modular Cardcage/Backplane assembly. The ISBC 635 supply includes logic whose purpose is to sense system AC power failure and generate a TTL signal for clean system power-down control.
**SPECIFICATIONS**

**Mating Connectors**

**AC Input**

<table>
<thead>
<tr>
<th>Connector</th>
<th>Molex</th>
<th>03-09-1042 or equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin</td>
<td>Molex</td>
<td>02-09-1118 or equivalent (18 to 22 gauge wire)</td>
</tr>
</tbody>
</table>

**DC Output**

<table>
<thead>
<tr>
<th>Header</th>
<th>Molex</th>
<th>09-66-1071</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AMP</td>
<td>87194-6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>&quot;AC Low&quot; Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connector</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Polarizing key</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Pin</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Notes**

1. Pins from a given vendor may only be used with connectors from the same vendor.
2. ISBC 635 DC output connectors are directly compatible with power input power connectors on ISBC 604 Modular Cardcage/Backplane assembly. Two connectors are provided.

**Physical Characteristics**

- **Height** — 3.19 in. max (8.11 cm)
- **Width** — 6.03 in. max (15.32 cm)
- **Depth** — 12.65 in. max (32.12 cm)
- **Weight** — 13 lb (5.90 kgm)

**Electrical Characteristics**

**Input Power** — Frequency: 47 - 63 Hz. Voltage (Nominal) (Single Phase): 100, 115, 215, or 230 VAC +10%

**Output Power:**

<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Current (AMPS/Max)</th>
<th>Current Limit Range (AMPS)</th>
<th>Max Short Circuit (AMPS)</th>
<th>Over-Voltage Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>+12</td>
<td>2.0</td>
<td>2.1 - 3.0</td>
<td>1.0 (Foldback)</td>
<td>+14 to +16 V</td>
</tr>
<tr>
<td>+ 5</td>
<td>14.0</td>
<td>14.7 - 21.0</td>
<td>7.0 (Foldback)</td>
<td>+5.8 to +6.6 V</td>
</tr>
<tr>
<td>- 5</td>
<td>0.9</td>
<td>0.9 - 1.4</td>
<td>1.4</td>
<td>+5.8 to +6.6 V</td>
</tr>
<tr>
<td>-12</td>
<td>0.8</td>
<td>0.8 - 1.2</td>
<td>1.2</td>
<td>-14 to -16 V</td>
</tr>
</tbody>
</table>

**Combined Line/Load Regulation** — ±1% at ±10% static line change and ±50% static load change, measured at the output connector (±0.2% measured at the power supply under the same conditions).

**Remote Sensing** — Provided for +5VDC output line regulation

**Output Ripple and Noise** — 10 mV peak-to-peak maximum (DC to 500 KHz)

**Output Transient Response** — Less than 50 μsec for ±50% load change

**Output Transient Deviation** — Less than ±5% of initial voltage for ±50% load change.

**Power Failure Indication (AC Low)** — A TTL open collector high signal is provided when the input voltage drops below 90% of its nominal value. DC voltages will remain within 5% of their nominal values for 3.0 milliseconds (minimum) after AC low goes true.
The “AC Low” signal will reset to a TTL low level when the AC input voltage is restored and after all output voltages are within specified regulation.

The “AC Low” threshold is adjustable for optimum powerdown performance at other input combinations (i.e. 100 VAC, 215 VAC, 50 Hz).

**Environmental Characteristics**

*Operating Temperature* — 0°C to +55°C with 35 CFM moving air

*Non-Operating* — −40°C to +85°C

**Equipment Supplied**

iSBC 635 Power Supply with AC and DC cables and connectors attached as shown in Figure 1.

**Reference Manual**

9800298C — iSBC 635 Power Supply Hardware Reference Manual (includes schematics) (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 635</td>
<td>Power Supply</td>
</tr>
</tbody>
</table>
iSBC 640
POWER SUPPLY

- ± 5V and ± 12V iSBC 80/86 power
- Sufficient power for 8-12 MULTIBUS computer, memory, and peripheral boards
- Current limiting and overvoltage protection on all outputs
- "AC low" power failure TTL logic level output provided for system power-down control
- Compact single chassis/slide rail mounts in iCS 80 Industrial Chassis or OEM environments
- DC power cables and connectors mate directly to iSBC 604 Modular Cardcage/Backplane assembly
- 100, 115, 215, and 230V AC operation
- 50 Hz or 60 Hz input

The iSBC 640 Power Supply provides low cost, off-the-shelf, single chassis power generation for OEM and industrial system products using Intel single board computers. The iSBC 640 supply provides regulated DC output power at + 12V, + 5V, - 5V and - 12V levels. The current capabilities of each of these output levels have been chosen to provide power over a 0°C to + 55°C temperature range for one fully loaded Intel single board computer, plus residual capability for most combinations of up to eleven iSBC memory, I/O, or combination expansion boards. Current limiting and over-voltage protection is provided on all outputs. Access for AC input is provided via a standard 4-pin keyed connector. DC output power levels are provided on cables with keyed connectors directly compatible with the iSBC 604/614 Modular Backplane/Cardcage assemblies. The iSBC 640 supply includes logic whose purpose is to sense system AC power failure and generate a TTL signal for clean system power-down control.
SPECIFICATIONS

**Electrical Characteristics**

**Input Power**
- Frequency: 50 Hz ± 5%, 60 Hz ± 5%
- Voltage: 115V ± 10%, 230V ± 10%, 215VAC ± 10%, 100VAC ± 10%
  - Via user configured wiring options

**Output Power**

<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Current (Amps)(Max)</th>
<th>Current Limit Range (Amps)</th>
<th>Short Circuit (Amps)(Max)</th>
<th>Overvoltage Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>+12V</td>
<td>4.5A</td>
<td>4.7- 6.8</td>
<td>2.3</td>
<td>15V ± 1V</td>
</tr>
<tr>
<td>+5V</td>
<td>30A</td>
<td>31.5-45.0</td>
<td>15.0</td>
<td>6.2V ± 0.4V</td>
</tr>
<tr>
<td>-5V</td>
<td>1.75A</td>
<td>1.8- 3.2</td>
<td>0.9</td>
<td>-6.2V ± 0.4V</td>
</tr>
<tr>
<td>-12V</td>
<td>1.75A</td>
<td>1.8- 3.2</td>
<td>0.9</td>
<td>-15V ± 1V</td>
</tr>
</tbody>
</table>

**Combined Line/Load Regulation** — ±1% at ±10% static line change and ±50% static load change, measured at the output connector (±0.2% measured at the power supply under the same conditions).

**Remote Sensing** — Provided for +5 VDC output line regulation.

**Output Ripple and Noise** — 10 mV peak-to-peak maximum (DC to 500 KHz)

**Output Transient Response** — Less than 50 μsec for ±50% load change.

**Output Transient Deviation** — Less than ±10% of initial voltage for ±50% load change.

**Power Failure Indication (AC Low)** — A TTL open collector high signal is provided when the input voltage drops below 90% of its nominal value. DC voltages will remain within 5% of their nominal values for 3.0 milliseconds (minimum, 7.5 ms typical) after AC Low goes true.

The "AC Low" signal will reset to a TTL low level when the AC input voltage is restored and after all output voltages are within specified regulation.

The "AC Low" threshold is adjustable for optimum powerdown performance at other input combinations (i.e., 100 VAC, 215 VAC, 50 Hz).

**Mating Connectors**

- **AC Input**

<table>
<thead>
<tr>
<th>Housing</th>
<th>Molex</th>
<th>03-09-2042 or equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin</td>
<td>Molex</td>
<td>02-09-2116 or equivalent (18 to 22 gauge wire)</td>
</tr>
</tbody>
</table>

**DC Output**

<table>
<thead>
<tr>
<th>Housing</th>
<th>Molex</th>
<th>26-03-3071</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amp</td>
<td>3-87025-3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pins</th>
<th>Molex</th>
<th>08-50-0187 or 08-50-0189</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amp</td>
<td>87023-1</td>
<td></td>
</tr>
<tr>
<td>Key</td>
<td>Molex</td>
<td>15-04-9209</td>
</tr>
<tr>
<td>Amp</td>
<td>87116-2</td>
<td></td>
</tr>
</tbody>
</table>

Compatible with Molex 09-66-1071 Header

**Notes**
1. Pins from given vendor may only be used with connectors from the same vendor.
2. iSBC 640 DC output connectors are directly compatible with input power connectors on iSBC 604 Modular Cardcage/Backplane assembly. Four connectors are provided.

**Physical Characteristics**

- Height — 6.66 in. max. (16.92 cm)
- Width — 8.19 in. max. (20.80 cm)
- Depth — 12.65 in. max. (32.12 cm)
- Weight — 30 lbs. max (13.63 kg)

**Environmental Characteristics**

- Temperature — 0°C to 55°C with 55 CFM moving air
- Non-Operating — —40°C to +85°C

**Equipment Supplied**

iSBC 640 Power Supply with AC and DC cables with keyed connectors.

**Reference Manuals**

9800803 — iSBC 640 Power Supply Hardware Reference Manual (includes schematic and assembly drawings) (NOT SUPPLIED)

9800798 — iCS 80 Systems Site Planning and Installation Manual (for installation of iSBC 640 supply into iCS 80 Industrial Chassis) (NOT SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3085 Bowers Avenue, Santa Clara, California 95051.
iSBC 665/iSBC 645™
SYSTEM CHASSIS AND POWER SUPPLY

• Intel MULTIBUS™ system bus 4-slot packaging
• Complete package of rack-mounting, cooling, controls, and power
• Advanced 110 watt switching power supply generates ±5, ±12 VDC
• Meets U.S. and International EMI and safety requirements

• Wide AC voltage margins keep systems running during “brownouts”
• Front panel switches, indicators, and adjustments for operational and service convenience
• Power sense circuitry interrupts system 6 msec prior to power failure

The Intel iSBC 665/iSBC 645 Chassis system provides the MULTIBUS system bus user with a compact set of products offering new standards in 4-slot rack-mount packaging. A high-efficiency switching power supply allows use of 115/230 VAC (+15/-20%), with large surge and noise components, to deliver smooth, stable DC power to the OEM board load. Advanced power-fail sense and restart logic gives the user sufficient time to bring the system to an orderly shutdown in the event of AC mains power failure. Mechanical design features include EMI suppression and a retainer/cover for system boards and I/O edge connectors.
FUNCTIONAL DESCRIPTION

iSBC 665™ System Chassis
The iSBC 665 Chassis is a complete microcomputer package providing four board slots in a 3.5" vertical space.

RACK MOUNT PACKAGE
The iSBC 665 Chassis mounts in a 19" EIA standard rack, using its front panel and hangers at the rear of the chassis to secure it to both sets of rails in the cabinet. If slide mounting is preferred, a tray with slides should be used as a platform for the chassis. The physical integrity of the system is enhanced by addition of a connector retainer at the (rear-facing) opening of the cardcage.

INTEGRAL COOLING
The fan on the power supply is utilized to draw ambient air across the boards prior to its being used to cool the supply.

FRONT PANEL
The front panel of the iSBC 665 Chassis forms a complete control center for the system installed in the chassis (see Figure 1).

iSBC 645 Power Supply
The 110-watt supply of the iSBC 665 Chassis is designed to provide advanced features to the Intel system builder who faces complex power supply and chassis requirements.

<table>
<thead>
<tr>
<th>Label</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls&lt;br&gt;DC ON/OFF</td>
<td>Controls all DC power to the chassis.</td>
</tr>
<tr>
<td></td>
<td>RESET</td>
</tr>
<tr>
<td></td>
<td>INTRPT</td>
</tr>
<tr>
<td>Indicators&lt;br&gt;HALT, RUN</td>
<td>Indicate status of system CPU board.</td>
</tr>
<tr>
<td>AC ON</td>
<td>Indicates AC power present in supply (AC power switch is located at the rear of the supply).</td>
</tr>
<tr>
<td>OV</td>
<td>Indicates power supply shut-down due to an overvoltage condition on +5 or ±12 VDC outputs.</td>
</tr>
<tr>
<td>AC LO</td>
<td>Indicates that AC voltage is below the operating range and the supply has shut down.</td>
</tr>
<tr>
<td>Adjustments&lt;br&gt;+5</td>
<td>Adjusts +5 VDC output voltage.</td>
</tr>
<tr>
<td>–V</td>
<td>Adjusts negative adjustable voltage; set to –5 VDC at the factory.</td>
</tr>
<tr>
<td>AC LO</td>
<td>Adjusts AC sense threshold at which the system generates power-fail signals; set to 88/176 VAC at factory.</td>
</tr>
</tbody>
</table>

INTERNATIONAL ACCEPTANCE
The supply is a UL-recognized component; the supply/chassis combination is also designed to meet the safety requirements of CSA (Canada) and VDE (Germany) as industrial, computer, and office equipment.¹

EMI STANDARDS
The FCC standards for conducted and radiated EMI (electromagnetic interference) are met by the supply, thus the chassis packaging will enhance the OEM’s efforts to assemble systems which must comply with the FCC Part 15 Rules. In addition, the supply/chassis design meets the most stringent VDE requirements (0871/0875) for conducted and radiated EMI.¹

NOTE:
1. CSA and VDE testing have not been officially completed; testing at independent laboratories indicates that these safety and EMI requirements are met. Official testing should be completed in late 1981.

Figure 1. iSBC 665™ Chassis Front Panel Controls

11-16
BROWNOUT PROTECTION
The wide AC voltage input range allows microcomputer systems packaged in the chassis to function normally at extremely low AC voltage supply levels.

POWER-FAIL WARNING AND RECOVERY
In the event of a complete power failure, an interrupt is generated 6 ms prior to the supply's issuing a subsequent memory protect signal, giving sufficient time for execution of a user program to bring the entire system to an orderly shut-down.

POWER TRANSIENT TOLERANCE
The supply provides immunity for the system from the high-voltage transient surges and spikes seen in AC power systems. The supply itself provides this isolation with a metal-oxide varistor (MOV) and line filter in the input circuitry.

SPECIFICATIONS
Electrical Characteristics

INPUT POWER
Frequency: 47-66 Hz
Voltage: 115/230 VAC Single Phase
Range: 90 to 126 VAC/180 to 252 VAC
Consumption (Max.): 230 watts

OUTPUT POWER

<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Current Limit Point (Amps)</th>
<th>Overvoltage Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 5</td>
<td>15</td>
<td>18.75</td>
</tr>
<tr>
<td>+ 12</td>
<td>3</td>
<td>3.75</td>
</tr>
<tr>
<td>− 12</td>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>− Adjustable</td>
<td>1</td>
<td>1.25</td>
</tr>
</tbody>
</table>

NOTES:
2. Total output power is 110 watts; a maximum of 128 watts is available, but proper operation of the power-fail circuitry is not guaranteed above 110 watts.
3. A minimum load is required on the +5 VDC output; this load must be at least ½ the sum of the loads (in watts) of the remaining three outputs.
4. −2.5 to −12 VDC; factory set to −5 VDC.

POWER LINE CLOCK
A clock signal is developed from the AC line at twice the line frequency; this gives the system user an extremely accurate time base.

Figure 2. ISBC 645™ Power Supply

OUTPUT REGULATION (COMBINED LINE AND LOAD) — ±1% under any conditions of AC mains voltage variation (within operational range) and output load change.

PERIODIC AND RANDOM DEVIATION (PARD) — 50 millivolts peak-to-peak, all outputs.

LINE TRANSIENT TOLERANCE — A signal of up to 1000 VDC, with a pulse width of up to 50 microseconds, will have no affect on operation.

POWER FAIL INDICATION — An AC low condition generates ACLO and PFIN/ after AC voltage drops below the allowed voltage range. These signals are available on the P2 connector to generate interrupts. The DC voltages will remain within specifications for 6 milliseconds (worst case) following these interrupts, after which Memory Protect (MPRO/) will go true.

OUTPUT VOLTAGE TEMPERATURE COEFFICIENT — 0.03% per °C over the operating range.

SYSTEM CLOCK — 2x line frequency clock signal available on P2 connector.
ISBC 665/ISBC 645™

Physical Characteristics (See Figure 3)
WIDTH — 19.0 in. (48.3 cm)
LENGTH — 16.25 in. (41.3 cm)
HEIGHT — 3.5 in. (8.9 cm)
WEIGHT — 12.0 lb (5.4 kg)

Environmental Characteristics
AMBIENT (INLET) AIR TEMPERATURE — Chassis: 0°C to 55°C; Power Supply: 0°C to 65°C (Full Rated Output)
HUMIDITY — Up to 95% non-condensing.

Equipment Supplied
ISBC 665 SYSTEM CHASSIS — Includes ISBC 645 Power Supply, ISBC 604 Modular Cardcage/Backplane, connector retainer, schematics for cardcage/backplane, chassis, and power supply.
ISBC 645 POWER SUPPLY — Includes power supply, schematics for supply.

Reference Manuals (Not Supplied)
142836 — ISBC 665™ System Chassis Hardware Reference Manual

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
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<tr>
<td>SBC 665</td>
<td>System Chassis</td>
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<tr>
<td>SBC 645</td>
<td>Power Supply (110 Watt)</td>
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</tbody>
</table>
iMBX 100/110/120
MULTIBUS® EXCHANGE
HARDWARE SUBSCRIPTION SERVICE

- Monthly product updates
- History of Engineering Change Orders
- Customized to the subscriber's selection of Intel® board level products
- Ancillary Notes clarifying and correcting product documentation
- Offers full update alternatives — documentation, parts kit, and factory update
- Timely announcements of technological and product developments
- Available for iSBC,™ iCS,™ and iSBX™ products

The Intel MULTIBUS EXCHANGE hardware subscription service consists of a monthly update publication which provides summary descriptions of Engineering Change Orders that alert and inform subscribers of all the latest developments and/or improvements applicable to their Intel board level products. In addition, the update contains order numbers and prices for optional update parts kits. This timely service allows users to closely track product changes and, by evaluating or implementing these changes, to take advantage of technological and product developments.
PRODUCTS
The MULTIBUS EXCHANGE hardware subscription service supports Intel manufactured Single Board Computer, Industrial Control Series and MULTIMODULE products. Users can subscribe to any combination of over 60 products.

NEW SUBSCRIBERS
New subscribers receive a history (back to the earliest purchase date of each product) for each subscribed-to product and a handsome notebook in which future updates may be orderly stored.

MONTHLY UPDATES
Each month MULTIBUS EXCHANGE subscribers receive an update containing summaries of Engineering Change Orders and documentation clarification articles relating to each subscribed-to product. Each change description includes the change made, the rationale behind the change, and the user's alternatives concerning updating his product. Subscribers receive the monthly update even if no changes have occurred to their products.

ORDERS
Orders for the MULTIBUS EXCHANGE are a combination of a base (iMBX 100) order, plus orders for each product to be included (iMBX 110s and/or iMBX 120s). For each MULTIBUS board, power supply, or chassis, an iMBX 110 is ordered. For each MULTIMODULE board, an iMBX 120 is ordered.

CHARGES
For an annual subscription fee, subscribers receive twelve monthly updates. All new subscribers will also receive a history for each subscribed-to product at no extra charge. For additional specified charges, subscribers can purchase the associated documentation and parts kits listed in the MULTIBUS EXCHANGE updates.

ORDERING INFORMATION

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<th>Part Number</th>
<th>Description</th>
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</thead>
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<td>MBX 100</td>
<td>Base order for the MULTIBUS EXCHANGE hardware subscription service for one year</td>
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<tr>
<td>MBX 110</td>
<td>MULTIBUS EXCHANGE subscription covering one MULTIBUS board, power supply or chassis for one year</td>
</tr>
<tr>
<td>MBX 120</td>
<td>MULTIBUS EXCHANGE subscription covering one MULTIMODULE board for one year</td>
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</table>
MODEL 225
INTELLEC® SERIES II/85
MICROCOMPUTER DEVELOPMENT SYSTEM

- Complete microcomputer development system for MCS®-86, MCS®-85, MCS®-80, MCS®-48, and MCS®-51 microprocessor families
- Integral 250K byte floppy disk drive with total storage capacity expandable to over 2M bytes of floppy disk storage and 7.3M bytes of hard disk storage
- High performance 8085A-2 CPU, 64K bytes RAM memory, and 4K bytes ROM memory
- Powerful ISIS-II Disk Operating System with relocating macroassembler, linker, locater, and CRT based editor
- Self-test diagnostic capability
- Supports PL/M, FORTRAN, BASIC, PASCAL and COBOL high level languages
- Built-in interfaces for high speed paper tape reader/punch, printer, and universal PROM programmer
- Software compatible with previous Intellec® systems

The Intellec Series II/85 Model 225 Microcomputer Development System is a performance enhanced, complete microcomputer development system integrated into one compact package. The Model 225 includes a CPU with 64K bytes of RAM, 4K bytes of ROM, a 2000-character CRT, detachable full ASCII keyboard with cursor controls and upper/lower case capability, and a 250K-byte floppy disk drive. Powerful ISIS-II Disk Operating System software allows the Model 225 to be used quickly and efficiently for assembling and debugging programs for Intel’s MCS-86, MCS-85, MCS-80, MCS-48, or MCS-51 microprocessor families. ISIS-II performs all file handling operations for the user, leaving him free to concentrate on the details of his own application. When used with an optional in-circuit emulator (ICE™) module, the Model 225 provides all of the hardware and software development tools necessary for the rapid development of a microcomputer-based product. Optional storage peripherals provide over 2 million bytes of floppy disk, and 7.3 million of hard disk storage capacity.
FUNCTIONAL DESCRIPTION

Hardware Components

The Intellec Series II/85 Model 225 is a highly-integrated microcomputer development system consisting of a CRT chassis with a 6-slot cardcage, power supply, fans, cables, single floppy disk drive, and two printed circuit cards. A separate, full ASCII keyboard is connected with a cable. A block diagram of the Model 225 is shown in Figure 1.

CPU Cards — The master CPU card contains its own microprocessor, memory, I/O, interrupt and bus interface circuitry implemented with Intel’s high technology LSI components. Known as the integrated processor card (IPC), it occupies the first slot in the cardcage. A second slave CPU card is responsible for all remaining I/O control including the CRT and keyboard interface. This card, mounted on the rear panel, also contains its own microprocessor, RAM and ROM memory, and I/O interface logic, thus, in effect, creating a dual processor environment. Known as the I/O controller (IOC), the slave CPU card communicates with the IPC over an 8-bit bidirectional data bus.

Expansion — Five remaining slots in the cardcage are available for system expansion. Additional expansion of 4 slots can be achieved through the addition of an Intellec Series II expansion chassis.
System Components

The heart of the IPC is an Intel NMOS 8-bit microprocessor, the 8085A-2, running at 4.0 MHz. 64K bytes of RAM memory are provided on the board using 16K RAMs. 4K of ROM is provided, pre-programmed with system bootstrap "self-test" diagnostics and the Intellec Series II/85 System Monitor. The eight-level vectored priority interrupt system allows interrupts to be individually masked. Using Intel's versatile 8259A interrupt controller, the interrupt system may be user programmed to respond to individual needs.

Input/Output

IPC Serial Channels — The I/O subsystem in the Model 225 consists of two parts: the IOC card and two serial channels on the IPC itself. Each serial channel is RS232 compatible and is capable of running asynchronously from 110 to 9600 baud or synchronously from 150 to 56K baud. Both may be connected to a user defined data set or terminal. One channel contains current loop adapters. Both channels are implemented using Intel's 8251A USART. They can be programmed to perform a variety of I/O functions. Baud rate selection is accomplished through an Intel 8253 interval timer. The 8253 also serves as a real-time clock for the entire system. I/O activity through both serial channels is signaled to the system through a second 8259A interrupt controller, operating in a polled mode nested to the primary 8259A.

IOC Interface — The remainder of system I/O activity takes place in the IOC. The IOC provides interface for the CRT, keyboard, and standard Intellec peripherals including printer, high speed paper tape reader/punch, and universal PROM programmer. The IOC contains its own independent microprocessor, an 8080A-2. The CPU controls all I/O operations as well as supervising communications with the IPC. 8K bytes of ROM contain all I/O control firmware. 8K bytes of RAM are used for CRT screen refresh storage. These do not occupy space in Intellec Series II main memory since the IOC is a totally independent microcomputer subsystem.

Integral CRT

Display — The CRT is a 12-inch raster scan type monitor with a 50/60 Hz vertical scan rate and 15.5kHz horizontal scan rate. Controls are provided for brightness and contrast adjustments. The interface to the CRT is provided through an Intel 8275 single-chip programmable CRT controller. The master processor on the IPC transfers a character for display to the IOC, where it is stored in RAM. The CRT controller reads a line at a time into its line buffer through an Intel 8257 DMA controller and then feeds one character at a time to the character generator to produce the video signal. Timing for the CRT control is provided by an Intel 8253 interval timer. The screen display is formatted as 25 rows of 80 characters. The full set of ASCII characters is displayed, including lower case alphas.

Keyboard — The keyboard interfaces directly to the IOC processor via an 8-bit data bus. The keyboard contains an Intel UPI-41™ Universal Peripheral Interface, which scans the keyboard, encodes the characters, and buffers the characters to provide N-key rollover. The keyboard itself is a high quality typewriter style keyboard containing the full ASCII character set. An upper/lower case switch allows the system to be used for document preparation. Cursor control keys are also provided.

Peripheral Interface

A UPI-41 Universal Peripheral Interface on the IOC board provides interface for other standard Intellec peripherals including a printer, high speed paper tape reader, high speed paper tape punch, and universal PROM programmer. Communication between the IPC and IOC is maintained over a separate 8-bit bidirectional data bus. Connectors for the four devices named above, as well as the two serial channels, are mounted directly on the IOC itself.

Control

User control is maintained through a front panel, consisting of a power switch and indicator, reset/boot switch, run/halt light, and eight interrupt switches and indicators. The front panel circuit board is attached directly to the IPC, allowing the eight interrupt switches to connect to the primary 8259A, as well as to the Intellec Series II bus.

Integral Floppy Disk Drive

The integral floppy disk is controlled by an Intel 8271 single chip, programmable floppy disk controller. It transfers data via an Intel 8257 DMA controller between an IOC RAM buffer and the diskette. The 8271 handles reading and writing of data, formatting diskettes, and reading status, all upon appropriate commands from the IOC microprocessor.
**MULTIBUS™ Interface Capability**

All Intellec Series II/85 models implement the industry standard MULTIBUS protocol. The MULTIBUS protocol enables several bus masters, such as CPU and DMA devices, to share the bus and memory by operating at different priority levels. Resolution of bus exchanges is synchronized by a bus clock signal derived independently from processor clocks. Read/write transfers may take place at rates up to 5 MHz. The bus structure is suitable for use with any Intel microcomputer family.

**SPECIFICATIONS**

**Host Processor (IPC)**

8085A-2 based, operating at 4.0 MHz.
RAM — 64K on the CPU card
ROM — 4K (2K in monitor, 2K in boot/diagnostic)
Bus — MULTIBUS™ bus, maximum transfer rate of 5 MHz
Clocks — Host processor, crystal controlled at 4.0 MHz, bus clock, crystal controlled at 9.8304 MHz

**I/O Interfaces**

Two Serial I/O Channels, RS232C, at 110-9600 baud (asynchronous) or 150-56K baud (synchronous). Baud rates and serial format fully programmable using Intel 8251A USARTs. Serial Channel 1 additionally provided with 20 mA current loop. Parallel I/O interfaces provided for paper tape punch, paper tape reader, printer, and UPP-103 Universal PROM Programmer.

**Interrupts**

8-level, maskable, nested priority interrupt network initiated from front panel or user selected devices.

**Direct Memory Access (DMA)**

Standard capability on MULTIBUS interface; implemented for user selected DMA devices through optional DMA module—maximum transfer rate of 5 MHz.

**Memory Access Time**

RAM — 470 ns max
PROM — 540 ns max

**Integral Floppy Disk Drive**

Floppy Disk System Capacity — 250K bytes (formatted)
Floppy Disk System Transfer Rate — 160K bits/sec
Floppy Disk System Access Time —
  Track to Track: 10 ms max
  Average Random Positioning: 260 ms
  Rotational Speed: 360 rpm
  Average Rotational Latency: 83 ms
  Recording Mode: FM

**Physical Characteristics**

**CHASSIS**

Width — 17.37 in. (44.12 cm)
Height — 15.81 in. (40.16 cm)
Depth — 19.13 in. (48.59 cm)
Weight — 73 lb. (33 kg)

**KEYBOARD**

Width — 17.37 in. (44.12 cm)
Height — 3.0 in. (7.62 cm)
Depth — 9.0 in. (22.86 cm)
Weight — 6 lb. (3 kg)
MODEL 225

Electrical Characteristics

<table>
<thead>
<tr>
<th>DC POWER SUPPLY</th>
<th>Volts Supplied</th>
<th>Amps Supplied</th>
<th>Typical System Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 5 ±5%</td>
<td>30.0</td>
<td></td>
<td>17.0</td>
</tr>
<tr>
<td>+12 ±5%</td>
<td>2.5</td>
<td></td>
<td>1.1</td>
</tr>
<tr>
<td>-12 ±5%</td>
<td>0.3</td>
<td></td>
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<td></td>
<td>0.08</td>
</tr>
<tr>
<td>+15 ±5%*</td>
<td>1.5</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>+24 ±5%*</td>
<td>1.7</td>
<td></td>
<td>1.7</td>
</tr>
</tbody>
</table>

*Not available on bus.

Equipment Supplied

Model 225 Chassis including:
- Integrated Processor Card (IPC)
- I/O Controller Board (IOC)
- CRT
- ROM-Resident System Monitor
- Detachable keyboard
- ISIS-II System Diskette with MCS-80/MCS-85 Macroassembler
- ISIS-II CREDIT Diskette CRT-Based Text Editor

AC REQUIREMENTS FOR MAINFRAME

110V, 60 Hz — 5.9 Amp
220V, 50 Hz — 3.0 Amp

Environmental Characteristics

Operating Temperature — 16°C to 32°C (61°F to 90°F)
Humidity — 20% to 80%

ORDERING INFORMATION

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<td>MDS-225*</td>
<td>Intellec® Series II/85 Model 225 Microcomputer Development System (110V/60 Hz)</td>
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<tr>
<td>MDS-226*</td>
<td>Intellec® Series II/85 Model 226 Microcomputer Development System (220V/50 Hz)</td>
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"MDS" is an ordering code only, and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corp.
MODEL 286
INTELLEC® SERIES III
MICROCOMPUTER DEVELOPMENT SYSTEM

- Supports Intellec 432/100 Evaluation and Educational System
- Compatible with iSBC-090 Series 90 Memory System Upgrade: 512K Byte to 1M Byte
- Complete 16-bit High Performance, Microcomputer Development Solution for Intel iAPX 86,88 Applications. Also Supports MCS-85™, MCS-80 and MCS-48 Families
- Supports Full Range of iAPX 86,88-Resident, High-Level Languages: PL/M 86/88, PASCAL 86/88, and FORTRAN 86/88
- 2 Host CPUs—iAPX 86 and 8085A—for Enhanced System Performance and Two Native Execution Environments
- 96K Bytes of User Program RAM Memory Available for IAPX 86,88 Programs
- Series II/80 and Series II/85 Upgradeable to 8085/iAPX 86 Series III Functionality
- Intellec Model 800 Upgradeable to 8080/iAPX 86 Series III Functionality
- Compatible with Intellec Distributed Development Systems
- Compatible with Previous Intellec Systems
- Software Applications Debugger for User iAPX 86,88 Programs
- Upgradeable to a Complete Ethernet* Communications Development System Environment, Using the Model 677 Upgrade

The Intellec Series-III Microcomputer Development System is a high-performance system solution designed specifically for iAPX 86,88 microprocessor development. It contains two host CPUs, an iAPX 86 and an 8085, that provide two native execution environments for optimum performance and compatibility with the Intellec software packages for both CPUs. The basic system includes 96K bytes of iAPX 86,88 user RAM memory and a 250K byte floppy disk drive. The powerful Disk Operating System maximizes system processing by utilizing the power of both host processors. Standard software includes a full range of iAPX 86,88 resident software. The high-level languages PL/M 86/88, PASCAL 86/88, and FORTRAN 86/88 are also available. A ROM resident software debugger not only provides self-test diagnostic capability, but also gives the user a powerful iAPX 86,88 applications debugger.

*Ethernet is a trademark of Xerox Corporation.
FUNCTIONAL DESCRIPTION

Hardware Components

The Intellec Series III is contained in a single package consisting of a CRT chassis with a 6-slot card cage, power supply, fans, cables, single floppy disk drive, detachable upper/lower case full ASCII keyboard, and four printed circuit cards. A block diagram of the system is shown in Figure 1.

System Components

Two CPU cards reside on the Intellec MULTIBUS bus, each containing its own microprocessor, memory, I/O, interrupt and bus interface circuitry implemented with Intel's high technology LSI components. The integrated processor card (IPC-85), occupies the first slot in the cardcage. A second CPU card, the resident processor board (RPB-86) contains Intel's 16-bit HMOS microprocessor. These CPUs provide the dual processor environment.

A third CPU card performs all remaining I/O including interface to the CRT, integral floppy disk, and keyboard. This card, mounted on the rear panel, contains its own microprocessors, RAM and ROM memory, and I/O interface logic. Known as the I/O controller (IOC), this slave CPU card communicates with the IPC-85 over an 8-bit bidirectional data bus. A 64K byte RAM expansion memory board is also included.

Expansion

Two additional slots in the system cardcage are available for system expansion. The Intellec expansion chassis Model 201 is available to provide 4 additional expansion slots for either memory or I/O expansion.

THE INTELLEC DEVELOPMENT SYSTEM FOR ETHERNET (DS/E)

The Intellec Series III can be expanded to provide the user with the tools necessary to develop and test

Figure 1. INTELLEC Series III Block Diagram
communications software and applications that will use Ethernet as a communications subsystem. The power of the Intellec Series III combined with Model 677 allows the user to develop either 8- or 16-bit Ethernet-based applications.

THE INTELLEC 432/100 EVALUATION AND EDUCATIONAL SYSTEM
The Intellec Series III provides a complete system environment necessary for evaluation of the Intel iAPX 432 32-bit micromainframe. The iSBC 432/100 board plugs into a Multibus slot in the Intellec Series III, sharing system memory and resources. A comprehensive set of documentation, system software and hardware provides the evaluation and educational environment for the powerful iAPX 432.

iAPX 286 Evaluation System
The Intellec Series III provides a complete system environment for evaluation of the iAPX 286 microprocessor's architecture and its instruction set, segmentation timing, memory mapping and protection features. A user can begin the development of complex iAPX 286 programs, systems and operating system nuclei with the Intellec Series III and iAPX 286 evaluation package.

CPU Cards

IPC-85
The heart of the IPC-85 is an Intel NMOS 8-bit microprocessor, the 8085A-2, running at 4.0 MHz. 64K bytes of RAM memory are provided on the board using 16K dynamic RAMs. 4K of ROM is provided, preprogrammed with system bootstrap "self-test" diagnostics and the Intellec System Monitor. The eight-level vectored priority interrupt system allows interrupts to be individually masked. Using Intel's versatile 8259A interrupt controller, the interrupt system may be user programmed to respond to individual needs.

RPB-86
The heart of the RPB-86 is an Intel HMOS 16-bit microprocessor, the iAPX 86 (8086), running at 5.0 MHz. 64K bytes of RAM memory are provided on the board. 16K of ROM is provided on board, preprogrammed with an iAPX 88/86 applications debugger which provides features necessary to debug and execute application software for the iAPX 88/86 microprocessors.

The 8085A-2 and iAPX 86 access two independent memory spaces. This allows the two processors to execute concurrently when an iAPX 88/86 program is run. In this mode, the IPC-85 becomes an intelligent I/O processor board to the RPB-86.

Input/Output

IPC-85 SERIAL CHANNELS
The I/O subsystem in the Series III consists of two parts: the IOC card and two serial channels on the IPC-85 itself. Each serial channel is independently configurable. Both are RS232-compatible and is capable of running asynchronously from 110 to 9600 baud or synchronously from 150 to 56K baud. Both may be connected to a user defined data set or terminal. One channel contains current loop adapters. Both channels are implemented using Intel's 8251A USART. They can be programmed to perform a variety of I/O functions. Baud rate selection is accomplished through an Intel 8253 interval timer. The 8253 also serves as a real-time clock for the entire system. I/O activity through each serial channel is independently signaled to the system through a second 8259A (slave) interrupt controller, operating in a polled mode nested to the master 8259A.

IOC INTERFACE
The remainder of the system I/O activity is handled by the IOC. The IOC provides the interface and control for the keyboard, CRT, integral floppy disk drive, and standard Intellec-compatible peripherals including printer, high speed paper tape reader/punch, and universal PROM programmer. The IOC contains its own independent microprocessor, an 8080A-2. This CPU issues commands, receives status, and controls all I/O operations as well as supervising communications with the IPC-85. The IOC contains interval timers, its own IOC bus system controller, and 8K bytes of ROM for all I/O control firmware. The 8K bytes of RAM are used for CRT screen refresh storage. Neither the ROM nor the RAM occupy space in the Intellec Series III main memory address range because the IOC is a totally independent microcomputer subsystem.

Integral CRT

DISPLAY
The CRT is a 12-inch raster scan type monitor with a 50/60 Hz vertical scan rate and 15.5 kHz horizontal scan rate. Controls are provided for brightness and contrast adjustments. The interface to the CRT is provided through an Intel 8275 single chip programmable CRT controller. The master processor on the IPC-85 transfers a character for display to the IOC, where it is stored in RAM. The CRT controller reads a line at a time into its line buffer through an Intel 8257 DMA Controller. It then feeds one character at a time to the character generator to produce the video signal. Timing for the CRT control is provided by an Intel 8253 programmable interval
timer. The screen display is formatted as 25 rows of 80 characters. The full set of ASCII characters are displayed, including lower case alphas.

KEYBOARD
The keyboard interfaces directly to the IOC processor via an 8-bit data bus. The keyboard contains an Intel UPI-41A Universal Peripheral Interface, which scans the keyboard and encodes the characters to provide N-key roll over. The keyboard itself is a typewriter style keyboard containing the full ASCII character set. An upper/lower case switch allows the system to be used for document preparation. Cursor control keys are also provided.

Peripheral Interface
A UPI-41A Universal Peripheral Interface on the IOC board provides built-in interface for standard Intellec-compatable peripherals including a printer, high speed paper tape reader, high speed paper tape punch, and universal PROM programmer. Communication between the IPC-85 and IOC is maintained over a separate 8-bit bidirectional data bus. Connectors for the four devices named above, as well as the two serial channels, are mounted directly on the IOC itself.

Control
User control is maintained through a front panel, consisting of a power switch and indicator, reset/boot switch, run/halt light and eight interrupt switches and LED indicators. The front panel circuit board is attached directly to the IPC-85, allowing the eight interrupt switches to connect the master 8259A, as well as to the Intellec Series III bus.

User program control in the iAPX 88/86 environment of the Intellec Series III is also directed through keyboard control sequences to transfer control to the iAPX 88/86 applications debugger, abort a user program or translator and returning control to the IPC-85.

DISK SYSTEM
Integral Floppy Disk Drive
The integral floppy disk is controlled by an Intel 8271 single chip, programmable floppy disk controller. The disk provides capacity of 250K bytes. It transfers data via an Intel 8257 DMA Controller between an IOC RAM buffer and the diskette. The 8271 handles reading and writing of data, formatting diskettes, and reading status, all upon appropriate commands from the IOC microprocessor.

Dual Drive Floppy Disk System (Option)
The Intellec Series III Double Density Diskette System provides direct access bulk storage, intelligent controller and two diskette drives. Each drive provides 1/2 million bytes of storage with a data transfer of 500,000 bits/second. The controller is implemented with Intel's powerful Series 3000 Bipolar Microcomputer Set and supports up to four diskette drives to allow more than 2 million bytes of on-line storage.

An additional cable and connectors are also supplied to optionally convert the integral floppy disk from single density to double density.

Hard Disk System (Option)
The Intellec Series III Hard Disk System provides direct access bulk storage, intelligent controller and a disk drive containing one fixed platter and one removable cartridge. Each provides approximately 3.65 million bytes of storage with a data transfer rate of 2.5 Mbits/second. The controller is implemented with Intel's Series 3000 Bipolar Microcomputer Set. The controller provides an interface to the Intellec Series III system bus, as well as supporting up to 2 disk drives. The disk system records all data in Double Frequency (FM) on 2 surfaces per platter. Each platter can be write protected by a front panel switch.

HARD DISK CONTROLLER BOARDS
The disk controller consists of two boards which reside in the Intellec Series III system chassis. The disk system is capable of performing six operations: recalibrate, seek, format track, write data, read data, and verify CRC. In addition to supporting a second drive, the disk controller may co-exist with the double-density diskette controller to allow up to 17 million bytes of on-line storage.
MULTIBUS Interface Capability

All models of the Intellec Series III implement the industry standard MULTIBUS protocol. The MULTIBUS architecture allows several bus masters, such as CPU and DMA devices, to share the bus and memory by operating at different priority levels. Resolution of bus exchange is synchronized by a bus clock signal derived independently from processor clocks. Read/write transfers may take place at rates up to 5 MHz. The bus structure is suitable for use with any Intel microcomputer family.

System Software Features

The Model 286 offers many key advantages for iAPX 86,88 applications and Intellec Development Systems: enhanced system performance through a dual host CPU environment, a full spectrum of iAPX 86,88-resident high-level languages, expanded user program space for iAPX 86,88 programs, and a powerful high-level software applications debugger for iAPX 86,88 microprocessor software.

Dual Host CPU—The addition of a 16-bit 8086 to the existing 8-bit host CPU increases iAPX 86,88 compilation speeds and provides for iAPX 86,88 code execution. When the 8086 is executing a program, the 8-bit CPU off-loads all I/O activity and operates as an intelligent I/O controller to double buffer data to and from the 8086. The 8086 also provides an execution vehicle for 8086 and 8088 object code. An added benefit of two host microprocessors is that 8-bit translations and applications are handled by the 8-bit CPU, and 16-bit translations and applications are handled by the 8086. This feature provides complete compatibility for current systems and means that software running on current Intellec Development Systems will run on the new system.

High-Level Languages for iAPX 86,88—The Model 286 allows the current Intellec system user to take advantage of a breadth of new resident iAPX 86,88 high-level languages: PL/M 86/88, PASCAL 86/88, and FORTRAN 86/88. The iAPX 86,88 Resident Macro Assembler and these high-level language compilers execute on the 8086 host CPU, thereby increasing system performance.

Expanded Program Memory—By adding a Model 286 to an existing Intellec Development System, 96K bytes of user program RAM memory are made available for iAPX 86,88 programs. System memory is expandable by adding additional RAM memory modules. This, combined with the two host CPU system architecture, dramatically increases the processing power of the system.

Software Applications Debugger—The RPB-86 contains the applications debugger which allows iAPX 86,88 programs to be developed, tested, and debugged within the Intellec system. The debugger provides a subset of In-Circuit Emulator commands such as symbolic debugging, control structures and compound commands specifically oriented toward software debug needs.

SPECIFICATIONS

Host Processor Boards

INTEGRATED PROCESSOR CARD
—(IPC-85) 8085A-2 based, operating at 4 MHz
—64K RAM, 4K ROM (2K in monitor and 2K in boot/diagnostic)

RESIDENT PROCESSOR BOARD
—(RPB-86) 8086 based, operating at 5 MHz, 64K RAM, 16K ROM (applications debugger)

BUS
—MULTIBUS bus, maximum transfer rate of 5 MHz

DIRECT MEMORY ACCESS
—(DMA) Standard capability on the MULTIBUS bus; implemented for user selected DMA devices through optional DMA module
—Maximum transfer rate of 2 MHz

Integral Floppy Disk

Capacity—250K bytes (formatted)
Transfer Rate—160K bits/sec
Access Time—
Track to Track: 10 ms max.
Average Random Positioning: 260 ns
Rotational Speed: 360 rpm
Average Rotational Latency: 83 ms
Recording Mode: FM

Dual Floppy Disk Option

Capacity—
Per Disk: 4.1 megabits (formatted)
Per Track: 53.2 kilobits (formatted)
Transfer Rate—500 kilobits/sec
Access Time—
Track to Track: 10 ms
Head Setting Time: 10 ms
Average Random Positioning Time—260 ms
Rotational Speed—360 rpm
Average Rotational Latency: 83 ms
Recording Mode: M² FM

Hard Disk Drive Option
Type—5440 top loading cartridge and one fixed platter
Tracks per Inch—200
Mechanical Sectors per Track—12
Recording Technique—double frequency (FM)
Tracks per Surface—400
Density—2,200 bits/inch
Bits per Track—62,500
Recording Surfaces per Platter—2
Capacity—
  Per Surface—15M bits
  Per Platter—29M bits
  Per Drive—59M bits
  Per Drive—7.3M bytes (formatted)
Transfer Rate—2.5M bits/sec
Access Time—
  Track to Track: 13 ms max
  Full Stroke: 100 ms
  Rotational Speed: 2,400 rpm

Physical Characteristics
Width—17.37 in. (44.12 cm)
Height—15.81 in. (40.16 cm)
Depth—19.13 in. (48.59 cm)
Weight—81 lb. (37 kg)

KEYBOARD
Width—17.37 in. (44.12 cm)
Height—3.0 in. (7.6 cm)
Depth—9.0 in. (22.86 cm)
Weight—6 lb. (3 kg)

DUAL FLOPPY DRIVE SYSTEM (OPTION)
Width—16.88 in. (42.88 cm)
Height—12.08 in. (30.68 cm)
Depth—1.0 in. (48.26 cm)
Weight—64 lb. (29 kg)

HARD DISK DRIVE SYSTEM (OPTION)
Width—18.5 in. (47.0 cm)
Height—34.0 in. (86.4 cm)
Depth—29.75 in. (75.6 cm)
Weight—202 lb. (92 kg)

ELECTRICAL CHARACTERISTICS

DC Power Supply

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</tr>
<tr>
<td>+24 ± 5%*</td>
<td>1.7</td>
<td>1.7</td>
</tr>
</tbody>
</table>

*Not available on bus

AC Requirements for Mainframe
110V, 60 Hz—5.9 Amp
220V, 50 Hz—3.0 Amp

ENVIRONMENTAL CHARACTERISTICS

System Operating Temperature—0° to 35°C (32°F to 95°F)
Humidity—20% to 80%

DOCUMENTATION SUPPLIED

Intellec Series III Microcomputer Development System Product Overview, 121575
A Guide to Intellec Series III Microcomputer Development Systems, 121632-001
Intellec Series III Microcomputer Development System Console Operating Instructions, 121609
Intellec Series III Microcomputer Development System Pocket Reference, 121610
Intellec Series III Microcomputer Development System Programmer's Reference, 121618
iAPX 88/86 Family Utilities User's Guide for 8086-Based Development Systems, 121616
8086/8087/8088 Macro Assembly Language Reference Manual for 8086-Based Development Systems, 121627
8086/8087/8088 Macro Assembly Language Pocket Reference, 9800749
### ORDERING INFORMATION

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<td>Intellec Series III Model 287 Microcomputer Development System with Dual Double Density Flexible Disk System (220V/50Hz)</td>
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MODEL 675
INTELLEC® DEVELOPMENT SYSTEM
FOR ETHERNET* DS/E

- Complies with the Intel, DEC, and Xerox Tricompny Ethernet Specification
- Provides a complete Ethernet Communications Development System Environment
- Includes an Ethernet Data Link Layer Software Library to allow user programs to access the Ethernet Data Link from the 8085 in Model 675 systems
- Supports the Ethernet Data Link and Physical Link Control via the MULTIBUS Ethernet Communications Controller
- Includes a special 10 meter Interconnect Cable for connecting two Model 675s for Ethernet software prototyping
- Supports the full range of iAPX 86, 88-resident, High-Level Languages: PL/M 86/88; PASCAL 86/88; and FORTRAN 86/88
- Includes a Software Applications Debugger for iAPX 86, 88 user programs
- Upgradable from Intellec Series II/85 and Series III

The Intellec Development System for Ethernet (DS/E) provides the user with the tools necessary to develop and test communication software and applications that will use Ethernet as a communication subsystem. It combines the power of the Intellec Microcomputer Development System with a dual board Ethernet Communications Controller for microprocessor development. This combination allows the user to develop either 8- or 16-bit Ethernet-based applications.

The Ethernet Communications Controller incorporates the Ethernet Data Link and Physical Link Control to meet the Ethernet specification for 10 Mbit per second data transmission rate over coaxial cable. The controller consists of two MULTIBUS compatible boards, the Processor board and the Serialization/Deserialization (SerDes) board. The Processor board provides the function of packet buffering, processing, and transferring of the processed packets to system memory. The SerDes board performs the serialization/deserialization, framing, CRC generation and checking, Manchester encoding/decoding, and destination address recognition. A 10 meter interconnect cable is included to permit two Model 675s to be connected in a functioning Ethernet environment without the need for Ethernet transceivers and coaxial cable.

*Ethernet is a trademark of Xerox Corporation.
COMPONENTS

Hardware Components

The Model 675 consists of a CRT chassis with a 6-slot cardcage, power supply, fans, cables, single floppy diskette drive, a detachable upper/lower case full ASCII keyboard, and six printed circuit boards. A block diagram of the Model 675 is shown in Figure 1.

System Components

Two CPU boards, the IPC-85 and the RPB-86, reside on the Model 675 MULTIBUS system bus, each containing its own microprocessor, memory, I/O, interrupt and bus interface circuitry implemented with Intel's high technology LSI components. The IPC-85 integrated processor board consists of an Intel NMOS 8-bit microprocessor, the 8085A-2, and 64 Kbytes of on board memory. The RPB-86 resident processor board contains Intel's HMOS 16-bit microprocessor, the iAPX 86 (8086), and 64 Kbytes of on board memory.

A third CPU board, known as the I/O controller (IOC) performs all remaining I/O including the interface to the CRT, integral floppy disk, and keyboard. The IOC contains its own microprocessor, RAM and ROM memory, and I/O interface logic. It is a slave CPU board which communicates with the IPC-85 over an 8-bit bidirectional data bus.

The Model 675 also includes an additional 64 Kbyte MULTIBUS compatible RAM board supplying the user with a total of 192 Kbytes of RAM. The two remaining boards are the Ethernet Communications Controller.

Figure 1. Model 675 DS/E Block Diagram
Expansion

The Intellec expansion chassis Model 201 is included in the basic Model 675. All Model 675 systems contain 10 MULTIBUS board slots—6 in the main system and 4 in the Model 201 chassis. The table below indicates the number of slots available for expansion in each.

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<td>675FD</td>
<td>2</td>
</tr>
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<td>675HD</td>
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Ethernet Communications Controller

PROCESSOR BOARD

The processor board interfaces to the MULTIBUS system bus and contains the Intel 5 MHz 8088 CPU, 16 Kbytes dynamic RAM for Ethernet and host interface program execution, 8K EPROM pre-programmed for the Data Link Control, and an 8K static RAM for transmit and receive channel DMA data buffering. The Processor board provides the necessary commands and control to the SerDes board and receives status and data from it.

SerDes BOARD

The SerDes board meets the required electrical specification to the transceiver and provides the Data Link Layer of the Ethernet architecture. The major functions of the SerDes board include serialization/deserialization, framing, Manchester encoding/decoding, transmit data flow control, receive data flow control, destination address decoding for received message, CRC generation and checking, and diagnostic for CRC error, loop-back, transmit timeout, and if used with transceivers, CSMA/CD (carrier-sense multiple-access with collision-detection).

DATA BUFFERING

All data transfers from the Ethernet Data Link control of the SerDes board are buffered through the 8K static RAM. This minimizes the amount of bus time used by the Ethernet Communications Controller by eliminating the possibility of data overruns and subsequent repeated I/O operations. In addition, the buffer allows the Ethernet Communications Controller to have a bus priority below higher-priority, time-critical parts of the system.

DIAGNOSTICS

Diagnostic functions are resident on the SerDes board and can be invoked on demand by the program on the Processor board. These functions include: transmitting packets with a bad CRC; receiving all packets regardless of address; reading data received in error; SerDes loop-back, this function allows data from static RAM to be transmitted and received simultaneously (the received data is verified but not written to the Static RAM). The CRC generation and checking can be used to verify transmit and receive data.

When the 10 meter interconnect cable between two Model 675s is used, point-to-point diagnostics are available to verify station-to-station communications, cable data sensitivity, CRC, packet length errors, and external carrier sense. In addition to these functions, a loop-back diagnostic is provided for use with transceivers. This function is similar to the SerDes loop-back diagnostic except the transceiver cable is also verified.

Figure 2 is a block diagram of the Ethernet Communications Controller.

Software

Three levels of program interface are provided to users of the Model 675 for Ethernet software prototyping and evaluation.

MULTIBUS MESSAGE EXCHANGE (MMX)-ISIS-II

MULTIBUS Message Exchange (MMX)-ISIS-II is a simple processor-to-processor protocol which permits ISIS-II user programs to communicate with the software residing on the Ethernet Communications Controller.

The model of use of MMX is as follows: The calling program will allocate a segment of memory in the 64 Kbyte segment accessible by ISIS-II, fill in application defined fields, and transmit via MMX to a socket on the Ethernet Communications Controller. The program then waits for the application level response to the command just given. There is an MMX module in ROM on the Ethernet Communications Controller, and another in the HOST RAM.

EXTERNAL DATA LINK (EDL)

The External Data Link (EDL) presents a subset of the Data Link Layer interface to users at the MMX-ISIS-II interface level. This allows a user to write Ethernet application programs to access the Ethernet Data Link on the 8085A-2 in ISIS-II systems. The External Data Link resides in the ROM on the Ethernet Communications Controller.
Figure 2. Block Diagram of the Ethernet Communications Controller

(a) Processor Board

(b) SerDes Board
ETHERNET DATA LINK LIBRARY

The Ethernet Data Link Library is provided to simplify the External Data Link (EDL), MMX-ISIS-II interface. This library provides synchronous interface procedures for the EDL functions. These procedures allow the user to simply call a subroutine without being aware of the MMX-ISIS-II transaction which is made with the Ethernet Communications Controller. The Ethernet Data Link Library is provided on a diskette. It is designed to be linked with the user's software residing in the HOST RAM.

About the Ethernet

The Ethernet local area network provides a communication facility for high speed data exchange among digital devices located within a moderate sized geographic area. The Ethernet architecture defines the system as a series of independent layers.

The lowest layer, the Physical Link Layer, is concerned with the coaxial cable interface. It completely specifies the essential physical characteristics of the Ethernet, such as data encoding, timing, and voltage levels.

The Data Link defines a medium-independent link level communication facility, built on the medium-dependent physical channel provided by the Physical Layer. It supports the peer protocol statistical contention resolution (CSMA/CD), variable size frames, and link management functions.

The higher levels of the overall network architecture, which use the Data Link Layer, are collectively referred to as the Client Layer. The identity and function of this layer are user specific. The intent, however, is that the Ethernet Physical and Data Link Layers support the higher layers of the ISO model (Network Layer, Transport Layer, Session Layer, etc.).

The overall structure of the layered architecture is shown in Figure 3.

DISK SUBSYSTEMS (OPTIONAL)

Dual Drive Floppy Disk Subsystem

The Model 675FD Double Density Diskette System provides direct access bulk storage, intelligent controller and two diskette drives. Each drive provides 1/2 Mbytes of storage with a data transfer of 500,000 bits/second. The controller provides an interface to the Model 675 system bus, as well as supporting up to four diskette drives to allow more than 2 Mbytes of on-line storage.

Hard Disk Subsystem

The Model 675HD Hard Disk System provides direct access bulk storage, intelligent controller and a disk drive containing one fixed platter and one removable cartridge. Each provides approximately 3.65 Mbytes of storage with a data transfer rate of 2.5 Mbits/second. The controller provides an interface to the system bus, as well as supporting up to 2 disk drives. The disk system records all data in Double Frequency (FM) on 2 surfaces per platter. Each platter can be write protected by a front panel switch.

SPECIFICATIONS

Host Processor Boards

INTEGRATED PROCESSOR CARD
—(IPC-85) 8085A-2 based, operating at 4 MHz
—64K RAM, 4K ROM (2K in monitor and 2K in boot/diagnostic)

RESIDENT PROCESSOR BOARD
—(RPB-86) 8086 based, operating at 5 MHz
—64K RAM, 16K ROM (application debugger)

BUS
—MULTIBUS system bus, maximum transfer rate of 5 MHz

DIRECT MEMORY ACCESS
—(DMA) standard capability on the MULTIBUS system bus; implemented for user selected DMA devices through optional DMA module
—Maximum transfer rate of 2 MHz
Ethernet Communications Controller

**PROCESSOR**
- 8088 based, operating at 5 MHz
- 16K dynamic RAM for program execution
- 8K EPROM for program execution
- 8K Static RAM for data buffer
- 3 DMA channels for receive data
- 1 DMA channel for transmit data

**SerDes**
- Serialization/Deserialization
- Framing
- CRC generation and checking
- Manchester encoding/decoding
- Destination address recognition

**Integral Floppy Disk**

Capacity—250 Kbytes (formatted)
Transfer Rate—160 Kbits/sec
Access Time—
  - Track to Track: 10 ms max
  - Average Random Positioning: 260 ns
  - Rotational Speed: 360 rpm
  - Average Rotational Latency: 83 ms
  - Recording Mode: FM

**Dual Floppy Disk Option**

Capacity—
  - Per Disk: 4.1 Mbits (formatted)
  - Per Track: 53.2 Kbits (formatted)
Transfer Rate—500 Kbits/sec
Access Time—
  - Track to Track: 10 ms
  - Head Setting Time: 10 ms
  - Average Random Positioning: 260 ms
  - Rotational Speed: 360 rpm
  - Recording Mode: M² FM

**Hard Disk Drive Option**

Type—5440 top loading cartridge and one fixed platter
Tracks per Inch—200
Mechanical Sectors per Track—12
Recording Technique—double frequency (FM)
Tracks per Surface—400 bits/inch
Density—2,200 bits/inch
Bits per Track—62,500
Recording Surfaces per Platter—2
Capacity—
  - Per Surface—15 Mbits
  - Per Platter—29 Mbits
  - Per Drive—59 Mbits
  - Per Drive—7.3 Mbytes (formatted)
Transfer Rate—2.5 Mbits/sec
Access Time—
  - Track to Track: 13 ms max
  - Full Stroke: 100 ms
  - Rotational Speed: 2,400 rpm

**Physical Characteristics**

Width—17.37 in. (44.12 cm)
Height—15.81 in. (40.16 cm)
Depth—19.13 in. (48.59 cm)
Weight—84.5 lb. (38.6 kg)

**Expansion Chassis**

Width—17.37 in. (44.12 cm)
Height—4.81 in. (12.22 cm)
Depth—19.13 in. (48.59 cm)
Weight—42 lb. (19 kg)

**Keyboard**

Width—17.37 in. (44.12 cm)
Height—3.0 in. (7.6 cm)
Depth—9.0 in. (22.86 cm)
Weight—6 lb. (3 kg)

**Dual Floppy Drive System (Option)**

Width—16.88 in. (42.88 cm)
Height—12.08 in. (30.68 cm)
Depth—1.0 in. (2.54 cm)
Weight—64 lb. (29 kg)

**Hard Disk Drive System (Option)**

Width—18.5 in. (47.0 cm)
Height—34.0 in. (86.4 cm)
Depth—29.75 in. (75.6 cm)
Weight—202 lb. (92 kg)

**ELECTRICAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Volts Supplied</th>
<th>Amps Supplied</th>
<th>Typical System Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5 ±5%</td>
<td>30.0</td>
<td>17.0</td>
</tr>
<tr>
<td>+12 ±5%</td>
<td>2.5</td>
<td>1.1</td>
</tr>
<tr>
<td>-12 ±5%</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>-10 ±5%</td>
<td>1.0</td>
<td>0.08</td>
</tr>
<tr>
<td>+15 ±5%*</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>+24 ±5%*</td>
<td>1.7</td>
<td>1.7</td>
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</table>

*Not available on bus.
AC Requirements for Mainframe

110V, 60 Hz—5.9 Amp
220V, 50 Hz—3.0 Amp

DC Power Supply for Expansion Chassis

<table>
<thead>
<tr>
<th>Volts Supplied</th>
<th>Amps Supplied</th>
<th>Typical System Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 5 ± 5%</td>
<td>24</td>
<td>None</td>
</tr>
<tr>
<td>+ 12 ± 5%</td>
<td>2.0</td>
<td>None</td>
</tr>
<tr>
<td>− 12 ± 5%</td>
<td>0.3</td>
<td>None</td>
</tr>
<tr>
<td>− 10 ± 5%</td>
<td>1.0</td>
<td>None</td>
</tr>
</tbody>
</table>

AC Requirements for Expansion Chassis

50–60 Hz, 115/230V AC

ENVIRONMENTAL CHARACTERISTICS

System Operating Temperature—16°C to 32°C (61°F to 90°F)
Humidity—20% to 80%

DOCUMENTATION SUPPLIED

Intellic Series III Microcomputer Development System Product Overview, 121575.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS675A KIT</td>
<td>Intellec Model 675 Development System for Ethernet (110V/60 Hz)</td>
<td>Intellec Model 675 Development System for Ethernet with Dual Density Flexible Disk System (220V/60 Hz)</td>
</tr>
<tr>
<td>DS675B KIT</td>
<td>Intellec Model 675 Development System for Ethernet (220V/50 Hz)</td>
<td>DS675AHD KIT Intellec Model 675 Development System for Ethernet with Pedestal Mounted Hard Disk (110V/60 Hz)</td>
</tr>
<tr>
<td>DS675AFD KIT</td>
<td>Intellec Model 675 Development System for Ethernet with Dual Density Flexible Disk System (110V/60 Hz)</td>
<td>DS675BHD KIT Intellec Model 675 Development System for Ethernet with Pedestal Mounted Hard Disk (220V/50 Hz)</td>
</tr>
</tbody>
</table>

All models listed above require a Software License.
EXPANSION CHASSIS
INTELLEC® SERIES II
MICROCOMPUTER DEVELOPMENT SYSTEM

- Four Expansion Slots for Intellec® Series II Systems
- Internal Power Supply
- Snug Fit Beneath All Intellec® Series II Units
- Cable Connectable to Main Intellec® Bus
- Standard Intellec MULTIBUS™ with Multi-Processor and DMA Capability
- Compatible with Standard Intellec/ iSBC™ Expansion Modules

The Intellec Series II Expansion Chassis provides four expansion slots for use with Intellec Series II microcomputer development systems. With its own separate power supply, the expansion chassis may be fully loaded with any boards needed to expand a user's Intellec Series II system. With the addition of the expansion chassis, Intellec Series II Models 220 and 230 contain a total of ten slots, sufficient for any configuration Intellec Series II system. The Intellec Series II Expansion Chassis is a compact chassis with a four slot cardcage, power supply, fans, and cable assemblies. It is designed to fit under any Intellec Series II system, connect directly to the system bus through an opening in the top of the chassis, and provide additional slots for the system users. The power supply is linked directly to the main chassis power supply, allowing power to flow to both chassis when the main power is turned on.
EXPANSION CHASSIS

SPECIFICATIONS

Physical Characteristics
Width — 17.37 in. (44.12 cm)
Height — 4.81 in. (17.22 cm)
Depth — 19.13 in. (48.59 cm)
Weight — 42 lb. (19 kg)

Electrical Characteristics

DC Power Supply

<table>
<thead>
<tr>
<th>Volts Supplied</th>
<th>Amps Supplied</th>
<th>System Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 5±5%</td>
<td>24</td>
<td>None</td>
</tr>
<tr>
<td>+ 12±5%</td>
<td>2.0</td>
<td>None</td>
</tr>
<tr>
<td>− 12±5%</td>
<td>0.3</td>
<td>None</td>
</tr>
<tr>
<td>− 10±5%</td>
<td>1.0</td>
<td>None</td>
</tr>
</tbody>
</table>

AC Requirements — 50-60 Hz, 115/230V AC

Environmental Characteristics
Operating Temperature — 0° to 35°C (95°F)

Equipment Supplied
Expansion chassis
Cables

Reference Manuals
9800550 — Intellec Series II Installation and Service Guide (SUPPLIED)
9800554 — Intellec Series II Schematic Drawings (SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

Part Number | Description
--- | ---
MDS-201* | Intellec® Series II Expansion Chassis

*MDS is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Science.
**MAINFRAME LINK FOR DISTRIBUTED DEVELOPMENT**

- Integrates user mainframe resources with Intellec® Development Systems.
- Uses IBM 2780/3780 standard BISYNC protocol supported by a majority of mainframes and minicomputers.
- Protocol supports full error detection with automatic retry.
- Software runs under ISIS-II on any Intellec® Development System.
- Communicates with remote systems on dedicated or switched (dial-up) telephone lines.
- Package also includes tests and a connector for loop-back self-test capability.

The Mainframe Link consists of software, modem cable to connect the development system to the modem and a loopback connector for diagnostic testing. The software runs under ISIS-II on Intellec Development Systems. It emulates the operation of an IBM 2780 or 3780 Remote Job Entry (RJE) terminal to (1) transmit ISIS-II files to a remote system or (2) receive files from a remote system using standard BISYNC 2780/3780 protocol. The remote system can be any mainframe or minicomputer which supports the IBM 2780 or 3780 communications interface standard. Files may contain ASCII or binary data so that either program source files (ASCII) or program object files (binary) may be transmitted.

The Mainframe Link allows the user to integrate in-house mainframe resources with Intellec Microcomputer Development resources. The mainframe can be used for storage, maintenance and management of program source and object files. The program source can be downloaded to a development system for compilation, assembly, link, and/or location. The linked modules can be transmitted and saved on the mainframe to be shared by all programmers. The linked program can then be downloaded to a development system for debugging using ICE emulation.
FEATURES

- Runs under ISIS-II on any Intellec® Microcomputer Development System.
- Communicates with a remote system using IBM 2780/3780 standard BISYNC protocol, which is supported by a majority of minicomputers and mainframes, on dedicated or switched (dia-up) telephone lines.
- The modem cable supplied with the package can be used to connect the Intellec® Development System to the modem (or modem eliminator) using the standard RS232C port.
- Supports user selectable data transmission rates of up to 9600 baud.
- Package includes diagnostic tests used to verify the operation of the Intellec® Development System using the loop-back connector supplied and data transmission up to the modem using the analog loop-back feature.
- System can be configured to match the requirements of the installation, i.e., using modem eliminators for connections up to fifty (50) feet, or by using modems and telephone lines.
- Software can be configured from several configuration options such as:
  - 2780, 3780 or Intel Mode
  - Transparent mode for binary data
  - Non-transparent mode for ASCII data
- Automatic translation from ASCII to EBCDIC and vice versa
- Receive chaining for receiving multiple files
- Intel mode is used mainly for file transfers between two Intellec® Development Systems. The files are duplicated exactly.
- Console commands support all standard features including:
  - SEND data in Transparent or Non-transparent mode, with or without translation to EBCDIC
  - RECEIVE in Transparent or Non-transparent mode, with or without translation to EBCDIC.
- Support for an IBM RJE console (such as HASP)
- Special utility programs are provided. STRZ strips extra binary zero's from the end of object files. CONSOL assigns system console input to an ISIS-II disk file.
- Can process commands interactively from the console or sequentially from an ISIS-II file under the SUBMIT facility for semi-automatic batch operation.
- Error detection in line transmission and error recovery by automatic retransmission.
- A special command such as DIAGNOSE, allows logging of all data activity on the line, during transmission and reception.
- When not used for communicating with the mainframe, the Intellec® Development System is available as a complete, stand-alone system.

 BENEFITS

- Allows the customer to use an in-house mainframe or minicomputer for program source preparation, editing, back-up and maintenance using inexpensive CRT's and multi-terminal access. The common files may be shared and others protected.
- Many programmers can use and share the high-performance devices normally available on large computer systems, e.g., fast printers to reduce listing time, the large capacity disks with their fast access time to store large program files.
- The source files can be downloaded using the Mainframe Link to an Intellec Development System (e.g., Model 240 or 245) for compilation, linking and locating.
- The compiled and/or linked object files may be transmitted back to the remote for storage. Updates and version numbers and dates can be tracked to ensure that the latest version is always used and back-up files are available. Binary object files can be later downloaded to an Intellec Development System for debugging using an ICE emulator.
- In short, provides a powerful and flexible tool combining the best of both micro and mainframe worlds, i.e., powerful CPU with large disk capacity, file sharing, multi-terminal access, etc., from a mainframe or minicomputer with Intels versatile and compatible software support systems (including PL/M, PASCAL, FORTRAN, Assembler, R & L) and sophisticated debugging tools such as ICE emulators.
SYSTEM SPECIFICATIONS

Operating Environment

Required Hardware:
Intellec® Microcomputer Development System
Model 800
Models 220, 225, 230, 235, 240 or 245
64KB of Memory
One Diskette Drive
Single or Double Density
System Console
Intel CRT or non-Intel CRT

Recommended Hardware for Compilation:
Hard Disk (Models 240, 245, or Model 740 Upgrade)
Additional Hardware Required for Model 800
iSBC-955™, iSBC-534™

Required Software:
ISIS-II Diskette Operating System
Single or Double Density

Documentation Package
Mainframe Link User’s Guide (121565-001)

Shipping Media
Flexible Diskettes
Single and Double Density

Remote System Requirements

- IBM 2780/3780 BISYNC protocol as supported by a majority of mainframes and minicomputers including: all IBM-360/370 Systems, PDP-11/70, VAX-11/780, Data General ECLIPSE.
- Users should purchase this standard software package from the remote system vendor and any additional required hardware such as a synchronous communications interface.
- The operating system at the remote must be configured (SYSGEN'ed) with correct options such as line address, 2780 or 3780, . . .

Communication Equipment Requirements

The Intellec Development System may be connected to the remote system using any one of the following methods:

- For short distances (up to 50 feet), use a synchronous modem eliminator (e.g., SPECTRON ME-81FS-2).
- For distances up to four miles, use short haul synchronous modems and telephone lines.
- For distances greater than four miles, use synchronous modems and telephone lines. The following BELL modems or their equivalents are recommended:
  - BELL 201C 2400 bits/second (half duplex, switched line)
  - BELL 208A 4800 bits/second (full duplex, leased line)
  - BELL 208B 4800 bits/second (half duplex, switched line)
  - BELL 209A 9600 bits/second (full duplex, leased line)
- Modems at either end must be compatible.

ORDERING INFORMATION

Part Number Description
*MDS-384 Kit Mainframe Link for Distributed Development

*MDS is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corporation.
MODEL 503
DOUBLE DENSITY UPGRADE KIT FOR
INTELLEC® MICROCOMPUTER DEVELOPMENT SYSTEM

- Converts integral single density drive of Model 220 or Model 240 system to double density, doubling the data capacity from ¼ to ½ million bytes
- Data recorded on double density flexible disk is in soft sectored format which allows ½ million bytes data capacity with up to 200 files per flexible disk
- Associated software and hardware supports up to three double density drives, providing up to 1 ½ million bytes in one system
- Provides total data compatibility with other Intellec® Double Density Flexible Disk Systems

The Double Density Upgrade Kit Model 503 provides an easy, cost effective method to convert the integral single density drive of Model 220 or Model 240 system to double density. In addition to doubling the data capacity, the upgrade kit maximizes the ease of data transportability between Intellec® Double Density Flexible Disk Systems.

© Intel Corporation 1980
**MODEL 503 DOUBLE DENSITY UPGRADE KIT**

### SPECIFICATIONS

#### Equipment Supplied
- Floppy Disk Controller Channel Board
- Double Density Floppy Disk Interface Board

#### Hardware
- Double Density Specified Flexible Disk
- One Recording Surface
- Soft Sector Format M2FM
- 77 Tracks/Diskette
- 52 Sectors/Track
- 128 Bytes/Sector

#### Physical Characteristics
- Mounting—Requires two slots of system card cage
- Height — 6.75 in. (17.15mm)
- Width — 12.00 in. (30.48mm)
- Depth — 0.50 in. (1.27mm)

### Electrical Characteristics

#### Channel Board
- 5V @ 3.75 (typ), 5A (max)

#### Interface Board
- 5V @ 1.5A (typ), 2.5A (max)
- -10V @ 0.1A (typ), 0.2A (max)

### Environmental Characteristics

#### Controller Boards
- Temperature:
  - Operating: 0 to 55°C
  - Non-Operating: -55°C to 85°C
- Humidity:
  - Operating: Up to 95% relative humidity without condensation
  - Non-Operating: All conditions without condensation of water or frost.

### Reference Manuals
- DOS Hardware Reference Manual
  - Part Number: 9800422
- Reference Schematics
  - Part Number: 9800425
- Installation Instructions
  - Part Number: 121505

### ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>MDS-503*</td>
<td>Integral drive single density to double density upgrade kit</td>
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</table>

**“MDS”** is an ordering code only, and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corp.
MODEL 556
iAPX 86 RESIDENT PROCESSOR BOARD PACKAGE

- Supports Intellec 432/100 Evaluation and Educational System
- Compatible with ISBC-090 Series 90 Memory System Upgrade: 512K Byte up to 1M Byte
- High Performance 8086-Based CPU Board for Increased Intellec® Development System Performance and iAPX 86/88 Development Environment
- Upgrades Intellec Series II/80, Series II/85, Model 800 Microcomputer Development Systems to the Functionality of Series III Systems
- 96K Bytes of User Program RAM Memory Available for iAPX 86/88 User Programs
- Software Applications Debugger for iAPX 86/88 User Programs
- Supports Full Range of iAPX 86/88-resident, High-level Languages: PL/M-86/88, PASCAL-86/88, and FORTRAN-86/88
- Includes iAPX 86/88 Resident Relocating Macro Assembler, Linker, Locater and Librarian
- Dual-Processor Disk Operating System Software with CRT-based Editor
- In Conjunction with Model 677 Provides a Complete Ethernet* Communications Development System Environment

The Model 556 is a performance enhancement package for Intellec Series II/80, Series II/85 and Model 800 Development Systems, specifically designed for iAPX 86,88 microprocessor development. The Model 556 includes two printed circuit boards (an iAPX 86-based CPU board and a 64K memory board), dual-processor disk operating system software, CRT-based editor, iAPX 86,88 Resident Relocating Macro Assembler, Linker, Locater and Librarian; software applications debugger for iAPX 86,88 user programs; and complete user documentation.

*Ethernet is a trademark of Xerox Corporation.
FUNCTIONAL DESCRIPTION

Hardware Components

Resident Processor Board (RPB-86)—The heart of the RPB-86 is an Intel 8086 16-bit HMOS microprocessor, running at 5.0 MHz. 64K bytes of RAM memory is provided on the board with transparent refresh from the Intel 8202 dynamic RAM controller. 16K bytes of ROM is on board, preprogrammed with an iAPX 86/88 applications debugger. The debugger provides features necessary to debug and control execution of application software for the iAPX 86/88 microprocessors. The RPB-86 occupies two card slots in an Intellec cardcage. The processors use interrupts for interprocessor communications.

RAM Memory Board—The memory board contains 64K bytes of read/write RAM memory and interfaces directly to the Intellec system bus. Refresh hardware is provided onboard for all the dynamic memory elements. Data buffering occurs for all data written to or read from the 64K memory array.

SYSTEM FEATURES

The Model 556 offers many key advantages for iAPX 86/88 applications and Intellec Development Systems: enhanced system performance through a dual host CPU environment, a full spectrum of iAPX 86/88-resident high-level languages, expanded user program space for iAPX 86/88 programs, and a powerful high-level software applications debugger for iAPX 86/88 microprocessor software.

Dual Host CPU—The addition of a 16-bit 8086 to the existing 8-bit host CPU increases iAPX 86/88 compilation speeds and provides for iAPX 86/88 code execution. When the 8086 is executing a program, the 8-bit CPU off-loads all I/O activity and operates as an intelligent I/O controller to double buffer data to and from the 8086. The 8086 also provides an execution vehicle for 8086 and 8088 object code. An added benefit of two host microprocessors is that 8-bit translations and applications are handled by the 8-bit CPU, and 16-bit translations and applications are handled by the 8086. This feature provides complete compatibility for current systems and means that software running on current Intellec Development Systems will run on the new system.

High-Level Languages for iAPX 86/88—The Model 556 allows the current Intellec system user to take advantage of a breadth of new resident iAPX 86/88 high-level languages: PLM 86/88, PASCAL 86/88, and FORTRAN 86/88. The iAPX 86/88 Resident Macro Assembler and these high-level language compilers execute on the 8086 host CPU, thereby increasing system performance.

Expanded Program Memory—By adding a Model 556 to an existing Intellec Development System, 96K bytes of user program RAM memory are made available for iAPX 86/88 programs. System memory is expandable by adding additional RAM memory modules. This, combined with the two host CPU system architecture, dramatically increases the processing power of the system.

Software Applications Debugger—The RPB-86 contains the applications debugger which allows iAPX 86/88 programs to be developed, tested, and debugged within the Intellec system. The debugger provides a subset of In-Circuit Emulator commands such as symbolic debugging, control structures and compound commands specifically oriented toward software debug needs.

SPECIFICATIONS

Resident Processor Board (RPB-86):
8086 based, operating at 5.0 MHz
2 RAM — 64K bytes on the CPU board
ROM — 16K bytes (applications debugger)
Bus — MULTIBUS architecture; 5 MHz maximum transfer rate

Environmental Characteristics

Operating Temperature: 0° to 35°C (32°F to 95°F)
Relative Humidity: To 90% without condensation

Equipment Supplied

- iAPX 86 Resident Processor Board (RPB-86)
- 64K Byte RAM Memory Board
- iAPX 86/88 Applications Debugger
- Self-test Diagnostics
- iAPX 86/88 Resident Macro Assembler and Utilities
- Dual Processor Disk Operating System Software
- CREDIT™ CRT-based text editor

DC POWER SUPPLY

<table>
<thead>
<tr>
<th>Voltage Requirements</th>
<th>Current Requirements (Amperes Max.)</th>
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<tbody>
<tr>
<td>+ 5± 5% Volts</td>
<td>8.6 A</td>
</tr>
<tr>
<td>+ 12± 5% Volts</td>
<td>1.0 A</td>
</tr>
<tr>
<td>− 12± 5% Volts</td>
<td>0.05 A</td>
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</tbody>
</table>
Documentation Supplied

A Guide to Intellec Series III Microcomputer Development Systems, 121632-001
Intellec Series III Microcomputer Development System Product Overview, 121575
Intellec Series III Microcomputer Development System Console Operating Instructions, 121609
Intellec Series III Microcomputer Development System Pocket Reference, 121610
Intellec Series III Microcomputer Development System Programmer's Reference, 121618
iAPX 86/88 Family Utilities User's Guide for 8086-Based Development Systems, 121616
8086/8087/8088 Macro Assembly Language Reference Manual for 8086-Based Development Systems, 121627
8086/8087/8088 Macro Assembly Language Pocket Reference, 9800749
8086/8087/8088 Macro Assembler Operating Instructions for 8086-Based Development Systems, 121628
Intellec Series III Microcomputer Development System Installation and Checkout Manual, 121612
Intellec Series III Microcomputer Development System Schematic Drawings, 121642
ISIS-II CREDIT (CRT-Based Text Editor) User's Guide, 9800902
ISIS-II CREDIT (CRT-Based Text Editor) Pocket Reference, 9800903
The 8086 Family User's Manual, 9800722
The 8086 Family User's Manual, Numerics Supplement, 121586

Additional manuals may be ordered from any Intel sales representative or distributor office, or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>DS556i Kit</td>
<td>Performance package for Intellec Series II/80 Microcomputer Development Systems. Specifically designed for iAPX 86/88 microprocessor development. The 556i package consists of the Model 556 software and hardware performance package, and the integrated 8085 processor board (IPC-85). This upgrade package is for Intellec Series II/80 Development Systems (110V/60 Hz or 220V/50 Hz) and upgrades all Intellec Series II/80 Models to the full performance and functionality of an Intellec Series III Development System.</td>
</tr>
<tr>
<td>DS556432 Kit</td>
<td>Model 556 combined with the Intellec 432/100 Evaluation and Educational System. This package provides all necessary hardware, software and literature to support iAPX 432 evaluation.</td>
</tr>
<tr>
<td>DS556i432 Kit</td>
<td>Upgrades Intellec Series II/80 users with all necessary hardware, software and literature to evaluate the iAPX 432. This package includes the DS556i and the Intellec 432/100 Evaluation and Educational System.</td>
</tr>
</tbody>
</table>

* MDS is an ordering code only, and is not used as a product name or trademark. MDS is a registered trademark of Mohawk Data Sciences Corp.
MODEL 677 DS/E
ETHERNET* UPGRADE KIT FOR
INTELLEC® DEVELOPMENT SYSTEMS

- Complies with the Intel®, DEC, and Xerox Tricompany Ethernet Specification
- Includes an Ethernet Data Link Layer Software Library to allow user programs to access the Ethernet Data Link from the 8085 in Series II and Series III
- Supports the Ethernet Data Link and Physical Link Control over the MULTIBUS
- Includes a special 10 meter Interconnect Cable for connecting two DS/E units for Ethernet software prototyping
- Upgrades Intellec® Series II/85 and Series III Development Systems

The DS/E Ethernet Upgrade Kit provides the Series II/85 or Series III user with the additional tools necessary to develop and test communication software and applications that will use Ethernet as a communication subsystem. It combines the power of the Intellec Microcomputer Development System with its dual board Ethernet Communications Controller for microprocessor development. This combination allows the user to develop either 8- or 16-bit Ethernet-based applications.

The Ethernet Communications Controller incorporates the Ethernet Data Link and Physical Link Control to meet the Ethernet specification for 10 Mbit per second data transmission rate over coaxial cable. The controller consists of two MULTIBUS compatible boards, the Processor board and the Serialization/Deserialization (SerDes) board. The Processor board provides the function of packet buffering, processing, and transferring of the processed packets to system memory. The SerDes board performs the serialization/deserialization, framing, CRC generation and checking, Manchester encoding/decoding, and destination address recognition. A 10 meter interconnect cable is included to permit two DS/E units to be connected in a functioning Ethernet environment without the need for Ethernet transceivers and coaxial cable.

*Ethernet is a trademark of Xerox Corporation.
Ethernet Communications Controller

PROCESSOR BOARD
The processor board interfaces to the MULTIBUS system bus and contains the Intel 5 MHz 8088 CPU, 16 Kbytes dynamic RAM for Ethernet and host interface program execution, 8K EPROM pre-programmed for the Data Link Control, and an 8K static RAM for transmit and receive channel DMA data buffering. The Processor board provides the necessary commands and control to the SerDes board and receives status and data from it.

SerDes BOARD
The SerDes board meets the required electrical specification to the transceiver and provides the Data Link Layer of the Ethernet architecture. The major functions of the SerDes board include serialization/deserialization, framing, Manchester encoding/decoding, transmit data flow control, receive data flow control, destination address decoding for received message, CRC generation and checking, and diagnostic for CRC error, loopback, transmit timeout, and if used with transceivers, CSMA/CD (carrier-sense multiple-access with collision-detection).

DATA BUFFERING
All data transfers from the Ethernet Data Link control of the SerDes board are buffered through the 8K static RAM. This minimizes the amount of bus time used by the Ethernet Communications Controller, by eliminating the possibility of data overruns and subsequent repeated I/O operations. In addition, the buffer allows the Ethernet Communications Controller to have a bus priority below higher-priority, time-critical parts of the system.

DIAGNOSTICS
Diagnostic functions are resident on the SerDes board and can be invoked on demand by the program on the Processor board. These functions include: transmitting packets with a bad CRC; receiving all packets regardless of address; reading data received in error; SerDes loop-back, this function allows data from static RAM to be transmitted and received simultaneously (the received data is verified but not written to the Static RAM). The CRC generation and checking can be used to verify transmit and receive data.

When the 10 meter interconnect cable between two DS/E Units is used, point-to-point diagnostics are available to verify station-to-station communications, cable data sensitivity, CRC, packet length errors, and external carrier sense. In addition to these functions, a loop-back diagnostic is provided for use with transceivers. This function is similar to the SerDes loop-back diagnostic except the transceiver cable is also verified.

Figure 1 is a block diagram of the Ethernet Communications Controller.

Software
Three levels of program interface are provided to users of the Model 675 for Ethernet software prototyping and evaluation.

MULTIBUS MESSAGE EXCHANGE (MMX)-ISIS-II
MULTIBUS Message Exchange (MMX)-ISIS-II is a simple processor-to-processor protocol which permits ISIS-II user programs to communicate with the software residing on the Ethernet Communications Controller.

The model of use of MMX is as follows: The calling program will allocate a segment of memory in the 64 Kbyte segment accessible by ISIS-II, fill in application defined fields, and transmit via MMX to a socket on the Ethernet Communications Controller. The program then waits for the application level response to the command just given. There is an MMX module in ROM on the Ethernet Communications Controller, and another in the HOST RAM.

EXTERNAL DATA LINK (EDL)
The External Data Link (EDL) presents a subset of the Data Link Layer interface to users at the MMX-ISIS-II interface level. This allows a user to write Ethernet application programs to access the Ethernet Data Link on the 8085A-2 in ISIS-II systems. The External Data Link resides in the ROM on the Ethernet Communications Controller.

ETHERNET DATA LINK LIBRARY
The Ethernet Data Link Library is provided to simplify the External Data Link (EDL), MMX-ISIS-II interface. This library provides synchronous interface procedures for the EDL functions. These procedures allow the user to simply call a subroutine without being aware of the EDL functions. These procedures allow the user to simply call a subroutine which is made with the Ethernet Communications Controller. The Ethernet Data Link Library is provided on a diskette. It is designed to be linked with the user's software residing in the HOST RAM.

About the Ethernet
The Ethernet local area network provides a communication facility for high speed data exchange among digital devices located within a moderate
Figure 1. Block Diagram of the Ethernet Communications Controller
sized geographic area. The Ethernet architecture defines the system as a series of independent layers.

The lowest layer, the Physical Link Layer, is concerned with the coaxial cable interface. It completely specifies the essential physical characteristics of the Ethernet, such as data encoding, timing, and voltage levels.

The Data Link defines a medium-independent link level communication facility, built on the medium-dependent physical channel provided by the Physical Layer. It supports the peer protocol statistical contention resolution (CSMA/CD), variable size frames, and link management functions.

The higher levels of the overall network architecture, which use the Data Link Layer, are collectively referred to as the Client Layer. The identity and function of this layer are user specific. The intent, however, is that the Ethernet Physical and Data Link Layers support the higher layers of the ISO model (Network Layer, Transport Layer, Session Layer, etc.).

The overall structure of the layered architecture is shown in Figure 2.

![Figure 2. Ethernet Architectural Layering](image)

**SPECIFICATIONS**

**Ethernet Communications Controller**

**PROCESSOR**
- 8088 based, operating at 5 MHz
- 16K dynamic RAM for program execution
- 8K EPROM for program execution
- 8K Static RAM for data buffer
- 3 DMA channels for receive data
- 1 DMA channel for transmit data

**SerDes**
- Serialization/Deserialization
- Framing
- CRC generation and checking
- Manchester encoding/decoding
- Destination address recognition

**ELECTRICAL CHARACTERISTICS**

**DS677 Kit**

Ethernet Development Upgrade Kit includes the Ethernet Communication Controller board set (2 boards), top assembly hardware, 10m interconnect cable, data link interface library, diagnostic test programs, manuals and documentation. Will give Ethernet development capability to any Series II/85 or Series III development system. (Shipping weight 10.5 lbs.)

**DC Power Supply for Mainframe**

<table>
<thead>
<tr>
<th>Volts Supplied</th>
<th>Current Requirements Amps Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5±5%</td>
<td>9.0</td>
</tr>
<tr>
<td>+12±5%</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**ENVIRONMENTAL CHARACTERISTICS**

System Operating Temperature—16°C to 32°C (61°F to 90°F)
Humidity—20% to 80%

**DOCUMENTATION SUPPLIED**

*Ethernet Development System Upgrade Kit Installation and Checkout Manual, 121778.*
*ISBC-550 Ethernet Communications Controller Hardware Reference Manual 121746.*

**ORDERING INFORMATION**

DS677 Ethernet Upgrade Kit requires a Software License.
**ISIS-II SOFTWARE TOOLBOX**

- Significantly Improves Programmer Productivity
- Collection of Utilities that Speed Up Software Design
- Enhances Capabilities of ISIS-II Operating System
- Most Utilities will Operate on NDS-I Workstations, and Remote Hard Disks

The ISIS-II Software Toolbox is a collection of system utilities that perform a variety of "productivity-oriented" functions. There are two major subsets of Toolbox tools, in addition to numerous ad hoc utilities. These subsets provide Conditional Submit File Control and Source File Management.

The Conditional Submit File Control tools provide "structured programming" at the ISIS-II command level. Jumps, Calls, Returns, etc. are supported, as well as conditional command execution, based on assertions such as file existence, program errors, file matching, and string matching.

The Source Management Tools support version number tracking, and allow users to identify which versions of each source module were used to create a load module. There is also a tool which compares source files and reports all differences.

The tools outside of the two major subsets assist the programmer in some very specific development and debugging tasks. One tool manages all PUBLIC/EXTERNAL declarations in a system. Another merges the locate maps into a program listing, giving absolute symbolic debugging information. There's a directory sorter, a file compactor, and a tool to display just the last block of a file.

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FUNCTIONAL DESCRIPTION

Submit File Execution Control

IF/ELSE/ENDIF—conditional submit file execution based on file existence, program errors, pattern matching, plus several other conditions
GOTO—causes submit execution to resume at a specified label
RETURN—causes execution to return to the “submitter” (calling file)
EXIT—halts submit file execution
LOOP—forces execution to resume at the beginning of the submit file
RESCAN—allows submit execution to begin anywhere in file
NOTE—allows “progress report” notes to be placed in submit files
WAIT—displays a message and waits for user input to continue or abort
STOPIF—halts submit file execution if specified listing contains errors

Source Management

XLA2E—submit-like tool with intelligent parameter substitution (for version control)
MRKOBJ—“marks” object modules with source version information
CHKLOD—lists source version data put in load modules by MRKOBJ
CLEAN—deletes all old versions off a specified disk
LATEST—displays latest version numbers of specified files

Operating System Functions

CONSOL—reassigns console input and console output as directed
DSORT*—alphabetically sorts floppy disk and hard disk directories
RELAB*—changes disk name to any other specified name

Program Development and Debugging

ERRS—fast display of program errors in PL/M 80, PL/M 86, and ASM 86 listings
MERG80—merges debug data from locate maps into PL/M 80 listings
MERG86—merges debug data from symbol maps into PL/M 86 and Pascal 86 listings
GENPEx—produces include file for PL/M external declarations (source level)
PASSIF—general purpose assertion checking, testing, and reporting tool

Text Processing

COMPAR—performs line-oriented text file comparison (shows source changes)
UPPER—changes all letters in an ASCII text file to uppercase
LOWER—changes all letters in an ASCII text file to lowercase
LAST—displays the last 512 bytes of a file
SORT—sophisticated line-oriented text file sorting tool

Disk Backup and File Processing

DCOPY—fast track-by-track diskette copying
HDBACK*—sophisticated hard disk to floppy disk backup program
PACK—compacts text files by removing strings of blanks
UNPACK—reconstitutes “packed” files

Disk Recovery

GANEF*—interactively reads and writes floppy or hard disk data blocks

Program Identification

WHICH—displays version number of Software Toolbox Programs

* These programs will not operate on the NDS-I remote hard disks.

ORDERING INFORMATION

Product Code    Description
MDS-363†        ISIS-II SOFTWARE TOOLBOX

† MDS is an ordering code only and is not used as a product name or trademark. MDS is a registered trademark of Mohawk Data Science.
CREDIT™
CRT-BASED TEXT EDITOR
MICROCOMPUTER DEVELOPMENT SYSTEMS

- Provides Interactive Editing of ASCII Text Files
- CRT Screen Display with Cursor-Based Editing Using Single Character Commands for Insertion, Deletion, Page Forward and Backward
- Command Line Editing with String Search, Deletion, Insertion and Move
- Displays Full Page of Text
- Dynamic Macro Command Definition
- Operates Under the ISIS-II Operating System on Intellec® and Intellec® Series II Microcomputer Development Systems

CREDIT is a CRT-based text editor that aids in the creation and editing of ASCII text files on Intellec Microcomputer Development Systems. Once the text has been edited to the programmer’s satisfaction, it can be directed to the appropriate language processor for compilation, assembly or interpretation. CREDIT features are easy to use and simplify the change or rearrangement of text files. CREDIT runs under ISIS-II on any Intellec or Intellec Series II Microcomputer Development System with an Intel supplied CRT, disk drive(s) and 64K bytes of memory. Alternatively, it may be configured to run with non-Intel CRTs supporting cursor controls.

There are two editing modes in CREDIT: a screen mode and a command line mode. The screen mode makes full use of the display characteristics of the CRT. The cursor position is visible on the screen and can be positioned by use of the cursor control keys. Display text can be corrected in two ways—either by simply retyping the text, or by using the single-stroke control keys. Specifically, the single-character control keys are used for change, deletion, insertion and paging forward and page backward.

In addition to screen editing, there is command line editing, which includes commands for more powerful and complex editing tasks. Some examples of functions available in the command line mode are search, block move and copy, macro definition and manipulation of external files. These easily used, high-level commands facilitate complex editing and speed microcomputer development.

The following are trademarks of Intel Corporation and may be used only to identify Intel products: BXP, CREDIT, Intellec, Multibus, I, ISBC, Multimodule, ICE, ISBX, PROMPT, ICS, Library Manager, Promware, Insite, MCS, RMX, Intel, Megachassis, UPI, Intelevision, Micromap, µScope and the combination of ICE, ICS, ISBC, ISBX, MCS, or RMX and a numerical suffix.
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CREDIT™ EDITOR FEATURES

- Two editing modes: cursor-driven screen editing and command line context editing

CRT Editing Includes:

- Displays full page of text
- Single control key commands for insertion, deletion, page forward and backward
- Type-over correction and replacement
- Immediate feedback of the results of each operation
- The current state of the text is always represented on the display

Command Line Editing Includes:

- String search and substitute
- String delete, change or insert
- Block move
- Block copy
- User-defined macros
- External file handling
- Change CREDIT features with ALTER command
- Conditional iteration
- User-defined tab settings
- Symbolic tag positions
- Automatic disk full warning
- Runs under ISIS-II SUBMIT facility
- Option to exit at any time with original file intact
- HELP command

BENEFITS OF CREDIT™ EDITOR

- Speeds source program creation and editing—lowers the cost of these functions
- Easy to learn and use—source text is clearly displayed—single command keys used for CRT editing—HELP command is available for easy reference when needed
- Complements existing software - source text used for PL/M, PASCAL, FORTRAN, BASIC, and Assemblers
- Aids in the management of source file libraries
- Offers full use of Intel supplied CRT cursor functions

Figure 1. Microcomputer Program Development
SCREEN MODE COMMANDS

MOVE CURSOR: Use the directional arrow keys on the keyboard.
REPLACE: Type over existing text with replacement new text.
INSERT: Insert one character.
INSERT more than one character.
DELETE: Delete one character.
Set boundaries and delete all text between them.
PAGE: Next Page: Get next screenful of text.
Previous Page: Get previous screenful.
View Page: Rewrite current page with possible reframing.

COMMAND MODE COMMANDS

HELP: Display summary of commands.
PRINT: Print n lines or up to tag.
JUMP: Move cursor position n characters or to tag.
Move cursor position n lines forward or backward.
MOVE: Transfer Copy block of text from tag1, for n lines or through tag2, to cursor position.
Transfer move: like Transfer Copy but the old copy is deleted.
TAGS: Set tag n, n = 0-9. Tag n is referenced as Tn.
EXIT: Normal exit.
INSERT: Insert before CP all text between delimiters.
DELETE: Delete n characters, or characters up to tag.
Delete n lines forward or backward.
FIND: Search for text; move pointer if found.
SUBST: newtext replaces oldtext if oldtext is found. (Optional query to user before replacement.)
FILES: Open file "filename" for Reading or Writing.
MACROS: Define a macro.
Delete a macro, or all macros if name=*.
Expand and execute macro contents, command mode.
Expand and execute macro contents, screen mode.
Print names and definitions of all macros.
CLOSE: Close the current external Read (Write) file.
GO TO: Go to beginning of current Read file.
READ: Read and insert n lines from the Read file.
WRITE: Write n lines to the external Write file.
GET: Get contents of file into command line.
QUERY: Query User: set Query Flag accordingly.
      Do command only if Query Flag is True.
      Do command only if Query Flag is False.
YES: Do command only if Yes (Search) Flag is False.

DO COMMAND only if Yes (Search) Flag is False.

LOOP: Exit current iteration loop.
ALERT: Configure the command input keys to work with alternative CRTs.
USER: Copy text to the console.
HELP: Display summary of commands.

SPECIFICATIONS

Operating Environment

Required Hardware

Intellec® Microcomputer Development System
—Model 800 or Series II with 64k bytes of RAM memory
—Series III
Diskette Drive(s)
—Single or double density
System Console
—Intel supplied CRT or alternative CRT supporting cursor controls

Optional Hardware

Line Printer
Additional diskette drive(s)

ORDERING INFORMATION

Part Number Description
MDS-360* ISIS-II CREDIT CRT-Based Text Editor

Required Software
ISIS-II Diskette Operating System
—Single or double density

Documentation Package

CREDIT* (CRT-Based Text Editor) User’s Guide (9800902)
CREDIT® Pocket Reference (9800903)

Shipping Media

Flexible Diskettes
—Single or double density

*MDS is an ordering code only, and is not used as a product name or trademark.
MDS® is a registered trademark of Mohawk Data Sciences Corporation.
INTELLEC® DOUBLE DENSITY FLEXIBLE DISK SYSTEM

- Flexible Disk System Providing High Speed Input/Output and Data Storage for Intellec® Microcomputer Development Systems
- Associated Software Supports Up to Four Double Density Drives and Two Single Density Drives, Providing Up to 2.5 Megabytes of Storage in One System
- Data Recorded on Double Density Flexible Disk is in Soft-Sected Format Which Allows ½ Million Byte Data Capacity with Up to 200 Files Per Flexible Disk
- Dynamic Allocation and Deallocation of Flexible Disk Sectors for Variable Length Files

The Intellec Flexible Disk System is a sophisticated, general purpose, bulk storage peripheral for use with the Intellec Microcomputer Development System. The use of a flexible disk operating system significantly reduces program development time. The software system known as ISIS-11 (Intel System Implementation Supervisor), provides the ability to edit, assemble, compile, link, relocate, execute and debug programs, and performs all file management tasks for the user.
FLEXIBLE DISK SYSTEM

HARDWARE

The Intellec® flexible disk system provides direct access bulk storage, intelligent controller, and two flexible disk drives. The double density drive provides ½ million bytes of storage with a data transfer rate of 500,000 bits/second. The controllers are implemented with Intel's powerful Series 3000 Bipolar Microcomputer Set. The controllers provide interface to the Intellec System bus. Each double density controller will support up to four drives. The flexible disk system records all data in soft sector format.

The double density flexible disk controllers each consists of two boards, the Channel Board and the Interface Board. These two printed circuit boards reside in the Intellec System chassis. The boards are shown in the photograph, and are described in more detail in the following paragraphs.

CHANNEL BOARD

The Channel Board is the primary control module within the flexible disk system. The Channel Board receives, decodes, and responds to channel commands from the Central Processor Unit (CPU) in the Intellec system. The Channel Board can access a block of Intellec system memory to determine the particular flexible disk operations to be performed and fetch the parameters required for the successful completion of the specified operation.

The control functions of the Channel Board have been achieved with an 8-bit microprogrammed processor, designed with Intel's Series 3000 Bipolar Microcom-

puter Set. This 8-bit processor includes four 3002 Central Processing Elements (2-bit slice per CPE), a 3001 Microprogram Control Unit, and 512 x 32 bits of 3604 programmable-read-only-memory (PROM) which stores the microprogram. It is the execution of the microprogram by the microcomputer set which actually effects the control capability of the Channel Board.

INTERFACE BOARD

The Interface Board provides the flexible disk controller with a means of communication with the flexible disk drives, as well as with the Intellec system bus. Under control of the microprogram being executed on the Channel Board, the Interface Board generates those signals which cause the read/write head on the selected drive to be loaded (i.e., to come in contact with the flexible disk platter), cause the head to move to the proper track and verify successful operation. The Interface Board accepts the data being read off the flexible disk, interprets synchronizing bit patterns, checks the validity of the data using a cyclic redundancy check (CRC) polynomial, and then transfers the data to the Channel Board.

During write operations, the Interface Board outputs the data and clock bits to the selected drive at the proper times, and generates the CRC characters which are then appended to the data.

When the flexible disk controller requires access to Intellec system memory, the Interface Board requests the DMA master control of the system bus, and generates the appropriate memory command. The Interface Board also acknowledges I/O commands as required by the Intellec bus.

The Flexible Disk System is capable of performing seven different operations: recalibrate, seek, format track, write data, write deleted data, read data, and verify CRC.

The channel board supports up to two sets of dual double density drives (four drives total).

The double density controller may co-reside with the Intel single density controller to allow conversion of single density flexible disk to double density format, and provide up to 2.5M bytes of storage.

FLEXIBLE DISK DRIVE MODULES

Each flexible disk drive consists of read/write and control electronics, drive mechanisms, read/write head, track positioning mechanism, and the removable flexible disk platter. These components interact to perform the following functions:

- Interpret and generate control signals
- Move read/write head to selected track
- Read and write data
ASSOCIATED SOFTWARE — INTEL SYSTEMS IMPLEMENTATION SUPERVISOR (ISIS-II)

The Flexible Disk Drive System is to be used in conjunction with the ISIS-II Operating System. ISIS-II provides total file management capabilities, file editing, library management, run-time supports, and utility management.

ISIS-II OPERATIONAL ENVIRONMENTAL

ISIS-II

32K bytes RAM memory
48K bytes when using Assembler Macro feature
64K bytes when using PLM or Fortran System Console
Double density Flexible Disk Drive

HARDWARE SPECIFICATIONS

MEDIA

Double Density

Double Density Specified
Flexible Disk
One Recording Surface
Soft Sector Format
77 Tracks/Diskette
52 Sectors/Track
128 Bytes/Sector

PHYSICAL CHARACTERISTICS

CHASSIS AND DRIVES

Mounting: Table-Top
Height: 5.7 in. (14.5 cm)
Width: 17.6 in. (44.7 cm)
Depth: 19.4 in. (49.3 cm)
Weight: 43.0 lb. (19.5 kg)

ELECTRICAL CHARACTERISTICS

CHASSIS

DC Power Supplies
Supplied Internal to the Cabinet
AC Power Requirements
3-wire input with center conductor (earth ground) tied to chassis
Single-phase, 115 VAC; 60 Hz; 1.2 Amp Maximum (For a Typical Unit)
230 VAC; 50 Hz; 0.7 Amp Maximum (For a Typical Unit)

FLEXIBLE DISK OPERATING SYSTEM CONTROLLER

DC Power Requirements (All power supplied by Intellec Development System)

CHANNEL BOARD

Double Density

5V @ 3.75A (typ), 5A (max)

5V @ 1.5A (typ), 2.5A (max)
– 10V @ 0.1A (typ), 0.2A (max)

FLEXIBLE DISK DRIVE PERFORMANCE SPECIFICATION

Double Density

Capacity (Unformatted):
Per Disk 6.2 megabits
Per Track 82 kilobits

Capacity (Formatted):
Per Disk 4.10 megabits
Per Track 53.2 kilobits

Data Transfer Rate
500 kilobits/ sec

Access Time:
Track-to-Track 10 ms
Head Setting Time 10 ms

Average Random Positioning Time 260 ms

Rotational Speed 360 rpm

Average Latency 83 ms

Recording Mode M^2FM

ENVIRONMENTAL CHARACTERISTICS

MEDIA

Temperature:
Operating: 15.6°C to 51.7°C
Non-Operating: 5°C to 55°C
Humidity:
Operating: 8 to 80% (Wet bulb 29.4°C)
Non-Operating: 8 to 90%

DRIVES AND CHASSIS

Temperature:
Operating: 10°C to 38°C
Non-Operating: -35°C to 65°C
Humidity:
Operating: 20% to 80% (Wet bulb 26.7°C)
Non-Operating: 5% to 95%

CONTROLLER BOARDS

Temperature:
Operating: 0 to 55°C
Non-Operating: -55°C to 65°C
Humidity:
Operating: Up to 95% relative humidity without condensation
Non-Operating: All conditions without condensation of water or frost
## FLEXIBLE DISK SYSTEM

### EQUIPMENT SUPPLIED

**DOUBLE DENSITY**
- Cabinet, Power Supplies, Line Cord, Two Drives
- Double Density FDC Channel Board
- Double Density FDC Interface Board
- Dual Auxiliary Board Connector
- Flexible Disk Controller Cable
- Flexible Disk Peripheral Cable
- Hardware Reference Manual
- Reference Schematics
- ISIS-II Double Density System Disk
- ISIS-II System User's Guide

### OPTIONAL EQUIPMENT

- MDS-BLD*
- MDS-730/731*
- 10 Blank Flexible Disks
- Second Drive Cabinet with two additional drives

### ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS-720-110V* 721/220V</td>
<td>Flexible Disk drive unit with two drives, double density drive controller, software, and cables.</td>
</tr>
<tr>
<td>MDS-730/110V* 731/220V</td>
<td>Add-on drive unit with two drives and double density cable, without controller and software. Can be used with double density controller.</td>
</tr>
</tbody>
</table>

*MDS is an ordering code only and is not used as a product name or trademark. MDS is a registered trademark of Mohawk Data Sciences Corporation.
MCS–80/85™
Development Systems
and Options
FORTRAN 80
8080/8085 ANS FORTRAN 77
INTELLEC® RESIDENT COMPILER

- Meets ANS FORTRAN 77
  Subset LanguageSpecification plus
  adds Intel microprocessor extensions

- Supports Intel Floating Point
  Standard with the FORTRAN 80 software
  routines, the iSBC-310™ High Speed
  Mathematics Board, or the iSBC-332™ math multimodule

- Executes on Intellec Microcomputer
  Development System and Intellec
  Series II Microcomputer Development
  System

- Supports full symbolic debugging with
  ICE-80™ and ICE-85™

- Produces relocatable and linkable
  object code compatible with resident
  PL/M 80 and 8080/8085 Macro
  Assembler

- Provides optional run-time library to
  execute in RMX-80™ environment

- Has well defined I/O interface for
  configuration with user-supplied drivers

FORTRAN 80 is a computer industry-standard, high-level programming language and compiler that translates
FORTRAN statements into relocatable object modules. When the object modules are linked together and located into
absolute program modules, they are suitable for execution on Intel 8080/8085 Microprocessors, iSBC-80 OEM Com-
puter Systems, and Intellec Microcomputer Development Systems. FORTRAN 80 meets the ANS FORTRAN 77
Language Subset Specification1. In addition, extensions designed specifically for microprocessor applications are
included. The compiler operates on the Intellec Microcomputer Development System under the ISIS-II Disk Operating
Systems and produces efficient relocatable object modules that are compatible for linkage with PL/M 80 and
8080/8085 Macro Assembler modules.

The ANS FORTRAN 77 language specification offers many powerful extensions to the FORTRAN language that are
especially well suited to Intel 8080/8085 Microprocessor software development. Because FORTRAN 80 conforms to
the ANS FORTRAN 77 standard, the user is assured of compatibility with existing FORTRAN software that meets the
standard as well as a guarantee of upward compatibility to other computer systems supporting an ANS FORTRAN 77
Compiler.

1 ANSI X3J3/90
FORTRAN 80 LANGUAGE FEATURES

Major ANS FORTRAN 77 features supported by the Intel® FORTRAN 80 Programming Language include:

- Structured Programming is supported with the IF ... THEN ... ELSE IF ... ELSE ... END IF constructs.
- CHARACTER data type permits alphanumeric data to be handled as strings rather than characters stored in array elements.
- Full I/O capabilities include:
  - Sequential and Direct Access files
  - Error handling facilities
  - Formatted, Free-formatted, and Unformatted data representation
  - Internal (in-memory) file units provide capability to format and reformat data in internal memory buffers
  - List Directly Formatting
- Supports arrays of up to seven dimensions.
- Supports logical operators
  - .EQV. — Logical equivalence
  - .NEQV. — Logical nonequivalence

Major extensions to FORTRAN 77 in Intel FORTRAN-80 include:

- Direct 8080/8085 port I/O supported by intrinsic subroutines.
- Binary and Hexadecimal integer constants.
- Well-defined interface to FORTRAN-80 I/O statements (READ, OPEN, etc.), allowing easy use of user-supplied I/O drivers.
- User-defined INTEGER storage lengths of 1, 2 or 4 bytes.
- User-defined LOGICAL storage lengths of 1, 2 or 4 bytes.
- REAL STORAGE lengths of 4 bytes.
- Bitwise Boolean operations using logical operators on integer values.
- Hollerith data constants.
- Implicit extension of the length of an integer or logical expression to the length of the left-hand side in an assignment statement.
- A format descriptor to suppress carriage return on a terminal output device at the end of the record.

FORTRAN 80 BENEFITS

FORTRAN 80 provides a means of developing application software for Intel® MCS-80/85 products in a familiar, widely accepted, and computer industry-standardized programming language. FORTRAN 80 will greatly enhance the user’s ability to provide cost-effective solutions for software development for Intel microprocessors as illustrated by the following:

- Completely Complementary to Existing Intel Software Design Tools — Object modules are linkable with new or existing Assembly Language and PL/M Modules.
- Incremental Runtime Library Support — Runtime overhead is limited only to facilities required by the program.
- Low Learning Effort — FORTRAN 80, like PL/M, is easy to learn and use. Existing FORTRAN software can be ported to FORTRAN 80, and programs developed in FORTRAN 80 can be run on any other computer with ANS FORTRAN 77.
- Earlier Project Completion — Critical projects are completed earlier than otherwise possible because FORTRAN 80 will substantially increase programmer productivity, and is complementary to PL/M Modules by providing comprehensive arithmetic, I/O formatting, and data management support in the language.
- Lower Development Cost — Increases in programmer productivity translates into lower software development costs because less programming resources are required for a given function.
- Increased Reliability — The nature of high-level languages, including FORTRAN 80, is that they lend themselves to simple statements of the program algorithm. This substantially reduces the risk of costly errors in systems that have already reached production status.
- Easier Enhancements and Maintenance — Like PL/M, program modules written in FORTRAN 80 are easier to read and understand than assembly language. This means it is easier to enhance and maintain FORTRAN 80 programs as system capabilities expand and future products are developed.
- Comprehensive, Yet Simple Project Development — The Intellic Microcomputer Development System, with the 8080/8085 Macro Assembler, PL/M 80 and FORTRAN 80 is the most comprehensive software development facility available for the Intel MCS-80/85 Microprocessor family. This reduces development time and cost because expensive (and remote) timesharing or large computers are not required.
SAMPLE FORTRAN-80 SOURCE PROGRAM LISTING

** THIS PROGRAM IS AN EXAMPLE OF ISIS-II FORTRAN-80 THAT
** CONVERTS TEMPERATURE BETWEEN CELSIUS AND FARRENHEIT

PROGRAM CONVRT

CHARACTER*1 CHOICE, SCALE

PRINT 100

** ENTER CONVERSION SCALE (C OR F)
10 PRINT 200
READ (5,300) SCALE
+ IF (SCALE .EQ. 'C')
   THEN
   PRINT 400
   ** ENTER THE NUMBER OF DEGREES FARRENHEIT
   READ (5,*1) DEGF
   DEGC = 5./9.*(DEGF-32)
   ** PRINT THE ANSWER
   WRITE (6,500) DEGF,DEGC
   ** RUN AGAIN?
   20 PRINT 600
   READ (5,300) CHOICE
   IF (CHOICE .EQ. 'Y')
   THEN
   GOTO 10
   ELSE IF (CHOICE .EQ. 'N')
   THEN
   CALL EXIT
   ELSE
   GOTO 20
   END IF
   ELSE IF (SCALE .EQ. 'F')
   THEN
   ** CONVERT FROM FARRENHEIT TO CELSIUS
   PRINT 700
   READ (5,*1) DEGC
   DEGF = 9./5.*DEGC+32.
   ** PRINT THE ANSWER
   WRITE (6,800) DEGC,DEGF
   GOTO 20
   ELSE
   ** NOT A VALID ENTRY FOR THE SCALE
   WRITE (6,900) SCALE
   GOTO 10
   END IF
100 FORMAT(' TEMPERATURE CONVERSION PROGRAM',//,
   + ' TYPE C FOR FARRENHEIT TO CELSIUS OR',/,
   + ' TYPE F FOR CELSIUS TO FARRENHEIT',//)
200 FORMAT(/, ' CONVERSION? ',$
300 FORMAT(A1)
400 FORMAT(/, 'ENTER DEGREES FARRENHEIT: ',$
500 FORMAT(/, F7.2, ' DEGREES FARRENHEIT = ', F7.2, ' DEGREES CELSIUS.')
600 FORMAT(/, ' AGAIN (Y OR N)? ',$
700 FORMAT(/, ' ENTER DEGREES CELSIUS: ',$
800 FORMAT(/, F7.2, ' DEGREES CELSIUS = ', F7.2, ' DEGREES FARRENHEIT.')
900 FORMAT(/,1H, A1, ' NOT A VALID CHOICE - TRY AGAIN!')
END
FORTRAN 80

The FORTRAN 80 Compiler is an efficient, multiphase compiler that accepts source programs, translates them into relocatable object code, and produces requested listings. After compilation, the object program may be linked to other modules, located to a specific area of memory, then executed. The diagram shown below illustrates a program development cycle where the program consists of modules created by FORTRAN 80, PL/M 80 and the 8080/8085 Macro Assembler.

SPECIFICATIONS

OPERATING ENVIRONMENT

Required Hardware:
- Intellec® Microcomputer Development System
  - MDS-800, MDS-888
  - Series II Model 220, Model 230
- 64K bytes of RAM memory
- Dual diskette drives
  - Single or Double Density
- System console
  - CRT or hardcopy interactive device

Optional Hardware:
- Line Printer
- ICE-80™, ICE-85™

Required Software:
- ISIS-II Diskette Operating System
  - Single or Double Density

Optional Software:
- iSBC-801 FORTRAN-80 Run-Time Software Package for RMX-80

DOCUMENTATION PACKAGE

FORTRAN-80 Programming Manual (9800481)
ISIS-II FORTRAN-80 Compiler Operator’s Manual (9800480)
FORTRAN-80 Programming Reference Card (9800547)

SHIPPING MEDIA

Flexible Diskettes
  - Single and Double Density

ORDERING INFORMATION

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<th>DESCRIPTION</th>
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<td>*MDS-301</td>
<td>FORTRAN 80 Compiler for Intellec Microcomputer Development Systems</td>
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</tbody>
</table>

*"MDS" is an ordering code only, and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corp.

15-4
BASIC-80
EXTENDED ANS 1978 BASIC INTELLEC® RESIDENT INTERPRETER

- Meets ANS 1978 Standard for Minimal BASIC and Adds Many Powerful Extensions
- Operates Under the ISIS-II Operating System on Intellec® and Intellec® Series-II Microcomputer Development Systems
- Full Sequential and Random Disk File I/O with ISIS-II
- Applications Range from Prototyping Microcomputer Software to Inexpensive Engineering and Management Problem Solving on the Intellec® Systems
- Supports the Intel® Floating Point Standard and Provides Integer and String Data Types
- Can Call User Subroutines Written in FORTRAN 80, PL/M 80, and 8080/85 Macro Assembler that are Resident in the Intellec® Memory
- Easily Learned Language and Interactive Environment Combine to Provide a Flexible and Powerful Facility for Developing Programs to Run on the Intellec® Microcomputer Development Systems

BASIC is an industry standard, high-level programming language which is designed to be easily learned and used by novices and experienced programmers alike. The interpreter provides an interactive environment which allows fast and easy program development, testing, and debugging. BASIC is widely used for problem solving in engineering and management; extensive software exists for business applications such as order entry, accounts receivable, accounts payable, and inventory control, and engineering applications such as numeric and statistical analysis.

Intel's BASIC-80 meets the standards of ANS 1978 BASIC and extends them to take advantage of the software development capabilities of the Intellec Microcomputer Development Systems. The matching of these resources with the ease of programming in BASIC-80 provides a very effective tool for both microprocessor systems development and inexpensive applications programming and problem solving on the Intellec systems.
BASIC-80 LANGUAGE FEATURES

Standard ANS 78 BASIC features, all supported by BASIC-80, include:
- String and numeric constants, variables, and arrays.
- FOR TO STEP NEXT statements for loop execution.
- IF THEN statements for conditional execution.
- ON GOTO statements for computed branching.
- GOSUB/RETURN subroutine calls and returns.
- Built in scientific functions:
  - ABS
  - EXP
  - INT
  - LOG
  - RND
  - SGN
  - SQRT
  - SIN
  - TAN
  - COS
- User defined single statement functions.

Major extensions to ANS 78 BASIC which BASIC-80 provides include:
- Support for the Intel single and double precision floating point standard.
- Disk file I/O, supporting both random access and sequential access files.
- Direct read and write to CPU I/O ports through the INP and OUT functions.
- Direct memory read and write through the PEEK and POKE functions.
- Calls to user-supplied external subroutines, which may have been written in FORTRAN-80, PL/M-80, or 8080/8085 Assembly Language and have been located at absolute memory locations using the ISIS-II facilities.
- User directed error trapping and handling functions.
- Program execution trace command.

BENEFITS OF BASIC-80

- Added Value to the Intellec Systems—with BASIC-80 the Intellec Microcomputer Development Systems can be effectively used in many engineering and management applications.
- Inexpensive and Accessible Computational Facility—the ease of use and flexibility inherent in BASIC-80 and its interpretive environment fit well with the “at hand” computational resources of the Intellec systems. The combination is a particularly useful tool for obtaining fast and accurate results.
- Easy to Learn—the language is designed to be easily understood and learned. Results are obtained faster and people who may benefit from using the system can do so easily.
- Aid in Microcomputer Software Design—microcomputer software can be prototyped in BASIC-80 to inexpensively develop and test program logic.
- Complemented by Existing Software—subroutines written in PL/M-80, FORTRAN-80, and ASM 8080/8085 can be called from BASIC-80 programs.
- Easy to Enhance and Maintain—BASIC-80, being straightforward and easily understood, provides for programs that are easy to maintain and modify in the future.

SPECIFICATIONS

Operating Environment

Required Hardware:
Intellec Microcomputer Development System
- Models 800 and 888
- Series-II Model 220, Model 230
48K bytes of RAM memory
Diskette drive
- Single or double density
System console
- CRT or hard copy interactive device

Optional Hardware:
Line printer
Additional diskette drive

Required Software:
ISIS-II Diskette Operating System
- Single or double density

Documentation Package:
Basic-80 Reference Manual (9800758A)
Basic-80 Programming Reference Card (9800774)

Shipping Media:
Flexible diskettes
- Single and double density
EXAMPLE BASIC-80 PROGRAM

list
10 PRINT "THIS PROGRAM CALCULATES THE MEAN AND STANDARD"
20 PRINT " DEVIATION OF INPUT DATA"
30 S=0:V=0
40 INPUT "NUMBER OF VALUES";N
50 FOR I=1 TO N
60 INPUT A(I)
70 S=S+A(I)
80 NEXT
90 S=S/N
100 REM CALCULATION OF VARIANCE
110 FOR I=1 TO N
120 V=V+(A(I)-S)**2/N
130 NEXT
140 SD=SQR(V)
150 PRINT "MEAN=":S
160 PRINT "STANDARD DEVIATION IS=":SD
Ok

run
THIS PROGRAM CALCULATES THE MEAN AND STANDARD
 DEVIATION OF INPUT DATA
NUMBER OF VALUES? 6
? 34.7
? 32.9
? 38.2
? 35
? 37.6
? 40.9
MEAN= 36.55
STANDARD DEVIATION IS= 2.642442
Ok

ORDERING INFORMATION

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<thead>
<tr>
<th>Product Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>MDS-320</td>
<td>ISIS-II BASIC-80 Disk-Based</td>
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</tbody>
</table>

*MDS is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Science Corporation.
PASCAL 80
SOFTWARE PACKAGE

- Offers a Superset of Standard Pascal
- Provides Highly Structured Language with Powerful Data Type Definitions to Suit Applications
- Compiles Pascal Source Code into Intermediate Code to Optimize Execution Speed and Storage
- Executes Compiler and Interprets the Intermediate Code on Intellec® Microcomputer Development Systems
- Provides a Utility to Produce Relocatable Object Modules Compatible with Other Intel® Languages
- Can Call Routines Written in PL/M 80, FORTRAN 80, or 8080/8085 Macro Assembler
- Allows Modular Breakdown of Large Programs and Separate Compilation of Individual Modules
- Gives Application Control Over Run-Time Errors by Providing User-Declared Error Procedures

PASCAL 80 Software Package consists of a compiler and an interactive Run-Time System designed to provide the Pascal programming language as a software development tool for Intellec Development System Users.

Pascal is a highly-structured, block-oriented programming language that is now gaining wide acceptance as a powerful software development tool. Its rigid structure encourages and enforces good programming techniques, which, combined with a high level of readability, helps produce more reliable software.

Standard Intel development tools, such as CREDIT editor can be used to create and modify Pascal source programs. The compiler compiles this source and creates a P-Code file. The Run-Time System executes this P-Code in an interpretive manner under ISIS-II.

LANGUAGE FEATURES

Data Structures
Pascal allows the user to define labels, constants, data types, variables, procedures, and functions.

Variable Types
Variables can be defined according to the following system-defined data types: boolean, integer, real, character, array, record, string, set, file, and pointer.

User-Defined Types
New types can be defined by the user for added flexibility.

FILE HANDLING PROCEDURES
Pascal provides procedures to allow a user’s program to interface with the ISIS-II file manager. Routines provided are: RESET, REWRITE, CLOSE, PUT, GET, SEEK, and PAGE.

Input/Output Procedures
Routines are provided to interact with the console or an ISIS file. These procedures are: READ, WRITE, READLN, WRITELN, plus BUFFER and BLOCK Read and Write.

Dynamic Memory Allocation
The procedures NEW, MARK, and RELEASE allow the user to obtain and release memory space at run-time for dynamically allocating variable storage.

String Handling
Pascal provides powerful tools for defining and manipulating strings and character arrays. These facilities enable concatenation of strings, character and pattern scans, insertion, deletion, and pointer manipulation.

Recursion
Pascal allows a PROCEDURE definition to include a call to itself, a powerful construct in many mathematical algorithms.

PROGRAM TRACING FACILITY
The PASCAL 80 System incorporates a program tracing facility which allows for selectively monitoring the execution of a Pascal program. When the TRACE flag is set, the line number of each program statement being executed is output to the console.

The TRACE flag may be manipulated in two ways:
—The TRACEON command (of the Run-Time System) will set the flag, and the TRACOFF command will reset the flag.
—Pressing the Interrupt 4 switch on the Intellec System front panel will toggle the TRACE flag; i.e., the flag will be set if it was reset, and vice-versa.

COMPILER DIRECTIVES (PARTIAL LIST)

Compiler Command Line Directives

NOLIST
No list file is produced; used for fast compilation of "clean" programs.

NOCODE
No code file is produced; used for syntax error checking.

ERRLIST
List file is limited to only those Pascal lines that contain errors, along with the error messages produced.

LIST (file-name)
Specifies the name of the list file.

CODE (file-name)
Specifies the name of the code file.

NOECHO
Error lines are echoed on the console unless this directive is specified.

Embedded Compiler Directives

$C text
Causes text to appear in code file (allows for comments, copyrights, etc.).

$1+
Causes checking for I/O completion after each I/O transfer. Failure results in a run-time error. ($1− causes no checking, and no errors on I/O failure.)
$R+$
Causes Range Checking to occur, so that an out-of-range value causes a Run-Time error. ($R-$ suppresses generation of code for Range Checking.)

$O+$
Causes the compiler to operate in overlay mode. Overlays allow less source code to reside in memory. ($O-$ causes no overlays, which decreases compile time, since there are fewer disk accesses.)

$T+$
Causes the compiler to generate tracing instructions to be used by the TRACE facility. ($T-$ suppresses tracing instructions.)

**BENEFITS**

Brings Pascal to Intellec Microcomputer Development Systems:

—Pascal is being acclaimed as the programming language of the future; it is being taught in many colleges and universities around the country.

—PASCAL 80 Run-Time System provides great ease in programming formatted I/O operations.

PASCAL 80 provides a portable language for application programs running under ISIS-II.

PASCAL 80 can be used to evaluate complicated algorithms using a natural language.

PASCAL 80 compiler generates intermediate Pseudo-code.

—P-code is optimized for speed and storage space.

—P-code is approximately 50% to 70% smaller than corresponding machine code.

—P-code is machine independent, providing code portability to any CPU.

Makes the Intellec Development System a more valuable tool. Extension of software support to include Pascal makes software development and resource management more flexible.

---

**Figure 1. Program Development Cycle**

---

AFN-01233B
**Table 1. Sample Program Listing Showing Nesting Levels**

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<thead>
<tr>
<th>Line</th>
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<th>Proc</th>
<th>Lev</th>
<th>Disp</th>
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<td>1</td>
<td>3</td>
<td></td>
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**SPECIFICATIONS**

**Operating Environment**

**REQUIRED HARDWARE**
- Intellec® Microcomputer Development System
  — Model 800
  — Series II Model 220, Model 230, Model 240
- 64KB of Memory
- Dual-Diskette Drives
  — Single- or Double-Density*
- System Console
  — Intel® CRT or non-Intel® CRT

*Recommended.

**REQUIRED SOFTWARE**
- ISIS-II Diskette Operating System
  — Single- or Double-Density

**OPTIONAL SOFTWARE**
- ISIS-II CREDIT™ (CRT-Based Text Editor)

**Documentation Package**
- PASCAL 80 User's Guide (9801015-01)

**Shipping Media**
- Flexible Diskettes
  — Single- and Double-Density
## ORDERING INFORMATION

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<td>PASCAL 80 Software Package</td>
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</table>

Requires Software License

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8080/8085 FUNDAMENTAL SUPPORT PACKAGE (FSP)

- Comprehensive Extension of the 8080 CPU Performance Features Through Standardized Software Building Blocks
- Library Routines Provide Extended Math Capabilities of ASM 80, PL/M 80, and FORTRAN 80
- Hardware-Independent Modules Selectable by the User for a Wide Variety of Frequently Needed Program Functions
- Available on Diskette as an ISIS-II Library File
- High Standard of Reliability Achieved Through Use of Proven Algorithms and Meticulous Testing of All Functions
- Efficient Integration with the User's Program Using the ISIS Utility Programs LINK and LOCATE
- Lowers Software Development Costs

FSP is a mathematical and technical applications library. It is a comprehensive collection of frequently needed program functions that complement and augment the capabilities of the 8080/8085 microprocessor. The inclusion of these functions eliminates the need to code and debug complicated math routines and permits the user to concentrate on his own application. The use of FSP functions thus makes a noteworthy contribution to the economy of software development.

FSP consists of a collection of subroutines stored as relocatable modules on a diskette. These modules can, with the help of ISIS utilities, LINK and LOCATE, be linked to user programs in assembly language, PL/M or FORTRAN.
The Fundamental Support Package consists of nine individual libraries that lie in a hierarchical structure, as shown in figure 1. These nine sections are:

- The **FSP Machine** (primitive subroutine) package performs fast string handling and binary and decimal integer arithmetic without error reporting.
- The **binary integer arithmetic** routines provide operations on signed and unsigned integers of various formats in binary representation.
- The **floating-point arithmetic** section provides operations on floating-point (real) numbers in four formats: single precision, single-precision extended, double precision, and double-precision extended.
- The **decimal arithmetic** routines provide integer and fixed-point arithmetic on numbers in decimal representation—i.e., stored as strings of ASCII characters.
- The **string handling** section contains routines to transform strings and to extract and insert substrings. A routine for scanning of general input and one for formatting of general output are included.
- The routines for **number conversion and numeric I/O** do transformation of numeric data from one internal format to another, input scanning of numeric strings and formatting of numeric strings for output.
- The **floating-point transcendental function** section provides trigonometric, exponential, and other transcendental functions for single precision, single-precision extended, double precision, and double-precision extended floating-point arguments.
- The **statistics** routines compute the mean, variance, and standard deviation of one group of statistical data, and the covariance and correlation factor of two groups of data.
- The **P.I.D. process control** routines direct the production of an appropriate output signal in response to an input signal, using a formula with proportional, integral, and/or derivative terms, for real-time process control applications.

In linking modules to an application program, the user must note the hierarchical structure of FSP and specify in order the lower level packages on which a higher level package must rely. Figure 1 shows the required subordination of subroutines; for example, the statistical package relies on the floating-point library, which in turn relies on the FSP machine.

All FSP routines are reentrant; that is, all local data used by each routine is stored on the stack. These routines may thus be interrupted, and during the interrupt the same routine or other routines may be called, without affecting the results of the interrupted routine.

---

**DESCRIPTION OF THE LIBRARIES**

**FSP Machine (FSLMCH.LIB)**

The routines in this library, together with the 8080/8085 hardware, constitute the FSP Machine. The routines fall into two categories: the first comprises a group of pseudo-operations that complement and augment the 8080/8085 instruction set. These pseudo-operations are accessible only from assembly language programs and resemble assembler commands. The second category consists of a set of routines that work on variable-length operands; the integer and decimal arithmetic and string-handling capabilities of the FSP are based on this foundation.

The routines in the FSP Machine do not return messages in the event of an error; they are optimized for speed of execution.

**String Handling (FSLSTR.LIB)**

This library contains routines for manipulating strings and for the processing of character input and output. The string manipulation routines fall into two groups. The first is character-oriented, while the second handles groups of string variables. In both groups, there are functions necessary for retrieval and manipulation of data.

The input scanner recognizes simple symbols like alphabetic names, numbers, boundaries, and gaps in input strings. The routines work with one of the user-defined tables and returns as a result an operand that can be utilized by the other string manipulation routines.

---

![Figure 1. Hierarchy of FSP Modules](image-url)
The output formatter arranges data into a form required for further manipulation. For example, it permits:

- Copying a character from the input string into the output buffer
- Including a literal in a given position in the output string
- Collapsing leading blanks
- Inserting the sign (i.e., of a number) in a given position in the output string

### Decimal Arithmetic (FSLDEC.LIB)

The routines available in this library operate directly on signed decimal numbers without converting them internally into binary. Only integer operands are permitted. These are represented as ASCII strings up to 32 characters long. Addition, subtraction, and multiplication are accomplished by means of one operation each. For division there are two functions; one to calculate the integer quotient, one to calculate a remainder. Additional functions allow for negation, absolute value, and comparison of operands. Also available are utilities to limit the length of operands and to scale decimal variables.

### Integer Arithmetic (FSLINT.LIB)

In this library there are routines for unsigned (8- and 16-bit) and signed (8-, 16-, and 32-bit) decimal arithmetic. For each of the fundamental operations—addition, subtraction, multiplication and division, as well as for the comparison of two integer operands—there is one routine. Additional functions provide for manipulation of the signs of operands and conversion of operands between different internal storage formats.

For signed integer operands, the following formats are possible:

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 byte, including sign</td>
<td>(-2^7 \text{ to } 2^7 - 1)</td>
</tr>
<tr>
<td>2 bytes, including sign</td>
<td>(-2^{15} \text{ to } 2^{15} - 1)</td>
</tr>
<tr>
<td>4 bytes, including sign</td>
<td>(-2^{31} \text{ to } 2^{31} - 1)</td>
</tr>
<tr>
<td>8 bytes, including sign</td>
<td>(-2^{63} \text{ to } 2^{63} - 1)</td>
</tr>
</tbody>
</table>

For unsigned operands, there are three possible formats:

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 byte, without sign</td>
<td>0 to (2^8 - 1)</td>
</tr>
<tr>
<td>2 bytes, without sign</td>
<td>0 to (2^{16} - 1)</td>
</tr>
<tr>
<td>4 bytes, without sign</td>
<td>0 to (2^{32} - 1)</td>
</tr>
</tbody>
</table>

### Floating-Point (FSLFLP.LIB)

The routines in this library provide an extensive range of floating-point arithmetic functions. In addition to addition, subtraction, multiplication, and division, there is a module function, a square root function and a routine to compare two floating point operands. Floating-point operands can be represented in any of four formats:

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>STORAGE</th>
<th>MANTISSA</th>
<th>EXPONENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Precision</td>
<td>4 Byte</td>
<td>24 bits</td>
<td>8 bits</td>
</tr>
<tr>
<td>Extended Single Precision</td>
<td>6 Byte</td>
<td>32 bits</td>
<td>15 bits</td>
</tr>
<tr>
<td>Double Precision</td>
<td>8 Byte</td>
<td>53 bits</td>
<td>11 bits</td>
</tr>
<tr>
<td>Extended Double Precision</td>
<td>10 Byte</td>
<td>64 bits</td>
<td>15 bits</td>
</tr>
</tbody>
</table>

Additional functions provide for truncation, rounding and conversion of floating-point operands from one of the above formats to another.

### Conversion and I/O (FSLCNV.LIB)

This library consists of routines for input and output of floating-point numbers and for the conversion of numeric data between different internal formats. There is an input scanner to read numeric data; there is an output formatter that writes output data to a buffer. There are various possible formats for input and output data; numeric data are handled as ASCII strings, as follows:

- Integers (single, decimal mantissa)
- Scaled integers (sign, decimal mantissa, decimal point)
- Floating point numbers (sign, decimal mantissa, decimal point, decimal exponent)

There are also other routines necessary for conversion of binary, decimal and floating point numbers. By means of the transformation of decimal into floating-point numbers and vice-versa, single and double precision are achieved.

### Statistics (FSLSTA.LIB)

This library makes available routines that provide elementary statistical functions. The calculation of means, variance, and standard deviation employs one-dimensional arrays of data, whereas the calculation of covariance and correlations presumes two-dimensional arrays. In both cases, data are supplied as single precision floating-point numbers; the statistical routines make use of the floating-point library. Results of calculations are returned as single precision floating point numbers.

### Process Control (FSLPID.LIB)

The routines in this library support digital process control using the 8080/8085. The PID algorithm

\[
M(t) = B + \frac{100}{P} \left( E(t) + \frac{1}{P} \int_{0}^{t} E(s) \, ds + D \frac{dE}{dt} \right)
\]
calculates an output signal \( M(t) \) as a function of an input signal \( E(t) \). The input quantity is a measure of the deviation of a controlled variable from a set point. The parameters \( B, P, R, \) and \( D \) are supplied by the user. The implementation is such that the user can select to exclude or include any combination of the terms in the PID equation (i.e., the proportional term, the integral term, the derivative term). There are also routines to initialize the control function and to change the measurement interval.

**SPECIFICATIONS**

**DEVELOPMENT ENVIRONMENT**

**Required Hardware:**

Intellic Microcomputer Development System
—Model 800
—Series II Model 220, 230, or 240

64KB of Memory
—Single or double density diskette drive

System Console
—Intel or Non-Intel CRT

**Required Software:**

ISIS-II Diskette Operating System
LINK, LOC Utilities
ASM80, FORTRAN-80, PL/M-80

**DOCUMENTATION PACKAGE**

8080/8085 Fundamental Support Package (FSP)
Reference and Operating Instructions for ISIS-II Users
Order Number 9800887

**Shipping Media**

Flexible Diskettes
—Single and double density

**ORDERING INFORMATION:**

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<th>Description</th>
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<tr>
<td>MDS-318*</td>
<td>8080/8085 Fundamental Support Package (FSP)</td>
</tr>
</tbody>
</table>

**"MDS"** is an ordering code only, and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corp.

**Transcendental Functions (FSLTRN.LIB)**

This library includes routines to calculate elementary mathematical functions in single, extended single, double, and extended double precision. The following functions are available:

- \( \sin, \cos, \tan \)
- \( \exp, \ln, \log_{10}, y^x \)
- \( \sinh, \cosh, \tanh \)
- \( \text{arc sin, arc cos, arc tan, arc tan (y/x)} \)
iCIS-COBOL SOFTWARE PACKAGE

- Meets and Exceeds Minimum ANSI Level 1 Standard for COBOL (X3.23-1974)
- Runs Under ISIS-II on Intellec® or Intellec® Series II Microcomputer Development Systems
- Compiler Compiles COBOL Source Programs into an Intermediate Code Which is Optimized for Speed and Memory Space
- Includes Execution Run-Time Interpreter and an Interactive Debugger
- Powerful Extensions for Interactive Programming
- Can Link/Call Routines Written in PL/M 80, FORTRAN 80 and 8080/8085 Assembly Language
- FORMS Utility Program Allows the User to Design and Test CRT Screen Format Input by Generating COBOL Source Code for the Data Descriptions Defining that CRT Screen Format
- Compile-Time Option Available to Flag Any Non-ANSI Standard Features for Portability
- Tested Using U.S. Dept. of Navy COBOL Validation System

iCIS-COBOL, an acronym for Intel's Compact Interactive Standard COBOL, is a package designed to provide a powerful interactive business language to users of Intel's Intellec and Intellec Series II Microcomputer Development Systems. iCIS-COBOL contains the most relevant parts of the ANSI 74 standard plus extra extensions to make this product especially useful to Intellec users. The compiler provides a feature to optionally disallow the iCIS-COBOL extensions and rigidly enforce the ANSI 74 specification. This will prove beneficial to users who may need to port COBOL programs from the Intellec system to any other ANS Level 1 COBOL compiler.

iCIS-COBOL Compiler generates object code for a COBOL "virtual machine." This code is designed for optimum representation of COBOL verbs and data types. The code generated is interpreted by a Run-Time System. This consists of an interpreter which emulates the COBOL virtual machine and interfaces to the ISIS-II operating system and the CRT.

After an application program has been tested and is ready for production use, it is possible to link it permanently to the Run-Time System to form a free-standing ISIS-II loadable program.
LANGUAGE FEATURES

COBOL consists of twelve different modules implemented either to Level 1 or Level 2 as defined in the ANSI specification X3.23. iCIS-COBOL includes the following modules implemented to Level 1:

- Nucleus
- Table Handling
- Sequential I/O
- Relative I/O
- Indexed I/O
- Library
- Interprogram Communication

Extensions to ANSI Specification:

- **Advanced screen formatting and data entry facilities.** These include protected and unprotected data, cursor manipulation, and numeric vet.

- **Run time input of filenames.** The actual value of the external filename may be moved to a file identifier location prior to OPENing the file, avoiding the need for an external linking mechanism.

- **Line sequential files.** Variable length records separated by carriage return/line feed saves space on disk and allows iCIS-COBOL programs to process files output by a text editor.

- **Hexadecimal literals.** These may be used to define control characters to output to special peripheral devices.

- **Rapid development facilities.** During development, compiled programs may be loaded directly by the Run-Time System “fast load” facility, thus avoiding the time otherwise spent in linking.

- **Interactive debugging.** Interactive debugging permits the setting of breakpoints, examination and modification of store, etc., at run time. Each COBOL statement is identified by a four-digit hexadecimal number.

- **Lower case.** This is permitted in COBOL words and comments, thus helping to produce easy to read documentation in the program.

INTERACTIVE CRT HANDLING

Intel has taken COBOL — traditionally a batch processing language — and extended it to become interactive. iCIS-COBOL offers many facilities for automatically formatting a CRT screen and facilitating input keying.

The user can format the screen of any system console (CRT) into protected and unprotected fields by using standard COBOL statements. The screen layout may be defined in the DATA DIVISION. An ACCEPT statement nominates a record description which permits input to the character positions corresponding to variables identified by data-names. These may be separated by FILLERs to position them on the screen. Conversely, a DISPLAY outputs only from non-FILLER fields in the record description which it nominates. The programmer can easily build up complex conversations for data entry and transaction processing.

When data is being keyed in, the operator has full cursor manipulation facilities, each variable acting as a tab stop. Non-numeric digits may not be keyed into fields defined as PIC 9. Finally, when the operator has checked that the data is correct, the RETURN key is pressed and processing continues.

SCREEN LAYOUT AND FORMAT FACILITIES

- **Screen as a record description**
- **FILLER**
- **REDEFINES**
- **AT line:column**
- **Character highlighting**
- **Clear screen**
- **Numeric vet for PIC fields**

Cursor Control Facilities

- **HOME** to the start of the first data field on the screen
- **FILLER**
- **REDEFINES**
- **AT line:column**
- **Character highlighting**
- **Clear screen**
- **Numeric vet for PIC fields**

FORMS UTILITY

A majority (up to 80%) of debugging time can be spent in designing, coding and testing the screen form input/output of a COBOL program. The FORMS utility included in the iCIS-COBOL package significantly reduces this debugging time.

Using the FORMS program, the user may:

- Store an image copy on disk of the form he has defined for subsequent use.
- Generate iCIS-COBOL source code for the data descriptions required to define the form just created. This may then be included in an iCIS-COBOL program using COPY.
- Choose to generate a checkout program which allows duplication of the many machine conversations which would take place during a run of the application which is being designed.

COMPILE TIME DIRECTIVES

- **ANS**
  If specified, the Compiler will accept only those iCIS-COBOL language statements that conform to the ANS 74 standard.
- **RESEQ**
  If specified, the Compiler generates COBOL sequence numbers, renumbering each line in increments of 10.
- **NOINT**
  No intermediate code file is output. The Compiler is, in effect, used for syntax checking only.
- **NOLIST**
  No list file is produced; used for fast compilation of “clean” programs.
- COPYLIST
  The contents of the file(s) nominated in COPY statements are listed.
- NOFORM
  No form feed or page headings are to be output by the Compiler in the list file.
- ERRLIST
  The listing is limited to those COBOL lines containing syntax errors together with the associated error message(s).
- INT (external-file-name)
  Specifies the file to which the intermediate code is to be directed.
- LIST (external-file-name)
  Specifies the file to which the listing is to be directed.
- FORM (integer)
  Specifies the number of COBOL lines per page of listing.
- NOECHO
  Error lines are echoed on the console unless this directive is specified.

**BENEFITS**
- Brings COBOL to Intellec Microcomputer Development Systems.
  COBOL is the industry standard high-level language for business-oriented applications.
- Most COBOL programs are self-documenting.
- Conversational verbs and phrases and common business terminology make COBOL easy to learn, use and maintain.
- More business and application programs are written in COBOL than any other language.
- Meets and exceeds ANSI Level 1 COBOL standard.
  Assures portability to and from all computers supporting ANSI Level 1 COBOL.
- Extensive testing and validation using U.S. NAVY COBOL VALIDATION SYSTEM assures functionality for all Level 1 features.
- iCIS-COBOL software package provides an easy to use, efficient and friendly environment for COBOL program development.
  CONFIGURATOR allows the user to reconfigure the software for any non-standard, non-InteICRT.
  Interactive debugger provides features aimed at a CRT based system (rather than batch-oriented).
- FORMS utility program reduces total program development time by 30%.
- All iCIS-COBOL utilities make use of CRT cursor control.
- Adds value to an Intellec development system.
  COBOL applications programs developed using iCIS-COBOL software package will increase utilization of Intellec development systems.

![Figure 1. Program Development Cycle](image1)
![Figure 2. Sample Program Listing Showing Source Format](image2)
SPECIFICATIONS

Operating Environment

Required Hardware:
Intellec Microcomputer Development System
   - Model 800
   - Series II Model 220, Model 230
48KB of Memory
Dual Diskette Drives
   - Single or Double Density
System Console
   - Intel or non-Intel CRT

Recommended Hardware:
64KB of Memory
Double Density Dual Diskette Drives

Optional Hardware:
Line Printer

Required Software:
ISIS-II Diskette Operating System
   — Single or Double Density

Optional Software:
ISIS-II CREDIT (CRT-Based Text Editor)

Documentation Package
iCIS-COBOL Language Reference Manual (9800927-01)
iCIS-COBOL Compiler Operating Instructions for ISIS-II Users (9800928-01)
iCIS-COBOL Pocket Reference (9800929-01)

Shipping Media
Flexible Diskettes
   — Single and Double Density

ORDERING INFORMATION:

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<th>Description</th>
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<tr>
<td>MDS-380*</td>
<td>iCIS-COBOL Software Package</td>
</tr>
</tbody>
</table>

Requires software license

*MDS is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Science Corporation.
PL/M 80
HIGH LEVEL PROGRAMMING LANGUAGE
INTELLEC® RESIDENT COMPILER

- Provides Resident Operation on Intellec® Microcomputer Development System and Intellec® Series II Microcomputer Development Systems
- Produces Relocatable and Linkable Object Code
- Sophisticated Code Optimization Reduces Application Memory Requirements
- Speeds Project Completion with Increased Programmer Productivity
- Cuts Software Development and Maintenance Costs
- Improves Product Reliability with Simplified Language and Consequent Error Reduction
- Eases Enhancement as System Capabilities Expand

The PL/M 80 High Level Programming Language Intellec Resident Compiler is an advanced, high level programming language for Intel 8080 and 8085 microprocessors, ISBC-80 OEM computer systems, and Intellec microcomputer development systems. PL/M has been substantially enhanced since its introduction in 1973 and has become one of the most effective and powerful microprocessor systems implementation tools available. It is easy to learn, facilitates rapid program development and debugging, and significantly reduces maintenance costs. PL/M is an algorithmic language in which program statements naturally express the algorithm to be programmed, thus freeing programmers to concentrate on system development rather than assembly language details (such as register allocation, meanings of assembler mnemonics, etc.). The PL/M compiler efficiently converts free-form PL/M programs into equivalent 8080/8085 instructions. Substantially fewer PL/M statements are necessary for a given application than would be using assembly language or machine code. Since PL/M programs are problem oriented and thus more compact, programming in PL/M results in a high degree of productivity during development efforts, resulting in significant cost reduction in software development and maintenance for the user.
FUNCTIONAL DESCRIPTION

The PL/M compiler is an efficient multiphase compiler that accepts source programs, translates them into object code, and produces requested listings. After compilation, the object program may be first linked to other modules, then located to a specific area of memory, and finally executed. The diagram shown in Figure 1 illustrates a program development cycle where the program consists of three modules: PL/M, FORTRAN, and assembly language. A typical PL/M compiler procedure is shown in Table 1.

Features

Major features of the Intel PL/M 80 compiler and programming language include:

- **Resident Operation** — on Intellec microcomputer development systems eliminates the need for a large in-house computer or costly timesharing system.
- **Object Code Generation** — of relocatable and linkable object codes permits PL/M program development and debugging in small modules, which may be easily linked with other modules and/or library routines to form a complete application.
- **Extensive Code Optimization** — including compile time arithmetic, constant subscript resolution, and common subexpression elimination, results in generation of short, efficient CPU instruction sequences.
- **Symbolic Debugging** — fully supported in the PL/M compiler and ICE-85 in-circuit emulators.
- **Compile Time Options** — includes general listing format commands, symbol table listing, cross reference listing, and “innerlist” of generated assembly language instructions.

Benefits

PL/M is designed to be an efficient, cost-effective solution to the special requirements of microcomputer software development as illustrated by the following benefits of PL/M use:

- **Low Learning Effort** — even for the novice programmer, because PL/M is easy to learn.
- **Earlier Project Completion** — on critical projects, because PL/M substantially increases programmer productivity while reducing program development time.
- **Lower Development Cost** — because increased programmer productivity requiring less programming resources for a given function translates into lower software development costs.
- **Increased Reliability** — because of PL/M’s use of simple statements in the program algorithm, which are easier to correct and thus substantially reduce the risk of costly errors in systems that have already reached full production status.
- **Easier Enhancement and Maintenance** — because programs written in PL/M are easier to read and easier to understand than assembly language, and thus are easier to enhance and maintain as system capabilities expand and future products are developed.
Simpler Project Development — because the Intellec microcomputer development system with resident PL/M 80 is all that is needed for developing and debugging software for 8080 and 8085 microcomputers, and the use of expensive (and remote) timesharing or large computers is consequently not required.

```plaintext
$OBJECT(:F1:FACT.OB2)
$DEBUG
$XREF
$TITLE('FACTORIAL GENERATOR — PROCEDURE')
$PAGEWIDTH(80)

1 FACT: DO;
2 1 DECLARE NUMCH BYTE PUBLIC;
3 1 FACTORIAL: PROCEDURE (NUM,PTR) PUBLIC;
4 2 DECLARE NUM BYTE, PTR ADDRESS;
5 2 DECLARE DIGITS BASED PTR (161) BYTE;
6 2 DECLARE (I,C,M) BYTE;
7 2 NUMCH = 1; DIGITS(1) = 1;
9 2 DO M = 1 TO NUM;
10 3 C = 0;
11 3 DO I = 1 TO NUMCH;
12 4 DIGITS(I) = DIGITS(I)*M + C;
13 4 C = DIGITS(I)/10;
14 4 DIGITS(I) = DIGITS(I) — 10*C;
15 4 END;
16 3 IF C <> 0 THEN
17 3 DO;
18 4 NUMCH = NUMCH + 1; DIGITS(NUMCH) = C;
20 4 C = DIGITS(NUMCH)/10;
21 4 DIGITS(NUMCH) = DIGITS(NUMCH) — 10*C;
22 4 END
24 2 END FACTORIAL;
25 1 END;
```

Table 1. PL/M-80 Compiler Sample Factorial Generator Procedure

---

**SPECIFICATIONS**

**Operating Environment**

**Required Hardware**
- Intellec microcomputer development system
- 65K bytes of memory
- Dual diskette drives
- System console — teletype

**Optional Hardware**
- CRT as system console
- Line printer

**Required Software** — ISIS-II diskette operating system

**Shipping Media**
- Diskette

**Reference Manuals**
- 980026 — PL/M 80 Programming Manual (SUPPLIED)
- 9800300 — ISIS-II PL/M 80 Compiler Operator's Manual (SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

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**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Description</th>
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<tr>
<td>MDS-PLM*</td>
<td>PL/M 80 High level language compiler</td>
</tr>
</tbody>
</table>

*MDS is an ordering code only and is not used as a product name or trademark. MDS* is a registered trademark of Mohawk Data Sciences Corporation.
ICE-80™
8080 IN-CIRCUIT EMULATOR

- Connects Intellec® System to User Configured System Via an External Cable and 40-pin Plug, Replacing the User System 8080
- Allows Real-Time (2 MHz) Emulation of User System 8080
- Shares Intellec® RAM, ROM, and PROM Memory and Intellec® I/O Facilities with User System
- Checks for Up to Three Hardware and Four Software Break Conditions
- Offers Full Symbolic Debugging Capabilities
- Eliminates Need for Extraneous Debugging Tools Residing in User System
- Provides Address, Data, and 8080 Status Information on Last 44 Machine Cycles Emulated
- Provides Capability to Examine and Alter CPU Registers, Main Memory, Pin, and Flag Values
- Integrates Hardware and Software Development Efforts
- Available in Diskette or Paper Tape Versions

The Intellec ICE-80 8080 In-Circuit Emulator is an Intellec resident module designed to interface with any user configured 8080 system. With ICE-80 as a replacement for a prototype system 8080, the designer may emulate the system's 8080 in real time, single step the system's program, and substitute Intellec memory and I/O for user system equivalents. Powerful Intellec debug functions are extended into the user system. For the first time the designer may examine and modify his system with symbolic references instead of absolute values.

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© Intel Corporation 1980
FUNCTIONAL DESCRIPTION

Integrated Hardware/Software Development

Use of the ICE-80 module enables the system integration phase, which can be so costly and frustrating when attempting to mesh completed hardware and software products, to become a convenient two-way debug tool when begun early in the design cycle. The user prototype need consist of no more than an 8080 CPU socket and a user bus to begin integration of software and hardware development efforts. With the ICE-80 mapping capabilities, system resources may be accessed for missing prototype hardware. Hardware designs may be tested using system software to drive the final product. A functional block diagram of the ICE-80 module is shown in Figure 1.

Symbolic Debugging Capability

ICE-80 provides for user-defined symbolic references to program memory addresses and data. Symbols may be substituted for numeric values in any of the ICE-80 commands. The user is thus relieved from looking up addresses of variables or program subroutines.

Symbolic Reference — ICE-80 provides symbolic definition of all 8080 registers, flags, and selected pins. The following symbolic references are also provided for user convenience: TIMER, a 16-bit register containing the number of \( \frac{1}{2} \) clock pulses elapsed during emulation; ADDRESS, the address of the last instruction emulated; INTERRUPTENABLED, the user 8080 interrupt mechanism status; and UPPERLIMIT, the highest RAM address occupied by user memory.

Debug Capability Inside User System

ICE-80 provides for user debugging of full prototype or production systems without introducing extraneous hardware or software test tools. ICE-80 connects to the user system through the socket provided for the user 8080 in the user system (See Figure 2). Intellec memory is used for the execution of the ICE-80 software, while \( \text{I/O} \) provides the user with the ability to communicate with ICE-80 and receive information on the generation of the user system. A sample ICE-80 debug session is shown in Figure 3.

I/O Mapping and Memory

Memory and \( \text{I/O} \) for the user system may be resident in the user system or “borrowed” from the Intellec system through ICE-80’s mapping capability.
ICE-80™ IN-CIRCUIT EMULATOR

Figure 2. ICE-80 Module Installed in User System

Memory Blocking — ICE-80 separates user memory into 16 4K blocks. User I/O is divided into 16 16-port blocks. Each block of memory or I/O may be defined independently. The user may assign system equivalents to take the place of devices not yet designed for the user system during prototyping. In addition, memory or I/O may be accessed in place of user system devices during prototype or production checkout.

Error Messages — The user may also designate a block of memory or I/O as nonexistent. ICE-80 issues error messages when memory or I/O designated as nonexistent is accessed by the user program.

Real-Time Trace
ICE-80 captures valuable trace information while the user is executing programs in real time. The 8080 status, the user memory or port addressed, and the data read or written (snap data), is stored for the last 44 machine cycles executed. This provides ample data for determining how the user system was reacting prior to emulation break. It is available whether the break was user initiated or the result of an error condition. For detailed information on the actions of CPU registers, flags, or other system operations, the user may operate in single or multiple step sequences tailored to system debug needs.

Hardware
The heart of the ICE-80 is a microcomputer system utilizing Intel's 8080 microprocessor as its nucleus. This system communicates with the Intellec host processor via I/O commands. Host processor commands and ICE-80 status are interchanged through registers on the ICE-80 trace board. ICE-80 and the system also communicate through a control block resident in the Intellec main memory, which contains detailed configuration and status information transmitted at an emulation break. ICE-80 hardware consists of two PC boards — the processor and trace boards residing in the Intellec chassis — and a 6-foot cable interfacing to the user system. The trace and processor boards communicate with the system on the bus, and also with each other on a separate ICE-80 bus. ICE-80 connects to the user system through a cable that plugs directly into the socket provided for the user’s 8080.

Trace Board
The trace board talks to the system as a peripheral device. It receives commands to ICE-80 and returns ICE-80 responses. While ICE-80 is executing the user program, the trace board collects data for each machine cycle emulated (snap data). The information is continuously stored in high-speed bipolar memory.

Breakpoint — The trace board also contains two 24-bit hardware breakpoint registers which can be loaded by the user. While in emulation mode, a hardware comparator is constantly monitoring address and status lines for a match to terminate an emulation. A user probe is also available for attachment to any user signal. When this signal goes true a break condition is recognized.

Interrogation — The trace board signals the processor board when a command to ICE-80 or break condition has been detected. The ICE-80 CPU then sends data stored on the trace board to the control block in memory. Snap data, along with information on 8080 registers and pin status and the reason for the emulation break, are then available for access during interrogation mode. Error conditions, if present, are transmitted and automatically displayed for the user.

Processor Board
An 8080 CPU resides on the processor board. During emulation it executes instructions from the user’s program. At all other times it executes instructions from the control program in the trace module’s ROM.

Timing — The processor board contains an internal clock generator to provide clocks to the user emulation CPU at 2 MHz. The CPU can alternately be driven by a clock derived from user system signal lines. The clock source is selected by a jumper option on the board. A timer on the trace board counts the f12 clock pulses during emulation and can provide the user with the exact timing of the emulation.

On/Off Control — The processor board turns on an emulation when ICE-80 has received a run command from the system. It terminates emulation when a break condition is detected on the trace board, or the user’s program attempts to access memory or I/O ports designated as nonexistent in the user system, or the user 8080 is inactive for a quarter of a second.

Status Storage — The address map located on the processor board stores the assigned location of each user memory or I/O block. During emulation the processor board determines whether to send/receive information...
120
121
01E3
C0
EQU
1E3H
:SDK-80 CONSOLE OUT DRIVER

120 0601
START: MVI B,1 :SET UP B VALUE

123 3A3613
LDA DAI1 :LOAD A WITH DAI1 VALUE

135 4F
LOOP: MDV C,A :SUBTRACT B FROM A

1326 CDE301
CALL C0 :SEND C VALUE TO CONSOLE

1329 79
MOV A,C :RESTORE A

132A 93
SBB B :SUBTRACT B FROM A

132B 323713
STA RSLT :STORE RESULT IN RSLT

132E FE40
CPI 40H :LAST VALUE TO PRINT

1330 C22513
JNZ LOOP :LOOP AGAIN IF A>40H

1333 C32013
JMP START :ELSE RESTART WHOLE PROCEDURE

1336 5A
DATI: DB 5AH

1337
RSLT: DS 1

0000 END

ISIS, V1.0 INITIAL ICE-80 SESSION

-ICE80 (Note: The SDK-80 Monitor has already been used to initialize the SDK-80 Board)

Notes

1. Set up user memory and I/O. The program is set up to execute in block 1 (1000H–1FFFH) of user memory, and requires access to the SDK-80 monitor (block 0) and I/O ports in block 0FH. Both ports and memory are defined as available to the user system. All other memory and I/O is initialized by ICE-80 as nonexistent (guarded).

2. A load command generates an error. The type and command numbers indicate that a data mismatch occurred on a write to memory command. The data to be written is located at 1333H. When ICE-80 read the data after writing it, a 04H was detected. A change command to a different memory address hints that bit 1 does not go to 1 anywhere in this memory block. Examination indicates that a pin was shorted on the RAM located at 1300H–13FFH in the prototype system. The problem is fixed and a subsequent load succeeds.

3. Real-time emulation is begun. The program is executed from 'START' (1320H) and continues until 'RSLT' is written (in location 1328H, the contents of the accumulator is stored in (written into) 'RSLT').

4. An error condition results: TYPE 07, CMND 02 indicate the program accessed is a guarded area.

5. The last 5 machine cycles executed are displayed. The last instruction executed was a call (CDH). The fourth and fifth cycles are a push operation (designated by status 04H) to store the program counter before executing the call. The stack pointer was not initialized in the program and is accessing memory location FFFFH.

6. After making a note to initialize the stack pointer in the next assembly, a temporary fix is effected by setting the stack pointer to the top of user available memory.

7. After setting the base for displays to hex and adding the symbol 'STOP' to the symbol table, emulation is started which will terminate when the instruction at 1333H ("STOP") is executed. When emulation terminates, a dump of the contents of user 8000 registers is requested. One can see that the value of the accumulator is set at 40H, the stack pointer is set at 13FFH, the last address executed ("*) is 1333H, and the program counter has been set to 1320H.

8. Exit returns control to the MDS monitor.

Figure 3. Sample ICE-80 Debug Session
ICE-80™ IN-CIRCUIT EMULATOR

on the Intellec or user bus by consulting the address map. The processor board allows the ICE-80 CPU to gain access to the bus as a master to "borrow" Intellec facilities. At an emulation break, the processor board stores the status of specified 8080 input and output signals, disables all interaction with the user bus, and commands the trace board to send stored information to a control block in Intellec memory for access during interrogation mode.

Cable Card
The cable card is included for cable driving. It transmits address and data bus information to the user system through a 40-pin connector that plugs into the user system in the socket designed for the 8080 when enabled by the processor module's user bus control logic.

Software
The ICE-80 software driver is a RAM-based program providing easy to use English language commands for defining breakpoints, initiating emulation, and interrogating and altering the user system status recorded during emulation. ICE-80 commands are configured with a broad range of modifiers to provide the user with maximum flexibility in describing the operation to be performed. Listings of emulation commands, interrogation commands, and utility commands are provided in Table 1, Table 2, and Table 3, respectively.

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>Establishes mode of display for output data.</td>
</tr>
<tr>
<td>Display</td>
<td>Prints contents of memory, 8080 registers, input ports, 8080 flags, 8080 pins, snap data, symbol table, or other diagnostic data on list device. May also be used for base-to-base conversion, or for addition or subtraction in any base.</td>
</tr>
<tr>
<td>Change</td>
<td>Alters contents of memory, register, output port, or 8080 flag.</td>
</tr>
<tr>
<td>XFORT</td>
<td>Defines memory and I/O status.</td>
</tr>
<tr>
<td>Search</td>
<td>Looks through memory range for specified value.</td>
</tr>
</tbody>
</table>

Table 2. ICE-80 Interrogation Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load</td>
<td>Fetches user symbol table and object code from input device.</td>
</tr>
<tr>
<td>Save</td>
<td>Sends user symbol table and object code to output device.</td>
</tr>
<tr>
<td>Equate</td>
<td>Enters symbol name and value to user symbol table.</td>
</tr>
<tr>
<td>Fill</td>
<td>Fills memory range with specified value.</td>
</tr>
<tr>
<td>Move</td>
<td>Moves block of memory data to another area of memory.</td>
</tr>
<tr>
<td>Timeout</td>
<td>Enables/disables user CPU ¼ second wait state timeout.</td>
</tr>
<tr>
<td>List</td>
<td>Defines list device (diskette-based version only).</td>
</tr>
<tr>
<td>Exit</td>
<td>Returns program control to monitor.</td>
</tr>
</tbody>
</table>

Table 3. ICE-80 Utility Commands

SPECIFICATIONS

Paper Tape-Based
Operating Environment
Required Hardware
Intellec system
System console
Reader device
Punch device
ICE-80 module
Required Software
System monitor

Diskette-Based
Operating Environment
Required Hardware
Intellec system
32K bytes RAM memory
System console
Intellec diskette operating system
ICE-80 module
Required Software
System monitor
ISIS-II
ICE-80™ IN-CIRCUIT EMULATOR

System Clock
Crystal controlled 2.185 MHz ± 0.01%. May be replaced by user clock through jumper selection.

Physical Characteristics
Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 8.00 lb (3.64 kg)

Electrical Characteristics
DC Power Requirements
\[ V_{CC} = +5V, \pm 5\% \]
\[ I_{CC} = 9.81A \text{ max; } 6.90A \text{ typ} \]
\[ V_{DD} = +12V, \pm 5\% \]

Environmental Characteristics
Operating Temperature — 0°C to 40°C
Operating Humidity — Up to 95% relative humidity without condensation

Equipment Supplied
Printed circuit modules (2)
Interface cables and buffer board
ICE-80 software driver, paper tape version
(ICE-80 software driver, diskette-based version is supplied with diskette operating systems)
Operator's Manual

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS-80-ICE*</td>
<td>8080 CPU in-circuit emulator, cable assembly and interactive software included</td>
</tr>
</tbody>
</table>

*MDS is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corporation.
ICE-85B™
MCS-85™ IN-CIRCUIT EMULATOR
WITH MULTI-ICE™ SOFTWARE

- Connects the Intellec® system resources to the user-configured system via a 40-pin adaptor plug
- Executes user system software in real-time (5 MHz clock)
- Allows user-configured system to share Intellec® memory and I/O facilities
- Provides 1023 states of 8085 trace data
- Displays trace data from the user’s 8085 in assembler mnemonics and allows personality groupings of data sampled by the external 18-channel trace module
- Offers full symbolic debugging capability for both assembly language and Intel’s high-level compiler languages PL/M-80 and FORTRAN-80
- The Multi-ICE™ software provides:
  - for two In-Circuit Emulators to operate simultaneously in a single Intellec Microcomputer Development System.
  - support for ICE 85/85™, 85/49™, and 85/41A™ Emulator combinations
  - enhanced software features: symbolic display of addresses, macro commands, compound commands, software synchronization of processes, and INCLUDE file capability.

The ICE-85B™ module resides in the Intellec® Microcomputer Development System and interfaces to the user system’s 8085. It provides the ability to examine and alter MCS-85™ registers, memory, flag values, interrupt bits and I/O ports. Using the ICE-85B module, the designer can execute prototype software in real-time or single-step mode and can substitute Intellec® system memory and I/O for user system equivalent. ICE capability can be extended to the rest of the user system peripheral circuitry by allowing the user to create and execute a library of user-defined peripheral chip analyzer routines.

Multi-ICE In-Circuit Emulator is a software product which allows two Intel In-Circuit Emulators to run simultaneously in a single Intellec Microcomputer Development System. Multi-ICE software used in lieu of the standard ICE software gives users full control of the two ICE modules for debugging of multi-processor systems.

The following are trademarks of Intel Corporation and may be used only to identify Intel products: Intel, INTEL, INTEL™, MCS™, IMS, SBC, BXP, ISBC, INSITE, CREDIT RMX/80, μScope, Multibus, PROMPT, PROMware, Megachassis, Library Manager, MAIN MULTI MODULE, and the combination of MCS, ICE, SBM, RMX or iCS and a numerical suffix: e.g., IMSBC-80.

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AFN-01557A
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ICE-85B™ IN-CIRCUIT EMULATOR

SYMBOLIC DEBUGGING CAPABILITY

ICE-85B allows the user to make symbolic references to I/O ports, memory addresses and data in his program. Symbols and PL/M-80 statement number may be substituted for numeric values in any of the ICE-85 commands. The user is relieved from looking up addresses of variables or program subroutines.

The user symbol table generated along with the object file during a PL/M-80 or FORTRAN-80 compilation or by the ISIS-II 8080/8085 Macro Assembler is loaded into the Intellec® System memory along with the user program which is to be emulated. The user may add to this symbol table any additional symbolic values for memory addresses, constants, or variables that are found useful during system debugging. By referring to symbolic memory addresses, the user can examine, change or break at the intended location.

ICE-85B provides symbolic definition of all 8085 registers, interrupt bits and flags. The following symbolic references are also provided for user convenience: TIMER, the low-order 16 bits of a register containing the number of 2 MHz clock pulses elapsed during emulation; HTIMER, the high-order 16 bits of the timer counter; PPC, the address of the last instruction emulated; BUFFERSIZE, the number of frames of valid trace data (between 0 and 1022).

PERSONALITY GROUPED DISPLAYS

Trace data in the 1023 by 42-channel real-time trace memory buffer is displayed in easy to read format. The user has the option to specify trace data displays in actual 8085 assembler instruction mnemonics. The data collected from the External Trace Module can be grouped and symbolically named according to user specifications and displayed in the appropriate number base designation. Simple ICE-85B commands allow the user to select any portion of the 42-bit trace buffer for immediate display.

MEMORY AND I/O MAPPING

Memory and I/O for the user system can be resident in the user system or "borrowed" from the Intellec® System through ICE-85B's mapping capability.

ICE-85B separates user memory into 32 2K blocks. Each block of memory can be defined independently. The user may assign Intellec® System equivalents to take the place of devices not yet designed for the user system during prototyping. In addition, Intellec® System memory or I/O can be accessed in place of suspect user system devices during prototyping or production checkout.

User ready synchronization—resource borrowing from the Intellec System is (at user option) independent of the user system; the user does not need to provide ready acknowledge when accessing resources mapped to the Intellec.

The user can also designate a block of memory or I/O as nonexistent. ICE-85B issues error messages when memory or I/O designated as nonexistent is accessed by the user program.

INTEGRATED HARDWARE/SOFTWARE DEVELOPMENT

The user prototype need consist of no more than an 8085 CPU socket and a user bus to begin integration of software and hardware development efforts. Through ICE-85B mapping capabilities, Intellec® System equivalents can be accessed for missing prototype hardware. Hardware designs can be tested using the system software which will drive the final product.

The system integration phase, which can be so costly when attempting to mesh completed hardware and software products, becomes a convenient two-way debug tool when begun early in the design cycle.

INTERROGATION AND UTILITY COMMANDS

DISPLAY/CHANGE Display/Changes the values of symbols and the contents of 8085 registers, pseudo-registers, status flags, interrupt bits, I/O ports and memory.

EVALUATE Displays the value of an expression in the binary, octal, decimal or hexadecimal.

SEARCH Searches user memory between locations in a user program for specified contents.

CALL Emulates a procedure starting at a specified memory address in user memory.

ICALL Executes a user-supplied procedure starting at a specified memory address in the Intellec® System memory.

EXECUTE Saves emulated program registers and emulates a user-supplied subroutine to access peripheral chips in the user's system.
ICE-85B™ IN-CIRCUIT EMULATOR

REAL TIME TRACE

ICE-85B captures valuable trace information from the emulating CPU and the External Trace Module while the user is executing programs in real time. The 8085 status, the user memory or port addressed, the data read or written, the serial data lines and data from 18 external signals, is stored for the last 1023 machine states executed (511 machine cycles). This provides ample data for determining how the user system was reacting prior to emulation break. It is available whether the break was user-initiated or the result of an error condition.

For detailed information on the actions of CPU registers, flags, or other system operations, the user may operate in single or multi-step sequences tailored to system debug needs.

EXTERNAL TRACE MODULE

TTL level signals from 18 points in the user system may be synchronously sampled by the External Trace Module and collected in ICE-85B’s trace buffer. The signals can be collected from a single peripheral chip via the supplied 40-pin DIP clip or may be placed by the user on up to 18 separate signal nodes using the supplied 18 individual probe clips. These signals are included in the 42-channel breakpoint comparisons and clock qualifiers. Also, data from these 18 channels may be displayed in meaningful, user-defined groupings.

SYNCHRONOUS OPERATION WITH OTHER DESIGN AIDS

ICE-85B can be synchronized with other Intellec® design aids by means of two external synchronization lines. These lines are used to enable and disable ICE-85B trace data collection and to cause break conditions based on an external signal which may not be included in the ICE-85B breakpoint registers. In addition, ICE-85B can generate signals on these lines which may be used to control other design aids.

BREAK REGISTERS/TRACE MEMORY

ICE-85B has two breakpoint registers which are used to break emulation, and two trace qualifier registers which are used to control the collection of trace data during emulation. Each register is 42 entries wide, one entry for each channel and each entry can take any one of the three values 0, 1 or "don't care."

The trace buffer, also 42 entries wide, collects data sampled from 24 8085 processor channels and 18 external channels sampled by the External Trace Module. The signals collected from the 8085 include address lines, data lines, status lines and serial input and output lines. The 18 channels extending from the External Trace Module synchronously sample and collect into the trace buffer any user-specified TTL compatible signal from the rest of the prototype system. “Break” and “trace qualification” may therefore occur as a result of a match of any combination of up to 42 channels of CPU and external circuitry signals.

MULTI-ICE™ OPERATION

Multi-ICE software is a debug tool which allows two ICE emulators to begin and stop in sequence. Once started, two ICE emulators emulate simultaneously and independently. Thus, Multi-ICE software permits the debugging of asynchronous or synchronous multi-processor systems.
A conceptual model for the Multi-ICE software can be illustrated with the following block diagram.

![Block Diagram of Multi-ICE Operation](image)

There are three processes in the Multi-ICE environment: the Host process and the two ICE processes to control the two ICE hardware modules. The processor for these three processes is the microcomputer in the Intellec Microcomputer Development System. Only the Host process is active when Multi-ICE software is invoked. The Parser interfaces with the console, receives commands from the console or from a file, translates them into intermediate code, and loads the code into the Host command code buffer or ICE command code buffers.

The Host process executes commands from its command code buffer using the execution software and hardware of the Host's current environment, either environment 1 or environment 2 (EN1 or EN2), as required. EN1 and EN2 are the operating environments of the two In-Circuit Emulators.

The user can change the execution environment (from EN1 to EN2 or vice versa) with the SWITCH command. Once the environment is selected, ICE operation is the same as with standard ICE software. In addition, the enhanced software capabilities are available to the user.

The two ICE processes (PR1 and PR2) execute commands from their command code buffers in their own environments (PR1 in EN1 and PR2 in EN2). The main functions of the two ICE execution processes are to control the operations of the two ICE hardware sets. The ACTIVATE command controls the execution of the ICE processes. Commands are passed on to each ICE unit to initiate the desired ICE functions.

The two ICE hardware units accept commands from the Host process or ICE processes. Once emulations start, the two ICE hardware sets will operate until a break condition is met or processing is interrupted by commands from the ICE execution processes.

**Symbolic Display of Addresses**

The user has the option of displaying a 16-bit address in the form of a symbol name or line number plus a hex number offset.

**Macro Command**

A macro is a set of commands which is given a name. Thus, a group of commands which is executed frequently may be defined as a macro. Each time the user wants to execute that group of commands, he may just invoke the macro by typing a colon followed by the macro name. Up to ten parameters may be passed to the macro.

Macro commands may be defined at the beginning of a debug session and can be used throughout the whole session. If the user wants to save the macros for later use, he may use the PUT command to save the macro on diskette, or the user may edit the macro file off-line using the Intellec text editor. Later, the user may use the INCLUDE command to bring in the macro definition file that he created.

**Example:**

```
*DEFINE MACRO INITMEM ;This macro clears the memory and then loads the programs.
*SWITCH = EN1 ;Select environment 1 (ICE Module 1)
*BYTE 0 TO 100=0 ;Initialize memory to 0.
*LOAD:F1:DRIVER ;Load user program into memory for ICE Module 1.
*SWITCH = EN2 ;Select environment 2 (ICE Module 2)
*LOAD:F1:DR2 ;Load user program into memory for ICE Module 2
*EM ;End of Macro
* ;To execute this Macro, user types :INITMEM
```

**Compound Command**

Compound commands provide conditional execution of commands (IF Command) and execution of commands repeatedly until certain conditions are met (COUNT, REPEAT Commands).

Compound commands and Macro commands may be nested any number of times.

**Example:**

```
*DEFINE .I = 0 ;Define symbol .I to 0
*COUNTh 100H ;Repeat the following commands 100H times
*IF .I AND 1 THEN ;Check if .I is odd
..*BYT .I = .I ;Fill the memory at location .I to value .I
..*END
..*.I = .I + 1 ;Increment .I by 1
..*END ;Command executes upon carriage-return after END
```

**INCLUDE File Capability**

The INCLUDE command causes input to be taken from the file specified until the end of the file is encountered, at which point, input continues to be
ICE-85BTM IN-CIRCUIT EMULATOR

taken from the previous source. Nesting of INCLUDE is permitted. Since the command code file can be complex, the ability to edit offline becomes desirable. The INCLUDE command allows the user to pull in command code files and Macro commands created offline which can then be used for the particular debugging session.

Example:
*INCLUDE :F1:PROG1 ;Cause input to be taken from file PROG1
*MAP 0 LENGTH 64K =USER

*MAP IO 0 TO FF =USER
*SWITCH = EN2
*LOAD :F2:LED.HEX
*SWITCH = EN1

;End of the file PROG1
;After the end of file is reached, control is returned to console.

Software Synchronization of Processes

Up to three processes (Host, PR1 and PR2) can be active simultaneously in the system. An ICE process can be activated (ACTIVATE), suspended (SUSPEND), killed (KILL), or continued (CONTINUE). The Host process can wait for other processes to become dormant before it becomes active again. Through these synchronization commands, the user can create a system test file off-line yet be able to synchronize the three processes when the actual system test is executed.

Example:

The capability of the software synchronization commands is demonstrated by the following example. The flowchart shows the synchronization requirements. The program steps show the actual implementation.

Flowchart of the Example for Demonstrating Multi-ICE™ Synchronization Capability
ICE-85B™ IN-CIRCUIT EMULATOR

SPECIFICATIONS

ICE-85B™ Operating Environment

Required Hardware:
- Intellec® Microcomputer Development System
  (64K bytes RAM for Multi-ICE software)
  (32K bytes RAM single ICE software)
- System Console
- Intellec® Diskette Operating System
- ICE-85B Module

Required Software:
- System Monitor
- ISIS-II
- ICE-85B or Multi-ICE Software

Equipment Supplied

- 18-Channel External Trace Module
- Printed Circuit Boards (2)
- Interface Cable and Emulation Buffer Module
- Operator's Manuals
- ICE-85B Software
- Multi-ICE Software
  Contains software that supports 85/85 Emulators, 85/49 Emulators and 85/41A Emulators

Emulation Clock

User’s system clock or ICE-85B adaptor socket (10.0 MHz Crystal)

Physical Characteristics

Printed Circuit Boards:
- Width: 12.00 in. (30.48 cm)
- Height: 6.75 in. (1715 cm)
- Depth: 0.50 in. (1.27 cm)
- Packaged Weight: 6.00 lb (2.73 kg)

Electrical Characteristics

DC Power:
- $V_{cc} = +5V \pm 5\%$
- $I_{cc} = 12A$ maximum; $10A$ typical
- $V_{dd} = +12V \pm 5\%$
- $I_{dd} = 80mA$ maximum; $60mA$ typical
- $V_{bb} = -10V \pm 5\%$
- $I_{bb} = 1mA$ maximum; $10\mu A$ typical

Environmental Characteristics

Operating Temperature: 0° to 40°C
Operating Humidity: Up to 95% relative humidity without condensation.

ICE-85B™ BLOCK DIAGRAM
### Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS*-85B-ICE</td>
<td>8085 CPU In-Circuit Emulator, 18-Channel External Trace Module and Multi-ICE software</td>
</tr>
<tr>
<td>MDS*-85U-ICE</td>
<td>Upgrade kit to convert ICE-85 or ICE-85A to ICE-85B functionality. Consists of Multi-ICE software and 5MHz Hardware</td>
</tr>
</tbody>
</table>

"MDS" is an ordering code only, and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corp.
iAPX 86/88 Support Options
iAPX 86,88
SOFTWARE DEVELOPMENT PACKAGES
FOR SERIES II

- PL/M 86/88 High Level Programming Language
- ASM 86/88 Macro Assembler for iAPX 86,88 Assembly Language Programming
- LINK 86/88 and LOC 86/88 Linkage and Relocation Utilities
- CONV 86/88 Converter for Conversion of 8080/8085 Assembly Language Source Code to iAPX 86, 88 Assembly Language Source Code
- OH 86/88 Object-to-Hexadecimal Converter
- LIB 86/88 Library Manager

The iAPX 86,88 Software Development Packages for Series II provide a set of software development tools for the iAPX 86/10 and iAPX 88/10 CPUs and the iSBC 86/12A single board computer. The packages operate under the ISIS-II operating system on Intellic Microcomputer Development Systems—Model 800 or Series II—thus minimizing requirements for additional hardware or training for Intel Microcomputer Development System users.

These packages permit 8080/8085 users to efficiently upgrade existing programs into iAPX 86/10 and 88/10 code from either 8080/8085 assembly language source code or PL/M 80 source code.

For the new Intel Microcomputer Development System user, the packages operating on an Intellic Series II, such as a Model 235, provide total iAPX 86,88 software development capability.
PL/M 86/88 COMPILER FOR SERIES II

- Language is Upward Compatible from PL/M 80, Assuring MCS-80/85™ Design Portability
- Supports 16-bit Signed Integer and 32-bit Floating Point Arithmetic in Accordance with IEEE Proposed Standard
- Easy-to-Learn, Block-Structured Language Encourages Program Modularity
- Produces Relocatable Object Code Which is Linkable to All Other 8086 Object Modules
- Supports Full Extended Addressing Features of the iAPX 86/10 and 88/10 Microprocessors (Up to 1 Mbyte)
- Code Optimization Assures Efficient Code Generation and Minimum Application Memory Utilization

Like its counterpart for MCS-80/85 program development, PL/M 86/88 is an advanced, structured high-level programming language. The PL/M 86/88 compiler was created specifically for performing software development for the Intel iAPX 86,88 Microprocessors.

PL/M 86/88 has significant new capabilities over PL/M 80 that take advantage of the new facilities provided by the iAPX 86,88 microsystem, yet the PL/M 86/88 language remains compatible with PL/M 80.

With the exception of hardware-dependent modules, such as interrupt handlers, PL/M 80 applications may be recompiled with PL/M 86/88 with little need for modification. PL/M 86/88, like PL/M 80, is easy to learn, facilitates rapid program development, and reduces program maintenance costs.

PL/M is a powerful, structured, high-level system implementation language in which program statements can naturally express the program algorithm. This frees the programmer to concentrate on the logic of the program without concern for burdensome details of machine or assembly language programming (such as register allocation, meanings of assembler mnemonics, etc.).

The PL/M 86/88 compiler efficiently converts free-form PL/M language statements into equivalent 86/10 or 88/10 machine instructions. Substantially fewer PL/M statements are necessary for a given application than if it were programmed at the assembly language or machine code level.

The use of PL/M high-level language for system programming, instead of assembly language, results in a high degree of engineering productivity during project development. This translates into significant reductions in initial software development and follow-on maintenance costs for the user.

FEATURES

Major features of the Intel PL/M 86/88 compiler and programming language include:

Block Structure

PL/M source code is developed in a series of modules, procedures, and blocks. Encouraging program modularity in this manner makes programs more readable, and easier to maintain and debug. The language becomes more flexible by clearly defining the scope of user variables (local to a private procedure, global to a public module, for example).

The use of procedures to break down a large problem is paramount to productive software development. The PL/M 86/88 implementation of a block structure allows the use of REENTRANT which is especially useful in system design.

Language Compatibility

PL/M 86/88 object modules are compatible with object modules generated by all other 86/88 translators. This means that PL/M programs may be linked to programs written in any other 86/88 languages.

Object modules are compatible with ICE-88 and ICE-86 units; DEBUG compiler control provides the In-Circuit Emulators with symbolic debugging capabilities.

PL/M 86/88 Language is upward-compatible with PL/M 80, so that application programs may be easily ported to run on the iAPX 86 or 88.
Supports Five Data Types

PL/M makes use of five data types for various applications. These data types range from one to four bytes, and facilitate various arithmetic, logic, and addressing functions:

- Byte: 8-bit unsigned number
- Word: 16-bit unsigned number
- Integer: 16-bit signed number
- Real: 32-bit floating point number
- Pointer: 16-bit or 32-bit memory address indicator

Another powerful facility allows the use of BASED variables that map more than one variable to the same memory location. This is especially useful for passing parameters, relative and absolute addressing, and memory allocation.

Two Data Structuring Facilities

In addition to the five data types and based variables, PL/M supports two data structuring facilities. These add flexibility to the referencing of data stored in large groups.

- Array: Indexed list of same type data elements
- Structure: Named collection of same or different type data elements
- Combinations of Each: Arrays of structures or structures of arrays

8087 Numerics Support

PL/M programs that use 32-bit REAL data may be executed using the Numeric Data Processor for improved performance. All floating-point operations supported by PL/M may be executed on the 8087 NDP, or the 8087 Emulator (a software module) provided with the package. Determination of use of the chip or emulator takes place at link-time, allowing compilations to be run-time independent.

Built-In String Handling Facilities

The PL/M 86/88 language contains built-in functions for string manipulation. These byte and word functions perform the following operations on character strings: MOVE, COMPARE, TRANSLATE, SEARCH, SKIP, and SET.

Interrupt Handling

PL/M has the facility for generating interrupts to the iAPX 86 or 88 via software. A procedure may be defined with the INTERRUPT attribute, and the compiler will automatically initialize an interrupt vector at the appropriate memory location. The compiler will also generate code to same and restore the processor status, for execution of the user-defined interrupt handler routine. The procedure SET$INTERRUPT, the function returning an INTERRUPT$PTR, and the PL/M statement CAUSE$INTERRUPT all add flexibility to user programs involving interrupt handling.

Segmentation Control

The PL/M 86/88 compiler takes full advantage of program addressing with the SMALL, COMPACT, MEDIUM, and LARGE segmentation controls. Programs with less than 64KB total code space can exploit the most efficient memory addressing schemes, which lowers total memory requirements. Larger programs can exploit the flexibility of extended one-megabyte addressing.

Code Optimization

The PL/M 86/88 compiler offers four levels of optimization for significantly reducing overall program size.

- Combination or "folding" of constant expressions; and short-circuit evaluation of Boolean expressions.
- "Strength reductions" (such as a shift left rather than multiply by 2); and elimination of common sub-expressions within the same block.
- Machine code optimizations; elimination of superfluous branches; re-use of duplicate code; removal of unreadable code.
- Byte comparisons (rather than 20-bit address calculations) for pointer variables; optimization of based-variable operations.

Compiler Controls

The PL/M 86/88 compiler offers more than 25 controls that facilitate such features as:

- Conditional compilation
- Intra- and Inter-module cross reference
- Corresponding assembly language code in the listing file
- Setting overflow conditions for run-time handling
BENEFITS

PL/M 86/88 is designed to be an efficient, cost-effective solution to the special requirements of iAPX 86 or 88 Microsystem Software Development, as illustrated by the following benefits of PL/M use:

Low Learning Effort

PL/M 86/88 is easy to learn and to use, even for the novice programmer.

Earlier Project Completion

Critical projects are completed much earlier than otherwise possible because PL/M 86/88, a structured high-level language, increases programmer productivity.

Lower Development Cost

Increases in programmer productivity translate immediately into lower software development costs because less programming resources are required for a given programmed function.

Increased Reliability

PL/M 86/88 is designed to aid in the development of reliable software (PL/M 86/88 programs are simple statements of the program algorithm). This substantially reduces the risk of costly correction of errors in systems that have already reached full production status, as the more simply stated the program is, the more likely it is to perform its intended function.

Easier Enhancements and Maintenance

Programs written in PL/M tend to be self-documenting, thus easier to read and understand. This means it is easier to enhance and maintain PL/M programs as the system capabilities expand and future products are developed.

iAPX 86,88 MACRO ASSEMBLER FOR SERIES II

- Powerful and Flexible Text Macro Facility with Three Macro Listing Options to Aid Debugging
- Highly Mnemonic and Compact Language, Most Mnemonics Represent Several Distinct Machine Instructions
- “Strongly Typed” Assembler Helps Detect Errors at Assembly Time
- High-Level Data Structuring Facilities Such as “STRUCTUREs” and “RECORDs”
- Over 120 Detailed and Fully Documented Error Messages
- Produces Relocatable and Linkable Object Code

ASM 86/88 is the "high-level" macro assembler for the iAPX 86,88 assembly language. ASM 86/88 translates symbolic 86/10, 88/10 assembly language mnemonics into 86/10, 88/10 relocatable object code.

ASM 86/88 should be used where maximum code efficiency and hardware control is needed. The iAPX 86,88 assembly language includes approximately 100 instruction mnemonics. From these few mnemonics the assembler can generate over 3,800 distinct machine instructions. Therefore, the software development task is simplified, as the programmer need know only 100 mnemonics to generate all possible 86/10, 88/10 machine instructions. ASM 86/88 will generate the shortest machine instruction possible given no forward referencing or given explicit information as to the characteristics of forward referenced symbols.

ASM 86/88 offers many features normally found only in high-level languages. The iAPX 86,88 assembly language is strongly typed. The assembler performs extensive checks on the usage of variables and labels. The assembler uses the attributes which are derived explicitly when a variable or label is first defined, then makes sure that each use of the symbol in later instructions conforms to the usage defined for that symbol. This means that many programming errors will be detected when the program is assembled, long before it is being debugged on hardware.
FEATURES

Major features of the Intel iAPX 86,88 assembler and assembly language include:

Powerful and Flexible Text Macro Facility

- Macro calls may appear anywhere
- Allows user to define the syntax of each macro
- Built-in functions
  conditional assembly (IF-THEN-ELSE, WHILE)
  repetition (REPEAT)
  string processing functions (MATCH)
  support of assembly time I/O to console (IN, OUT)
- Three Macro Listing Options include a GEN mode which provides a complete trace of all macro calls and expansions

High-Level Data Structuring Capability

- STRUCTURES: Defined to be a template and then used to allocate storage. The familiar dot notation may be used to form instruction addresses with structure fields.
- ARRAYS: Indexed list of same type data elements.
- RECORDS: Allows bit-templates to be defined and used as instruction operands and/or to allocate storage.

Fully Supports iAPX 86,88
Addressing Modes

- Provides for complex address expressions involving base and indexing registers and (structure) field offsets.
- Powerful EQU facility allows complicated expressions to be named and the name can be used as a synonym for the expression throughout the module.

Powerful STRING MANIPULATION
INSTRUCTIONS

- Permit direct transfers to or from memory or the accumulator.
- Can be prefixed with a repeat operator for repetitive execution with a count-down and a condition test.

Over 120 Detailed Error Messages

- Appear both in regular list file and error print file.
- User documentation fully explains the occurrence of each error and suggests a method to correct it.

Support for ICE-86™ Emulation and Symbolic Debugging

- Debug options for inclusion of symbol table in object modules for In-Circuit Emulation with symbolic debugging.

Generates Relocatable and Linkable Object Code—Fully Compatible with LINK 86/88, LOC 86/88 and LIB 86/88

- Permits ASM 86/88 programs to be developed and debugged in small modules. These modules can be easily linked with other ASM 86/88 or PL/M 86/88 object modules and/or library routines to form a complete application system.

BENEFITS

The iAPX 86,88 macro assembler allows the extensive capabilities of the 86/10 and 88/10 CPU's to be fully exploited. In any application, time and space critical routines can be effectively written in ASM 86/88. The 86,88 assembler outputs relocatable and linkable object modules. These object modules may be easily combined with object modules written in PL/M 86/88—Intel’s structured, high-level programming language. ASM 86/88 compliments PL/M 86/88 as the programmer may choose to write each module in the language most appropriate to the task and then combine the modules into the complete applications program using the iAPX 86,88 relocation and linkage utilities.
CONV 86/88
MCS-80/85™ to iAPX 86,88 ASSEMBLY LANGUAGE CONVERTER UTILITY PROGRAM

- Translates 8080/8085 Assembly Language Source Code to iAPX 86,88 Assembly Language Source Code
- Provides a Fast and Accurate Means to Convert 8080/8085 Programs to the iAPX 86/10 and the 88/10, Facilitating Program Portability
- Automatically Generates Proper ASM 86/88 Directives to Set Up a "Virtual 8080" Environment that is Compatible with PL/M 86/88

In support of Intel's commitment to software portability, CONV 86/88 is offered as a tool to move 8080/8085 programs to the iAPX 86/10 and the 88/10. A comprehensive manual, "MCS-86 Assembly Language Converter Operating Instructions for ISIS-II Users" (9800642), covers the entire conversion process. Detailed methodology of the conversion process is fully described therein.

- CONV 86/88 will accept as input an error-free 8080/8085 assembly-language source file and optional controls, and produce as output, optional PRINT and OUTPUT files.
- The PRINT file is a formatted copy of the 8080/8085 source and the 86/10 and 88/10 source file with embedded caution messages.
- The OUTPUT file is an 86/10 and 88/10 source file.
- CONV 86/88 issues a caution message when it detects a potential problem in the converted 86/10, 88/10 code.
- A transliteration of the 8080/8085 programs occurs, with each 8080/8085 construct mapped to its exact 86/10, 88/10 counterpart:
  - Registers
  - Condition flags
  - Instruction
  - Operands
  - Assembler directives
  - Assembler control lines
  - Macros

Because CONV 86/88 is a transliteration process, there is the possibility of as much as a 15%-20% code expansion over the 8080/8085 code. For compactness and efficiency it is recommended that critical portions of programs be re-coded in iAPX 86,88 assembly language.

Also, as a consequence of the transliteration, some manual editing may be required for converting instruction sequences dependent on:

- instruction length, timing, or encoding
- interrupt processing*
- PL/M parameter passing conventions*

*Mechanical editing procedures for these are suggested in the converter manual.

The accompanying figure illustrates the flow of the conversion process. Initially, the abstract program may be represented in 8080/8085 or iAPX 86,88 assembly language to execute on that respective target machine. The conversion process is porting a source destined for the 8080/8085 to the 86/10 or the 88/10 via CONV 86/88.
Figure 1. Porting 8080/8085 Source Code to the iAPX 86/10 and 88/10

LINK 86/88

- Automatic Combination of Separately Compiled or Assembled iAPX 86, 88 Programs Into a Relocatable Module
- Automatic Selection of Required Modules from Specified Libraries to Satisfy Symbolic References
- Extensive Debug Symbol Manipulation, Allowing Line Numbers, Local Symbols, and Public Symbols to be Purged and Listed Selectively
- Automatic Generation of a Summary Map Giving Results of the LINK 86/88 Process
- Abbreviated Control Syntax
- Relocatable Modules may be Merged into a Single Module Suitable for Inclusion in a Library
- Supports "Incremental" Linking
- Supports Type Checking of Public and External Symbols

LINK 86/88 combines object modules specified in the LINK 86/88 input list into a single output module. LINK 86/88 combines segments from the input modules according to the order in which the modules are listed.

LINK 86/88 will accept libraries and object modules built from PLM 86/88, ASM 86/88, or any other translator generating Intel's iAPX 86/10 Relocatable Object Modules.

Support for incremental linking is provided since an output module produced by LINK 86/88 can be an input to another link. At each stage in the incremental linking process, unneeded public symbols may be purged.

LINK 86/88 supports type checking of PUBLIC and EXTERNAL symbols reporting an error if their types are not consistent.

LINK 86/88 will link any valid set of input modules without any controls. However, controls are available to control the output of diagnostic information in the LINK 86/88 process and to control the content of the output module.

LINK 86/88 allows the user to create a large program as the combination of several smaller, separately compiled modules. After development and debugging of these component modules the user can link them together, locate them using LOC 86/88 and enter final testing with much of the work accomplished.
LIB 86/88

- LIB 86/88 is a Library Manager Program which Allows You to:
  - Create Specially Formatted Files to Contain Libraries of Object Modules
  - Maintain These Libraries by Adding or Deleting Modules
  - Print a Listing of the Modules and Public Symbols in a Library File

Libraries Can be Used as Input to LINK 86/88 Which Will Automatically Link Modules from the Library that Satisfy External References in the Modules Being Linked

Abbreviated Control Syntax

Libraries aid in the job of building programs. The library manager program LIB 86/88 creates and maintains files containing object modules. The operation of LIB 86/88 is controlled by commands to indicate which operation LIB 86/88 is to perform. The commands are:

CREATE: creates an empty library file
ADD: adds object modules to a library file
DELETE: deletes modules from a library file
LIST: lists the module directory of library files
EXIT: terminates the LIB 86 program and returns control to ISIS-II

When using object libraries, the linker will call only those object modules that are required to satisfy external references, thus saving memory space.

LOC 86/88

- Automatic Generation of a Summary Map Giving Starting Address, Segment Addresses and Lengths, and Debug Symbols and their Addresses
- Extensive Capability to Manipulate the Order and Placement of Segments in iAPX 86/10, 88/10 Memory
- Abbreviated Control Syntax

Automatic and Independent Relocation of Segments. Segments May Be Relocated to Best Match Users Memory Configuration

Extensive Debug Symbol Manipulation, Allowing Line Numbers, Local Symbols, and Public Symbols to be Purged and Listed Selectively

Abbreviated Control Syntax

Relocatability allows the programmer to code programs or sections of programs without having to know the final arrangement of the object code in memory.

LOC 86/88 converts relative addresses in an input module to absolute addresses. LOC 86/88 orders the segments in the input module and assigns absolute addresses to the segments. The sequence in which the segments in the input module are assigned absolute addresses is determined by their order in the input module and the controls supplied with the command.

LOC 86/88 will relocate any valid input module without any controls. However, controls are available to control the output of diagnostic information in the LOC 86/88 process, to control the content of the output module, or both.

The program you are developing will almost certainly use some mix of random access memory (RAM), read-only memory (ROM), and/or programmable read-only memory (PROM). Therefore, the location of your program affects both cost and performance in your application. The relocation feature allows you to develop your program on the Intellic development system and then simply relocate the object code to suit your application.
CONVERSIONS

- Converts an iAPX 86/10, 88/10 Absolute Object Module to Symbolic Hexadecimal Format
- Facilitates Preparing a File for Later Loading by a Symbolic Hexadecimal Loader, such as the iSBC™ Monitor SDK-86 Loader, or Universal PROM Mapper
- Converts an Absolute Module to a More Readable Format that can be Displayed on a CRT or Printed for Debugging

The OH 86/88 command converts an 86/10, 88/10 absolute object module to the hexadecimal format. This conversion may be necessary to format a module for later loading by a hexadecimal loader such as the iSBC 86/12 monitor or Universal Prom Mapper. The conversion may also be made to put the module in a more readable format that can be displayed or printed.

The module to be converted must be in absolute format; the output from LOC 86/88 is in absolute format.

Figure 2. iAPX 86,88 Software Development Cycle
SPECIFICATIONS

Operating Environment

REQUIRED HARDWARE
Intellec® Microcomputer Development System
  — Model 800
  — Series II
64K Bytes of RAM Memory
Dual Diskette Drives
  — Single or Double-Density
System Console
  — CRT or Hardcopy Interactive Device

OPTIONAL HARDWARE
Universal PROM Programmer
ICE-86™ Emulator

REQUIRED SOFTWARE
ISIS-II Diskette Operating System

Documentation
PL/M-86 Programming Manual (9800466)
ISIS-II PL/M-86 Compiler Operator's Manual (9800478)
MCS-86 User's Manual (9800722)
MCS-86 Software Development Utilities Operating Instructions for ISIS-II Users (9800639)
MCS-86 Macro Assembly Language Reference Manual (9800640)
MCS-86 Macro Assembler Operating Instructions for ISIS-II Users (9800641)
MCS-86 Assembly Language Converter Operating Instructions for ISIS-II Users (9800642)
Universal PROM Programmer User's Manual (9800819A)

Shipping Media
  — Single- and Double-Density Diskettes

ORDERING INFORMATION

iAPX 86,88 Software Development Packages for Series II:

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
<th>Shipping Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS-308*</td>
<td>Assembler and Utilities Package</td>
<td>Single- and Double-Density Diskettes</td>
</tr>
<tr>
<td>MDS-309*</td>
<td>PL/M compiler and Utilities Package</td>
<td>Single- and Double-Density Diskettes</td>
</tr>
<tr>
<td>MDS-311*</td>
<td>PL/M compiler, Assembler, and Utilities Package</td>
<td>Single- and Double-Density Diskettes</td>
</tr>
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</table>

The PL/M Compiler, Assembler, and Utilities Package is also available in the following development support packages:

<table>
<thead>
<tr>
<th>SP86A-KIT</th>
<th>SP86A Support Package (for Intellec® Model 800)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Includes ICE-86™ In-Circuit Emulator (MDS-86 ICE) and iAPX 86,88 Software Development Package (MDS-311)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SP86B-KIT</th>
<th>SP86B Support Package (for Series II)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Includes ICE-86™ In-Circuit Emulator (MDS-86 ICE), iAPX 86,88 Software Development Package (MDS/311), and Series II Expansion Chassis (MDS-201)</td>
</tr>
</tbody>
</table>

All Packages and Kits Require Software Licenses

*MDS is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corporation.
iAPX 286 EVALUATION PACKAGE

- Provides elementary program development and debug capability for the iAPX 286 microprocessor:
  - Assembly
  - System/task build
  - Symbolic debug

- Easy evaluation of all microprocessor dependencies: architecture, execution speed, program benchmarks

- Provides a programmatic understanding of the iAPX 286 architecture:
  - Instruction set
  - Memory protection
  - Segmentation
  - Program timing

- Includes an iAPX 286 demonstration program that exploits and illustrates architectural features of the 286

The Intel iAPX 286 Evaluation Package is an integrated set of software tools that aids the programmer in understanding how to use the iAPX 286 microprocessor. The package runs on a Series III Microcomputer Development System.

The Evaluation Package will allow a programmer to create, build, execute, and debug an assembly-level iAPX 286 task. It will also show how a programmer can take advantage of iAPX 286 architecture features.

The software tools contained in the package are a macro assembler, a task builder, run-time support procedures, an iAPX 286 simulator, and a demonstration program. The simulator has a built-in timer for benchmarking code sequences and programs. It also provides symbolic debugging capability, in addition to iAPX 286 program execution.

The benefits of using the iAPX 286 Evaluation Package are two-fold. System designers may now learn the iAPX 286 architecture (and determine its applicability) in the quickest manner possible. In addition, software may be developed now for a future 286 application, thereby getting a head start on a very time-consuming phase of design.

Sample Simulator Session

Segment Descriptor Table

The following are trademarks of Intel Corporation and may be used only to identify Intel products: BXp, CREDIT, i, ICE, iCS, Insite, Intel, int, Intelevisión, Inteltec, IRMX, ISBC, ISBX, Library Manager, MCS, Megachassis, Micromap, Multiibus, Multimodule, PROMPT, Promware, RMX/80, System 2000, UPI, mScope, and the combination of ICE, iCS, IRMX, ISBC, ISBX, MCS, or RMX and a numerical suffix.

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AFN-02052A

SEPTEMBER 1981

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FUNCTIONAL DESCRIPTION

iAPX 286 Evaluation Macro Assembler

The Evaluation Assembler (AS286E) accepts a source module written in the 286 Macro Assembly Language, and generates an object module and a listing file. The assembler is based upon ASM-86, and therefore performs type-checking on operands, supports complex data structures, and utilizes the same macro processor.

iAPX 286 Evaluation Builder

The Evaluation Builder (BD286E) accepts a single assembler object module, and generates a single-tasking executable load module. The Evaluation Builder performs the following functions:

- Assigns attributes to 286 segments: Privilege level, Access Rights, Base Address, Segment Length.
- Creates descriptor table entries (GDT & LDT) from segments.
- Initializes Segment Registers.
- Allows call gates, interrupt gates, and trap gates to be explicitly created, via the Interrupt Descriptor Table.
- Automatically creates call gates for X286E runtime procedures.
- Creates the Task State Segment for a one-task program.
- Produces a map showing all segments, gates, and public symbols.
- Binds segments to absolute addresses.

iAPX 286 Evaluation Simulator

The Evaluation Simulator (SM286E) loads and executes a 286 object module created by the Builder. Program execution functionally duplicates iAPX 286 processor operation; data protection, gates, processor traps and interrupts, and segmentation access are all supported in the same way as the iAPX 286. Compatibility mode and numerics are not included.

The symbolic debugger portion of the simulator supports two simultaneous code break-points and single-step execution, as well as modification of variables, registers, descriptor tables, and the task state segment. Code disassembly is also provided.

The Simulator has a built-in instruction timer to aid in benchmarking iAPX 286 programs. Another timer, which also counts clock cycles, can be used to generate interrupts at specific time intervals.

Run-Time Support Procedures

The Evaluation Package contains a set of run-time procedures (X286E) that may be "linked" to a user program at build-time to perform several software functions. These functions include creating and modifying segments, descriptors, and tables, creating new tasks, and dynamically allocating free memory for segments.

The Demonstration Program

The Demo Program (DM286E) is an application package that uses the Evaluation Tools (AS286E, BD286E, SM286E, X286E) to teach users how to program the iAPX 286.

It not only guides a programmer through the use of these tools, but the demo program itself illustrates how software can exploit the architecture of the 286. The following features are illustrated:

- Memory Protection using object descriptors.
- Gate creation and manipulation.
- Task switching, procedure entry and exit.
- Interrupt handling.
- Dynamic task creation.
- Inter-task communication.

The demonstration consists of a nucleus, a real-time clock interface, a time-of-day clock, a CPU-utilization spy, and a command interpreter. The user may execute these simultaneously on the simulator, and gain an understanding of how the 286 handles the functions listed above.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>MDS-322</td>
<td>iAPX 286 Evaluation Package</td>
</tr>
</tbody>
</table>

(Requires Software License)
PL/M 86/88 SOFTWARE PACKAGE

- Executes on Series III iAPX 86 Processor for Fastest Compilations
- Language Is Upward Compatible from PL/M 80, Assuring MCS-80/85 Design Portability
- Supports 16-Bit Signed Integer and 32-Bit Floating Point Arithmetic in Accordance with IEEE Proposed Standard
- Easy-To-Learn Block-Structured Language Encourages Program Modularity
- Improved Compiler Performance Now Supports More User Symbols and Faster Compilation Speeds
- Produces Relocatable Object Code Which Is Linkable to All Other 8086 Object Modules
- Code Optimization Assures Efficient Code Generation and Minimum Application Memory Utilization
- Built-In Syntax Checker Doubles Performance for Compiling Programs Containing Errors

Like its counterpart for MCS-80/85 program development, PL/M 86/88 is an advanced, structured high-level programming language. The PL/M 86/88 compiler was created specifically for performing software development for the Intel 8086 and 8088 Microprocessors.

PL/M is a powerful, structured, high-level system implementation language in which program statements can naturally express the program algorithm. This frees the programmer to concentrate on the logic of the program without concern for burdensome details of machine or assembly language programming (such as register allocation, meanings of assembler mnemonics, etc.).

The PL/M 86/88 compiler efficiently converts free-form PL/M language statements into equivalent 8088/8086 machine instructions. Substantially fewer PL/M statements are necessary for a given application than if it were programmed at the assembly language or machine code level.

The use of PL/M high-level language for system programming, instead of assembly language, results in a high degree of engineering productivity during project development. This translates into significant reductions in initial software development and follow-on maintenance costs for the user.
FEATURES

Major features of the Intel PL/M 86/88 compiler and programming language include:

Block Structure

PL/M source code is developed in a series of modules, procedures, and blocks. Encouraging program modularity in this manner makes programs more readable, and easier to maintain and debug. The language becomes more flexible, by clearly defining the scope of user variables (local to a private procedure, global to a public procedure, for example).

The use of procedures to break down a large problem is paramount to productive software development. The PL/M 86/88 implementation of a block structure allows the use of REENTRANT (recursive) procedures, which are especially useful in system design.

Language Compatibility

PL/M 86/88 object modules are compatible with object modules generated by all other 86/88 translators. This means that PL/M programs may be linked to programs written in any other 86/88 language.

Object modules are compatible with ICE-88 and ICE-86 units; DEBUG compiler control provides the In-Circuit Emulators with symbolic debugging capabilities.

PL/M 86/88 Language is upward-compatible with PL/M 80, so that application programs may be easily ported to run on the iAPX 86 or 88.

Supports Five Data Types

PL/M makes use of five data types for various applications. These data types range from one to four bytes, and facilitate various arithmetic, logic, and addressing functions:

- Byte: 8-bit unsigned number
- Word: 16-bit unsigned number
- Integer: 16-bit signed number
- Real: 32-bit floating point number
- Pointer: 16-bit or 32-bit memory address indicator

Another powerful facility allows the use of BASED variables that map more than one variable to the same memory location. This is especially useful for passing parameters, relative and absolute addressing, and memory allocation.

Two Data Structuring Facilities

In addition to the five data types and based variables, PL/M supports two data structuring facilities. These add flexibility to the referencing of data stored in large groups.

- Array: Indexed list of same type data elements
- Structure: Named collection of same or different type data elements
- Combinations of Each: Arrays of structures or structures of arrays

8087 Numerics Support

PL/M programs that use 32-bit REAL data may be executed using the Numeric Data Processor for improved performance. All floating-point operations supported by PL/M may be executed on the iAPX 86/20 or 88/20 NDP, or the 8087 Emulator (a software module) provided with the package. Determination of use of the chip or Emulator takes place at link-time, allowing compilations to be run-time independent.

Built-In String Handling Facilities

The PL/M 86/88 language contains built-in functions for string manipulation. These byte and word functions perform the following operations on character strings: MOVE, COMPARE, TRANSLATE, SEARCH, SKIP, and SET.

Interrupt Handling

PL/M has the facility for generating interrupts to the iAPX 86 or 88 via software. A procedure may be defined with the INTERRUPT attribute, and the compiler will automatically initialize an interrupt vector at the appropriate memory location. The compiler will also generate code to save and restore the processor status, for execution of the user-defined interrupt handler routine. The procedure SET$INTERRUPT, the function returning an INTERRUPT$PTR, and the PL/M statement CAUSES$INTERRUPT all add flexibility to user programs involving interrupt and handling.
Compiler Controls

Including several that have been mentioned, the PL/M 86/88 compiler offers more than 25 controls that facilitate such features as:
- Conditional compilation
- Including additional PL/M source files from disk
- Intra- and inter-module cross reference
- Corresponding assembly language code in the listing file
- Setting overflow conditions for run-time handling

Segmentation Control

The PL/M 86/88 compiler takes full advantage of program addressing with the SMALL, COMPACT, MEDIUM, and LARGE segmentation controls. Programs with less than 64KB total code space can exploit the most efficient memory addressing schemes, which lowers total memory requirements. Larger programs can exploit the flexibility of extended one-megabyte addressing.

Code Optimization

The PL/M 86/88 compiler offers four levels of optimization for significantly reducing overall program size.
- Combination or “folding” of constant expressions; and short-circuit evaluation of Boolean expressions.
- “Strength reductions” (such as a shift left rather than multiply by 2); and elimination of common sub-expressions within the same block.
- Machine code optimizations; elimination of superfluous branches; re-use of duplicate code; removal of unreadable code.
- Byte comparisons (rather than 20-bit address calculations) for pointer variables; optimization of based-variable operations.

Error Checking

The PL/M 86/88 compiler has a very powerful feature to speed up compilations. If a syntax or program error is detected, the compiler will skip the code generation and optimization passes. This usually yields a 2X performance increase for compilation of programs with errors.

A fully detailed set of programming and compilation errors is provided by the compiler.

Compiler Performance

Performance benchmarks may provide valuable information in estimating compile times for various programs. It is extremely important to understand, however, the effect of varying conditions on compiler performance. Storage media, coding style, program length, and the use of INCLUDE files significantly change the compiler’s overall performance. We tested typical PL/M programs of varying lengths. The results are listed in Table 1.

<table>
<thead>
<tr>
<th>Program Size</th>
<th>Compile Time(Sec)</th>
<th>Lines/Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMALL (71)</td>
<td>20</td>
<td>213</td>
</tr>
<tr>
<td>MEDIUM (610)</td>
<td>54</td>
<td>678</td>
</tr>
<tr>
<td>LARGE (1710)</td>
<td>128</td>
<td>802</td>
</tr>
<tr>
<td>LARGE (1403)</td>
<td>129</td>
<td>653</td>
</tr>
<tr>
<td>(with very dense code, plus include file)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: These programs were run on a Series III with ISIS 4.1 and a hard disk. The lines per minute figures reflect fifteen percent blank lines and comments.

The compiler allows approximately 1000 ten-character user symbols.
PL/M 86/88 SOFTWARE PACKAGE

BEGINNING OF MODULE

SORTPROC: PROCEDURE (PTR, COUNT, RECSIZE, KEYINDEX) PUBLIC;
   DECLARE PTR POINTER, (COUNT, RECSIZE, KEYINDEX) INTEGER.

"Parameters:
   PTR is pointer to first record.
   COUNT is number of records to be sorted.
   RECSIZE is number of bytes in each record—max is 128.
   KEYINDEX is byte position within each record of a BYTE scalar
   to be used as sort key.

DECLARE (RECORD BASED PTR) (1) BYTE.
   CURRENT (128) BYTE.
   (I, J) INTEGER.

SORT:   DO J = 1 TO COUNT-1:
   CALL MOVBI @RECORD(J) (RECSIZE), @CURRENT (RECSIZE):
   END DO;

FIND:   DO WHILE (J < COUNT) AND RECORD(J) (RECSIZE) - KEYINDEX
   CALL MOVBI @RECORD(J) (RECSIZE), @RECORD(J) (RECSIZE),
   (I, J) INTEGER:
   END DO:

   CALL MOVBI (@CURRENT) (RECSIZE), @RECORD(J) (RECSIZE):

END SORT;

END SORTPROC;

END M;

("End of module")

PUBLIC and EXTERNAL attributes promote program modularity.

Based" Variables allow manipulation of external data by passing the base of the data structure (a pointer). This minimizes the STACK space used for parameter passing, and the execution time to perform many STACK operations.

Variables allow manipulation of external data by passing the base of the data structure (a pointer). This minimizes the STACK space used for parameter passing, and the execution time to perform many STACK operations.

One of several PL/M built-in procedures for string manipulation.

Figure 1. Sample PL/M 86/88 Program

BENEFITS

PL/M 86/88 is designed to be an efficient, cost-effective solution to the special requirements of iAPX 86 or 88 Microsystem Software Development, as illustrated by the following benefits of PL/M use:

Low Learning Effort

PL/M 86/88 is easy to learn and to use, even for the novice programmer.

Earlier Project Completion

Critical projects are completed much earlier than otherwise possible because PL/M 86/88, a structured high-level language, increases programmer productivity.

Lower Development Cost

Increases in programmer productivity translate immediately into lower software development costs because less programming resources are required for a given programmed function.

Increased Reliability

PL/M 86/88 is designed to aid in the development of reliable software (PL/M 86/88 programs are simple statements of the program algorithm). This substantially reduces the risk of costly correction of errors in systems that have already reached full production status, as the more simply stated the program is, the more likely it is to perform its intended function.

Easier Enhancements and Maintenance

Programs written in PL/M tend to be self-documenting, thus easier to read and understand. This means it is easier to enhance and maintain PL/M programs as the system capabilities expand and future products are developed.
PL/M 86/88 SOFTWARE PACKAGE

SPECIFICATIONS

Operating Environment

REQUIRED HARDWARE:
Intelllec® Microcomputer Development System
— Series III or equivalent
Dual Diskette Drives
— Single- or Double-Density
System Console
— CRT or Hardcopy Interactive Device

OPTIONAL HARDWARE:
Universal PROM Programmer
Line Printer
ICE-86™

REQUIRED SOFTWARE:
ISIS-II Diskette Operating System, V4.1 or later
Series III Operating System

Documentation Package


ORDERING INFORMATION

Part Number Description
MDS-313* PL/M 86/88 Software Package

Requires Software License

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PASCAL 86/88
SOFTWARE PACKAGE

- Resident on iAPX 86 Based Intellec® Series III Microcomputer Development System for Optimal Performance
- Object Compatible and Linkable with PL/M 86/88, ASM 86/88 and FORTRAN 86/88
- ICE™ Symbolic Debugging Fully Supported
- Implements REALMATH for Consistent and Reliable Results
- Supports iAPX86/20, 88/20 Numeric Data Processors
- Strict Implementation of ISO Standard Pascal
- Useful Extensions Essential for Microcomputer Applications
- Separate Compilation with Type-Checking Enforced Between Pascal Modules
- Compiler Option to Support Full Run-Time Range-Checking

PASCAL 86/88 conforms to and implements the ISO Draft Proposed Pascal standard. The language is enhanced to support microcomputer applications with special features, such as separate compilation, interrupt handling and direct port I/O. To assist the development of portable software, the compiler can be directed to flag all non-standard features.

The PASCAL 86/88 compiler runs on the iAPX 86 Resident Intellec® Series III Microcomputer Development System. A well-defined I/O interface is provided for run-time support. This allows a user-written operating system to support application programs as an alternate to the development system environment. Program modules compiled under PASCAL 86/88 are compatible and linkable with modules written in PL/M 86/88, ASM 86/88 or FORTRAN 86/88. With a complete family of compatible programming languages for the iAPX 86, 88 one can implement each module in the language most appropriate to the task at hand.

PASCAL 86/88 object modules contain symbol and type information for program debugging using ICE-86™ emulator. For final production version, the compiler can remove this extra information and code.
FEATURES

Includes all the language features of Jensen & Wirth Pascal as defined in the ISO Draft Proposed Pascal Standard.

Supports required extensions for microcomputer applications.
- Interrupt handling
- Direct port I/O

Separate compilation extensions allow:
- Modular decomposition of large programs
- Linkage with other Pascal modules as well as PL/M 86/88, ASM 86/88 and FORTRAN 86/88.
- Enforcement of type-checking at LINK-time

Supports numerous compiler options to control the compilation process, to INCLUDE files, flag non-standard Pascal statements and others to control program listings and object modules.

Utilizes the IEEE standard for Floating-Point Arithmetic (the Intel REALMATH standard) for arithmetic operations.

Well-defined and documented run-time operating system interfaces allow the user to execute the applications under user-designed operating systems.

BENEFITS

Provides a standard Pascal for iAPX 86, 88 based applications.
- Pascal has gained wide acceptance as the portable application language for microcomputer applications
- It is being taught in many colleges and universities around the world
- It is easy to learn, originally intended as a vehicle for teaching computer programming
- Improves maintainability: Type mechanism is both strictly enforced and user extendable
- Few machine specific language constructs

Provides run-time support for co-processors. All real-type arithmetic is performed on the 86/20 numeric data processor unit or software emulator. Run-time library routines, common between Pascal and other Intel languages (such as FORTRAN), permit efficient and consistently accurate results.

Extended relocation and linkage support allows the user to link Pascal program modules with routines written in other languages for certain parts of the program. For example, real-time or hardware dependent routines written in ASM 86/88 or PL/M 86/88 can be linked to Pascal routines, further extending the user’s ability to write structured and modular programs.

PASCAL 86/88 programs "talk" to the resident operating system using Intel’s standard interface for translated programs. This allows users to replace the development operating system by their own operating systems in the final application.

PASCAL 86/88 takes full advantage of iAPX 86, 88 high level language architecture to generate efficient machine code without using time-consuming optimization algorithms.

Compiler options can be used to control the program listings and object modules. While debugging, the user may generate additional information such as the symbol record information required and useful for debugging using ICE emulation. After debugging, the production version may be streamlined by removing this additional information.

Standard Intel REALMATH is easy to use and provides reliable results, consistent with other Intel languages and other implementations of the IEEE proposed Floating-Point standard.
SPECIFICATIONS

Operating Environment

REQUIRED HARDWARE
Intellec® Series III Microcomputer Development System
—System Console
—Double Density Dual Diskette Drive OR Hard Disk

REQUIRED SOFTWARE
ISIS-II Diskette Operating System V4.1 or later

Documentation Package
PASCAL 86 User’s Guide (121539-001)

Shipping Media
Flexible Diskettes
—Single and Double Density

ORDERING INFORMATION

Part Number   Description
MDS*-314   PASCAL 86/88 Software Package

Requires software license.

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FORTRAN 86/88
SOFTWARE PACKAGE

- Features high-level language support for floating-point calculations, transcendents, interrupt procedures, and run-time exception handling
- Meets ANS FORTRAN 77 Subset Language Specifications
- Supports iAPX 86/20, 88/20 Numeric Data Processor for fast and efficient execution of numeric instructions
- Uses REALMATH Floating-Point Standard for consistent and reliable results
- Offers powerful extensions tailored to microprocessor applications
- Offers upward compatibility with FORTRAN 80
- Provides FORTRAN run-time support for iAPX 86,88-based design
- Provides users ability to do formatted and unformatted I/O with sequential or direct access methods

FORTRAN 86/88 meets the ANS FORTRAN 77 Language Subset Specification and includes many features of the full standard. Therefore, the user is assured of portability of most existing ANS FORTRAN programs and of full portability from other computer systems with an ANS FORTRAN 77 Compiler.

FORTRAN 86/88 programs developed and debugged on the iAPX 86 Resident Intellec Series III Microcomputer Development System may be: tested with the prototype using ICE symbolic debugging, and executed on an RMX-86 operating system, or on a user’s iAPX 86,88-based operating system.

FORTRAN 86/88 is one of a complete family of compatible programming languages for iAPX 86,88 development: PL/M, Pascal, FORTRAN, and Assembler. Therefore, users may choose the language best suited for a specific problem solution.
FEATURES

Extensive High-Level Language Numeric Processing Support

Single (32-bit), double (64-bit), and double extended precision (80-bit) floating-point data types

REALMATH Proposed IEEE Floating-Point Standard for consistent and reliable results

Full support for all other data types: integer, logical, character

Ability to use hardware (iAPX 86/20, 88/20 Numeric Data Processor) or software (simulator) floating-point support chosen at link time

ANS FORTRAN 77 Standard

Intel® Microprocessor Support

FORTRAN 86/88 language features support of iAPX 86/20, 88/20 Numeric Data Processor

Compiler generates in-line iAPX 86/20, 88/20 Numeric Data Processor object code for floating-point arithmetic (See Figure 1)

Intrinsics allow user to control iAPX 86/20, 88/20 Numeric Data Processor

iAPX 86,88 architectural advantages used for indexing and character-string handling

Symbolic debugging of application using ICE-86 and ICE-88 emulators

---

Figure 1. Object Code Generated by FORTRAN 86/88 for a Floating-Point Calculation Using iAPX 86/20, 88/20 Numeric Processor

```plaintext
FLOATING-POINT-STMTMENT

TEMPER = (PRESS - VOLUM / QUEK) - 3.45 / (PRESS - VOLUM / QUEK) & - (PRESS - VOLUM / QUEK) * (PRESS - VOLUM / QUEK)

OBJECT CODE GENERATED

Intel FORTRAN-86 Compiler

<table>
<thead>
<tr>
<th>IAPX 86/20, 88/20 MACHINE CODE</th>
<th>ASSEMBLER MNEMONICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0013 9BD9060C00</td>
<td>FLD VOLUM</td>
</tr>
<tr>
<td>0018 9BD8360000</td>
<td>FDIV QUEK</td>
</tr>
<tr>
<td>0010 9BD82E0800</td>
<td>FSUBR PRESS</td>
</tr>
<tr>
<td>0022 9BD0D1</td>
<td>FST TOS+1H</td>
</tr>
<tr>
<td>0025 9B2E083E0000</td>
<td>FDIVR CS:0CONST</td>
</tr>
<tr>
<td>0028 9BD9C9</td>
<td>FXCHG TOS+1H</td>
</tr>
<tr>
<td>002E 9BD0D2</td>
<td>FST TOS+2H</td>
</tr>
<tr>
<td>0031 9BDE9E</td>
<td>FSUBRP</td>
</tr>
<tr>
<td>0034 9BD9C1</td>
<td>FLD TOS+1H</td>
</tr>
<tr>
<td>0037 9BD8C8</td>
<td>FMUL TOS</td>
</tr>
<tr>
<td>003A 9BDDC2</td>
<td>FFREE TOS+2H</td>
</tr>
<tr>
<td>003D 9BDEE1</td>
<td>FSUBP</td>
</tr>
<tr>
<td>0040 9BD91E0400</td>
<td>FSTP TEMPER</td>
</tr>
<tr>
<td>0045 9B</td>
<td>WAIT</td>
</tr>
</tbody>
</table>

Figure 1. Object Code Generated by FORTRAN 86/88 for a Floating-Point Calculation Using iAPX 86/20, 88/20 Numeric Processor

16-22
FORTRAN 86/88 SOFTWARE PACKAGE

Microprocessor Application Support
— Direct byte- or word-oriented port I/O
— Reentrant procedures
— Interrupt procedures

Flexible Run-Time Support
Application object code may be executed in iAPX 86, 88-based environment of user’s choice:
— a Series III Intellect Development System with Series III Operating System
— an iAPX 86,88-based system with iRMX-86 Operating System
— an iAPX 86,88-based system with user-designed Operating System

Run-time exception handling for fixed-point numerics, floating-point numerics, and I/O errors
Relocatable object libraries for complete run-time support of I/O and arithmetic functions. In-line code execution is generated for iAPX 86/20, 88/20 Numeric Data Processor

BENEFITS
FORTRAN 86/88 provides a means of developing application software for the Intel iAPX 86,88 products lines in a familiar, widely accepted, and industry-standard programming language. FORTRAN 86/88 will greatly enhance the user’s ability to provide cost-effective software development for Intel microprocessors as illustrated by the following:

Early Project Completion
FORTRAN is an industry-standard, high-level numerics processing language. FORTRAN programmers can use FORTRAN 86/88 on microprocessor projects with little retraining. Existing FORTRAN software can be compiled with FORTRAN 86/88 and programs developed in FORTRAN 86/88 can run on other computers with ANSI FORTRAN 77 with little or no change. Libraries of mathematical programs using ANSI 77 standards may be compiled with FORTRAN 86/88.

Application Object Code Portability for a Processor Family
FORTRAN 86/88 modules “talk” to the resident Intellect development operating system using Intel’s standard interface for all development-system software. This allows an application developed on the Series III operating system to execute on iRMX/86, or a user-supplied operating system by linking in the iRMX/86 or other appropriate interface library. A standard logical-record interface enables communication with non-standard I/O devices.

Comprehensive, Reliable and Efficient Numeric Processing
The unique combination of FORTRAN 86/88, iAPX 86/20, 88/20 Numeric Data Processor, and REALMATH (Proposed IEEE Floating-Point Standard) provide universal consistency in results of numeric computations and efficient object code generation.

SPECIFICATIONS
Operating Environment
REQUIRED HARDWARE
Intellect® Series III Microcomputer Development System
— System Console
— Double-Density Dual-Diskette Drive. A Hard Disk is recommended
— Hard Disk

*Recommended.

REQUIRED SOFTWARE
ISIS-II Diskette Operating System V4.1 or later

Documentation Package
FORTRAN 86/88 User’s Guide (121539-001)

Shipping Media
Flexible Diskettes
— Single- and Double-Density
<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS**-315</td>
<td>FORTRAN 86/88 Software Package</td>
</tr>
</tbody>
</table>

Requires Software License

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SOFTWARE SUPPORT PACKAGE

- Program Generation for the 8087 Numeric Data Processor on the Intellec® Microcomputer Development System
- Consists of: 8086/8087/8088 Macro Assembler, 8087 Software Emulator
- Macro Assembler Generates Code for 8087 Processor or Emulator, While Also Supporting the 8086/8088 Instruction Set
- 8087 Emulator Duplicates Each 8087 Floating-Point Instruction in Software, for Evaluation of Prototyping, or for Use in an End Product
- Macro Assembler and 8087 Emulator are Fully Compatible with Other 8086/8088 Development Software
- Implementation of the IEEE Proposed Floating-Point Standard (the Intel® Realmath Standard)

The 8087 Software Support Package is an optional extension of Intel’s 8086/8088 Software Development Package that runs under ISIS-II on an Intellec or Series II Microcomputer Development System.

The 8087 Software Support Package consists of the 8086/8087/8088 Macro Assembler, and the Full 8087 Emulator. The assembler is a functional superset of the 8086/8088 Macro Assembler, and includes instructions for over sixty new floating-point operations, plus new data types supported by the 8087.

The 8087 Emulator is an 8086/8088 object module that simulates the environment of the 8087, and executes each floating-point operation using software algorithms. This emulator functionally duplicates the operation of the 8087 Numeric Data Processor.

Also included in this package are interface libraries to link with 8086/8087/8088 object modules, which are used for specifying whether the 8087 Processor or the 8087 Emulator is to be used. This enables the run-time environment to be invisible to the programmer at assembly time.
FUNCTIONAL DESCRIPTION

8086/8087/8088 Macro Assembler

The 8086/8087/8088 Macro Assembler translates symbolic macro assembly language instructions into appropriate machine instructions. It is an extended version of the 8086/8088 Macro Assembler, and therefore supports all of the same features and functions, such as limited type checking, conditional assembly, data structures, macros, etc. The extensions are the new instructions and data types to support floating-point operations. Realmath floating-point instructions (see Table 1) generate code capable of being converted to either 8087 instructions or interrupts for the 8087 Emulator. The Processor/Emulator selection is made via interface libraries at LINK-time. In addition to the new floating-point instructions, the macro assembler also introduces two new 8087 data types: QWORD (8 bytes) and TBYTE (ten bytes). These support the highest precision of data processed by the 8087.

Full 8087 Emulator

The Full 8087 Emulator is a 16-kilobyte object module that is linked to the application program for floating-point operations. Its functionality is identical to the 8087 chip, and is ideal for prototyping and debugging floating-point applications. The Emulator is an alternative to the use of the 8087 chip, although the latter executes floating-point applications up to 100 times faster than an 8086 with the 8087 Emulator. Furthermore, since the 8087 is a "co-processor," use of the chip will allow many operations to be performed in parallel with the 8086.

Table 1. 8087 Instructions

<table>
<thead>
<tr>
<th>Arithmetic Instructions</th>
<th>Processor Control Instructions</th>
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<tbody>
<tr>
<td><strong>Addition</strong></td>
<td></td>
</tr>
<tr>
<td>FADD</td>
<td>FINIT/FNINIT</td>
</tr>
<tr>
<td>FADDP</td>
<td>FDISI/FNDISI</td>
</tr>
<tr>
<td>FIADD</td>
<td>FENI/FNENI</td>
</tr>
<tr>
<td></td>
<td>FLDCW</td>
</tr>
<tr>
<td></td>
<td>FSTCW/FNSTCW</td>
</tr>
<tr>
<td></td>
<td>FSTSW/FNSTSW</td>
</tr>
<tr>
<td></td>
<td>FCLEX/FNCLEX</td>
</tr>
<tr>
<td></td>
<td>FSTENV/FNSTENV</td>
</tr>
<tr>
<td></td>
<td>FLDENV</td>
</tr>
<tr>
<td></td>
<td>FSAVE/FNSAVE</td>
</tr>
<tr>
<td></td>
<td>FRSTOR</td>
</tr>
<tr>
<td></td>
<td>FINCSTP</td>
</tr>
<tr>
<td></td>
<td>FDECSTP</td>
</tr>
<tr>
<td></td>
<td>FFREE</td>
</tr>
<tr>
<td></td>
<td>FNOP</td>
</tr>
<tr>
<td></td>
<td>FWAIT</td>
</tr>
<tr>
<td><strong>Subtraction</strong></td>
<td></td>
</tr>
<tr>
<td>FSUB</td>
<td>Initialize processor</td>
</tr>
<tr>
<td>FSUBP</td>
<td>Disable interrupts</td>
</tr>
<tr>
<td>FISUBP</td>
<td>Enable interrupts</td>
</tr>
<tr>
<td>FSUBR</td>
<td>Load control word</td>
</tr>
<tr>
<td>FSUBRP</td>
<td>Store control word</td>
</tr>
<tr>
<td>FISUBR</td>
<td>Store status word</td>
</tr>
<tr>
<td></td>
<td>Clear exceptions</td>
</tr>
<tr>
<td></td>
<td>Store environment</td>
</tr>
<tr>
<td></td>
<td>Load environment</td>
</tr>
<tr>
<td></td>
<td>Save state</td>
</tr>
<tr>
<td></td>
<td>Restore state</td>
</tr>
<tr>
<td></td>
<td>Increment stack pointer</td>
</tr>
<tr>
<td></td>
<td>Decrement stack pointer</td>
</tr>
<tr>
<td></td>
<td>Free register</td>
</tr>
<tr>
<td></td>
<td>No operation</td>
</tr>
<tr>
<td></td>
<td>CPU wait</td>
</tr>
<tr>
<td><strong>Multiplication</strong></td>
<td></td>
</tr>
<tr>
<td>FMUL</td>
<td></td>
</tr>
<tr>
<td>FMULP</td>
<td></td>
</tr>
<tr>
<td>FIMUL</td>
<td></td>
</tr>
<tr>
<td><strong>Division</strong></td>
<td></td>
</tr>
<tr>
<td>FDIV</td>
<td></td>
</tr>
<tr>
<td>FDIVP</td>
<td></td>
</tr>
<tr>
<td>FIDIV</td>
<td></td>
</tr>
<tr>
<td>FDIVR</td>
<td></td>
</tr>
<tr>
<td>FIDIVP</td>
<td></td>
</tr>
<tr>
<td>FIDIVR</td>
<td></td>
</tr>
<tr>
<td><strong>Other Operations</strong></td>
<td></td>
</tr>
<tr>
<td>FSQRT</td>
<td></td>
</tr>
<tr>
<td>FSCLAPE</td>
<td></td>
</tr>
<tr>
<td>FPREM</td>
<td></td>
</tr>
<tr>
<td>FRNINT</td>
<td></td>
</tr>
<tr>
<td>FXTRACT</td>
<td></td>
</tr>
<tr>
<td>FABS</td>
<td></td>
</tr>
<tr>
<td>FCHS</td>
<td></td>
</tr>
</tbody>
</table>

| Comparison Instructions    |                                |
| FCOM                        | Compare real                   |
| FCOMP                       | Compare real and pop           |
| FCOMPP                      | Compare real and pop twice     |
| FICOM                       | Integer compare                |
| FICOMP                      | Integer compare and pop        |
| FTST                        | Test                            |
| FXAM                        | Examine                        |
8087 SOFTWARE SUPPORT PACKAGE

Table 1. 8087 Instructions (cont’d)

<table>
<thead>
<tr>
<th>Transcendental Instructions</th>
<th>Data Transfer Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FPTAN</strong></td>
<td><strong>Real Transfers</strong></td>
</tr>
<tr>
<td><strong>Partial tangent</strong></td>
<td><strong>FLD</strong> Load real</td>
</tr>
<tr>
<td><strong>FPATAN</strong></td>
<td><strong>FST</strong> Store real</td>
</tr>
<tr>
<td><strong>Partial arctangent</strong></td>
<td><strong>FSTP</strong> Store real and pop</td>
</tr>
<tr>
<td><strong>F2XM1</strong></td>
<td><strong>FXCH</strong> Exchange registers</td>
</tr>
<tr>
<td><strong>2^-1</strong></td>
<td></td>
</tr>
<tr>
<td><strong>FYL2X</strong></td>
<td><strong>Integer Transfers</strong></td>
</tr>
<tr>
<td><strong>Y \cdot \log_X(X))</strong></td>
<td><strong>FILD</strong> Integer load</td>
</tr>
<tr>
<td><strong>FYL2XP1</strong></td>
<td><strong>FIST</strong> Integer store</td>
</tr>
<tr>
<td><strong>Y \cdot \log_{(X+1)})</strong></td>
<td><strong>FISTP</strong> Integer store and pop</td>
</tr>
<tr>
<td>Constant Instructions</td>
<td><strong>Packed Deciml Transfers</strong></td>
</tr>
<tr>
<td><strong>FLDZ</strong></td>
<td><strong>FBLD</strong> Packed decimal (BCD) load</td>
</tr>
<tr>
<td><strong>FLD1</strong></td>
<td><strong>FBSTP</strong> Packed decimal (BCD) store and pop</td>
</tr>
<tr>
<td><strong>Load +0.0</strong></td>
<td></td>
</tr>
<tr>
<td><strong>FLDPI</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Load \pi</strong></td>
<td></td>
</tr>
<tr>
<td><strong>FLDL2T</strong></td>
<td><strong>8086/8088 Software Development Package</strong></td>
</tr>
<tr>
<td><strong>Load log_{10}</strong></td>
<td><strong>ISIS-II Diskette Operating System</strong></td>
</tr>
<tr>
<td><strong>FLDL2E</strong></td>
<td>—Single or Double Density</td>
</tr>
<tr>
<td><strong>Load log_e</strong></td>
<td>**8086/8087/8088 Macro Assembly Language Re-</td>
</tr>
<tr>
<td><strong>FLDLG2</strong></td>
<td>ference Manual for 8080/8085-Based Develop-</td>
</tr>
<tr>
<td><strong>Load log_{10}2</strong></td>
<td>ments (121623-001)</td>
</tr>
<tr>
<td><strong>FLDLN2</strong></td>
<td>**8086/8087/8088 Macro Assembler Operating</td>
</tr>
<tr>
<td><strong>Load log_2*</strong></td>
<td>Instructions for 8080/8085-Based Develop-</td>
</tr>
<tr>
<td><strong>Packed Decimal (BCD) load</strong></td>
<td>ments (121624-001)</td>
</tr>
<tr>
<td><strong>Packed decimal (BCD) store and pop</strong></td>
<td></td>
</tr>
</tbody>
</table>

SPECIFICATIONS

Operating Environment

**REQUIRED HARDWARE**
Intellec® Microcomputer Development System
—Model 800
—Series II (Models 220, 225 or equivalent)

64K Bytes of RAM Memory
Minimum One Diskette Drive
—Single or Double* Density
System Console
—CRT or Hardcopy Interactive Device

**OPTIONAL HARDWARE**
Universal PROM Programmer*
Line Printer*

*Recommended

ORDERING INFORMATION

Part Number Description
MDS*-387 8087 Software Support Package
Requires Software License

*MDS® is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corporation.
The 8087 Support Library provides PL/M-86 and ASM-86 users with the equivalent numeric data processing capability of Fortran-86. With the Library, it is easy for PL/M-86 and ASM-86 programs to do floating point arithmetic. Programs can link in modules to do trigonometric, logarithmic and other numeric functions, and the user is guaranteed accurate, reliable results for all appropriate inputs. The 8087 Support Library implements Intel's REALMATH standard and also supports the proposed IEEE Floating Point Standard. Consequently, by using this Library, the PLM-86 user not only saves software development time, but is guaranteed that the numeric software meets industry standards and is portable—his software investment is maintained.

The 8087 Support Library consists of the common elementary function library, the decimal conversion module, the error handler module, the full 8087 Software emulator and interface libraries to the 8087 and to the 8087 emulator.
CEL87.LIB
THE COMMON ELEMENTARY FUNCTION LIBRARY

CEL87.LIB contains commonly used floating point functions. It is used along with the 8087 numeric coprocessor or the 8087 emulator and it provides a complete package of elementary functions, giving valid results for all appropriate inputs. This library provides PL/M-86 and ASM-86 users all the math functions supported intrinsically by the Fortran-86. Following is a summary of CEL87 functions, grouped by functionality.

Rounding and Truncation Functions:
mqerIX, mqerIE2, and mqerIE4 round a real number to the nearest integer; to the even integer if there is a tie. The answer returned is real, a 16-bit integer or a 32-bit integer respectively.
mqerIA, mqerIA2, mqerIA4 round a real number to the nearest integer, to the integer away from zero if there is a tie; the answer returned is real, a 16-bit integer or a 32-bit integer, respectively.
mqerICX, mqerIC2, mqerIC4 truncate the fractional part of a real input; the answer is real, a 16-bit integer or a 32-bit integer, respectively.

Logarithmic and Exponential Functions:
mqerLGD computes decimal (base 10) logarithms.
mqerLGE computes natural (base e) logarithms.
mqerEXP computes exponentials to the base e.
mqerY2X computes exponentials to any base.
mqerY12 raises an input real to a 16-bit integer power.
mqerY14 is as mqerY12, except to a 32-bit integer power.
mqerYIS is as mqerY12, but it accommodates PL/M-86 users.

Trigonometric and Hyperbolic Functions:
mqerSIN, mqerCOS, mqerTAN compute sine, cosine, and tangent.
mqerASN, mqerACS, mqerATN compute the corresponding inverse functions.
mqerSNH, mqerCSH, mqerTNH compute the corresponding hyperbolic functions.
mqerAT2 is a special version of the arc tangent function that accepts rectangular coordinate inputs.

Other Functions:
mqerDIM is FORTRAN's positive difference function.
mqerMAX returns the maximum of two real inputs.
mqerMIN returns the minimum of two real inputs.
mqerSGH combines the sign of one input with the magnitude of the other input.
mqerMOD computes a modulus, retaining the sign of the dividend.
mqerRMD computes a modulus, giving the value closest to zero.

DCON87.LIB
THE DECIMAL CONVERSION LIBRARY

DCON87.LIB is a library of procedures which convert binary representations of floating point numbers and ASCII-encoded string of digits.

The binary-to-decimal procedure mqcBIN DECLOW accepts a binary number in any of the formats used for the representation of floating point numbers in the 8087. Because there are so many output formats for floating point numbers, mqcBIN__DECLOW does not attempt to provide a finished, formatted text string. Instead, it provides the "building blocks" for you to use to construct the output string which meets your exact format specification.
The decimal-to-binary procedure mqcDEC_BIN accepts a text string which consists of a decimal number with optional sign, decimal point, and/or power-of-ten exponent. It translates the string into the caller's choice of binary formats.

Decimal-to-binary procedure mqcDECLOW_BIN is provided for callers who have already broken the decimal number into its constituent parts.

The procedures mqcLONG_TEMP, mqcSHORT_TEMP, mqcTEMP_LONG, and mqcTEMP_SHORT convert floating point numbers between the longest binary format, TEMP_REAL, and the shorter formats.

**EH87.LIB**

**THE ERROR HANDLER MODULE**

EH87.LIB is a library of five utility procedures which a user can utilize for writing trap handlers. Trap handlers are called when an unmasked 8087 error occurs.

The 8087 error reporting mechanism can be used not only to report error conditions, but also to let software implement IEEE standard options not directly supported by the chip. The three such extensions to the 8087 are: normalizing mode, non-trapping not-a-number (NaN), and non-ordered comparison. The utility procedures support these extra features.

DECODE is called near the beginning of the trap handler. It preserves the complete state of the 8087, and also identifies what function called the trap handler, and returns available arguments and/or results. DECODE eliminates much of the effort needed to determine what error caused the trap handler to be called.

NORMAL provides the "normalizing mode" capability for handling the "D" exception. By calling NORMAL in your trap handler, you eliminate the need to write code in your application program which tests for non-normal inputs.

SIEVE provides two capabilities for handling the "I" exception. It implements non-trapping NaN's and non-ordered comparisons. These two IEEE standard features are useful for diagnostic work.

ENCODE is called near the end of the trap handler. It restores the state of the 8087 saved by DECODE, and performs a choice of concluding actions, by either retrying the offending function or returning a specified result.

FILTER calls each of the above four procedures. If your error handler does nothing more than detect fatal errors and implement the features supported by SIEVE and NORMAL, then your interface to EH87.LIB can be accomplished with a single call to FILTER.

**E8087**

**THE FULL 8087 EMULATOR**

E8087 is an object module that functionally emulates the 8087 coprocessor chip. It is ideal for use during prototyping and debugging floating point programs. However, the target system should use the 8087 component because it executes 1000 times faster and uses significantly less memory.
**E8087.LIB, 8087.LIB, 87NULL.LIB**

**INTERFACE LIBRARIES**

E8087. LIB, 8087.LIB and 87NULL.LIB libraries configure a user's application program for his run-time environment: running with the emulator, with the 8087 component or without floating point arithmetic, respectively.

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**SPECIFICATIONS**

**OPERATING ENVIRONMENT**

8086/8088 Based Microcomputer System

**DEVELOPMENT ENVIRONMENT**

**Required Hardware**

Intellec Microcomputer Development System
- Model 800
- Series II (Models 220, 225 or equivalent)
- Series III
64K Bytes of RAM Memory
Minimum One Diskette Drive
- Single or Double* Density
System Console
- CRT or Hardcopy Interactive Device

**Optional Hardware**

Universal PROM Programmer*
Line Printer*

**Required Software**

For Series II:
8086/8088 Software Development Package—MDS-308, MDS-309 or MDS-311

**Documentation Package**
Numeric Support Library Manual

**Shipping Media**
1 Single and 1 Double Density Diskette

*Recommended

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**ORDERING INFORMATION**

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<tr>
<td>MDS* 319</td>
<td>8087 Support Library</td>
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</table>

Requires Software License

*MDS is an ordering code only and is not used as a product name or trademark. MDS is a registered trademark of Mohawk Data Sciences Corporation.
8089 IOP
SOFTWARE SUPPORT PACKAGE

- Program Generation for the 8089 I/O Processor on the Intellec® Microcomputer Development System
- Contains 8089 Macro Assembler, plus Relocation and Linkage Utilities
- Relocatable Object Module Compatible with All iAPX 86 and iAPX 88 Object Modules
- Fully Supports Symbolic Debugging with the RBF-89 Software Debugger
- Supports 8089-Based Addressing Modes with a Structure Facility that Enables Easy Access to Based Data
- Powerful Macro Capabilities
- Provides Timing Information in Assembly Listing
- Fully Detailed Set of Error Messages

The IOP Software Support Package extends Intellec Microcomputer Development System support to the 8089 I/O Processor. The macro assembler translates symbolic 8089 macro assembly language instructions into relocatable machine code. The relocation and linkage utilities provide compatibility with iAPX 86, iAPX 88, and 8089 modules, and make structured, modular programming easier.

The macro assembler also provides symbolic debugging capability when used with the RBF-89 software debugger. 8089 program modularity is supported with inter-segment jumps and calls. The macro assembler also provides instruction cycle counts in the listing file, for giving the programmer execution timing information. The programs in the 8089 Software Support Package run on any Intellec Series II or Model 800 with 64K bytes of memory.
FUNCTIONAL DESCRIPTION

The IOP Software Support Package contains:

**ASM89** — The 8089 Macro Assembler.

**LINK86** — Resolves control transfer references between 8089 object modules, and data references in 8086, 8088, and 8089 modules.

**LOC86** — Assigns absolute memory addresses to 8089 object modules.

**OH86** — Converts absolute object modules to hexadecimal format.

**UPM** — The Universal PROM Mapper, which supports PROM programming in all iAPX 86/11 and iAPX 88/11 applications.

ASM89 translates symbolic 8089 macro assembly language instructions into the appropriate machine codes. The ability to refer to both program and data addresses with symbolic names makes it easier to develop and modify programs, and avoids the errors of hand translation.

The powerful macro facility allows frequently used code sequences to be referred to by a single name, so that any changes to that sequence need to be made in only one place in the program. Common code sequences that differ only slightly can also be referred to with a macro call, and the differences can be substituted with macro parameters.

ASM89 provides symbolic debugging information in the object file. The RBF-89 debugger makes use of this information, so the programmer can symbolically debug 8089 programs. ASM89 also provides cycle counts for each instruction in the assembly listing file (see Table 1). These cycle counts help the programmer determine how long a particular routine or code sequence will take to execute on the 8089.

ASM89 provides relocatable object module compatibility with the 8086 and 8088 microprocessors. This object module compatibility, along with the 8086/8088 relocation and linkage utilities, facilitates the designing of iAPX 86/11 and iAPX 88/11 systems.

ASM89 fully supports the based addressing modes of the 8089. A structure facility allows the user to define a template that enables accessing of based data symbolically.

SPECIFICATIONS

Operating Environment

**REQUIRED HARDWARE**
- Intellect® Microcomputer Development System
  - Model 800
  - Series II (Models 220, 225 or equivalent)
- 64K Bytes of RAM Memory
- Minimum One Diskette Drive
  - Single or Double* Density
- System Console
  - CRT or Hardcopy Interactive Device

**OPTIONAL HARDWARE**
- Universal PROM Programmer*
- Line Printer*

**REQUIRED SOFTWARE**
- ISIS-II Diskette Operating System
  - Single or Double Density

**DOCUMENTATION PACKAGE**
- 8089 Macro Assembler User’s Guide (9800938)
- 8089 Macro Assembler Pocket Reference (9800936)
- MCS-86 Software Development Utilities Operating Instructions for ISIS-II Users (9800639)
- Universal PROM Programmer User’s Manual (9800819)

**SHIPPING MEDIA**
- Single and Double Density Diskettes

ORDERING INFORMATION

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*MDS is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corporation.
Table 1. Sample Program Listing

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**Macro Complete, No Errors Found**
ICE-86A™
iAPX 86 IN-CIRCUIT EMULATOR

- Real-Time In-Circuit Emulation of iAPX 86 Microsystems
- Emulate Both Minimum and Maximum Modes of 8086 CPU
- Full Symbolic Debugging
- Breakpoints to Halt Emulation on a Wide Variety of Conditions
- Comprehensive Trace of Program Execution
- Disassembly of Trace or Program Memory from Object Code into Assembler Mnemonics
- Software Debugging With or Without User System
- Handles Full 1 Megabyte Addressability of iAPX 86
- Enhance Existing ICE-86™ Emulators to ICE-86A™ Capabilities with ICE-86U™ Upgrade Package

The Intel® ICE-86A In-Circuit Emulator provides sophisticated hardware and software debugging capabilities for iAPX 86 microsystems and iAPX 86 Single-Board Computers. These capabilities include In-Circuit Emulation for the 8086 Central Processing Unit plus extensions to debug systems including the 8089 I/O Processor and 8087 Numeric Processor Extension. The emulator includes three circuit boards which reside in any Intellec® Microcomputer Development System. A cable and buffer box connect the Intellec system to the user system by replacing the user's 8086, thus extending powerful Intellec system debugging functions into the user system. Using the ICE-86A module, the designer can execute prototype 8086 or 8089 software in continuous or single-step modes and can substitute blocks of Intellec system memory for user equivalents. Breakpoints allow the user to stop emulation on user-specified conditions of the iAPX 86 system, and the trace capability gives a detailed history of the program execution prior to the break. All user access to the prototype system software may be done symbolically by referring to the source program variables and labels.

The ICE-86U In-Circuit Emulator upgrade package converts any existing ICE-86 module (non-A version) to the capabilities of an ICE-86A module.
INTEGRATED HARDWARE/SOFTWARE DEVELOPMENT

The ICE-86A emulator allows hardware and software development to proceed interactively. This is more effective than the traditional method of independent hardware and software development followed by system integration. With the ICE-86A module, prototype hardware can be added to the system as it is designed. Software and hardware testing occurs while the product is being developed.

Conceptually, the ICE-86A emulator assists three stages of development:

1. It can be operated without being connected to the user's system, so the ICE-86A module's debugging capabilities can be used to facilitate program development before any of the user's hardware is available.

2. Integration of software and hardware can begin when any functional element of the user system hardware is connected to the 8086 socket. Through ICE-86A emulator mapping capabilities, Intellec memory, ICE module memory, or diskette memory can be substituted for missing prototype memory. Time-critical program modules are debugged before hardware implementation by using the 2K-bytes of high-speed ICE-resident memory. As each section of the user's hardware is completed, it is added to the prototype. Thus each section of the hardware and software is "system" tested as it becomes available.

3. When the user's prototype is complete, it is tested with the final version of the user system software. The ICE-86A module is then used for real-time emulation of the 8086 to debug the system as a completed unit.

Thus the ICE-86A module provides the user with the ability to debug a prototype or production system at any stage in its development without introducing extraneous hardware or software test tools.

SYMBOLIC DEBUGGING

Symbols and PL/M statement numbers may be substituted for numeric values in any of the ICE-86A emulator commands. This allows the user to make symbolic references to I/O ports, memory addresses, and data in the user program. Thus the user need not remember the addresses of variables or program subroutines.

Symbols can be used to reference variables, procedures, program labels, and source statements. A variable can be displayed or changed by referring to it by name rather than by its absolute location in memory. Using symbols for statement labels, program labels, and procedure names simplifies both tracing and breakpoint setting. Disassembly of a section of code from either trace or program memory into its assembly mnemonics is readily accomplished.

Figure 1. ICE-86A™ Emulator Block Diagram
A typical iAPX 86 development configuration. It is based on Intellec® Series III Development System, which hosts the ICE-86A™ emulator. The ICE-86A™ module is shown connected to a user prototype system, in this case, an SDK-86.

Furthermore, each symbol may have associated with it one of the data types BYTE, WORD, INTEGER, SINTeger (for short, 8-bit integer), POINTER, REAL, DREAL, or TREAL. Thus the user need not remember the type of a source program variable when examining or modifying it. For example, the command "!VAR" displays the value in memory of variable VAR in a format appropriate to its type, while the command "$VAR = !VAR + 1$" increments the value of the variable.

The user symbol table generated along with the object file during a PL/M-86, PASCAL-86 or FORTRAN-86 compilation or an ASM-86 assembly is loaded into memory along with the user program which is to be emulated. The user can utilize the available symbol table space more efficiently by using the SELECT option to choose which program modules will have symbols loaded in the symbol table. The user may also add to this symbol table any additional symbolic values for memory addresses, constants, or variables that are found useful during system debugging.

The ICE-86A module provides access through symbolic definition to all of the 8086 registers and flags. The READY, NMI, TEST, HOLD, RESET, INTR, MN/MX, and RQ/GT pins of the 8086 can also be read. Symbolic references to key ICE-86A emulation information are also provided.

**MACROS AND COMPOUND COMMANDS**

The ICE-86A module provides a programmable diagnostic facility which allows the user to tailor its operation using macro commands and compound commands.

A macro is a set of ICE-86A commands which is given a single name. Thus, a sequence of commands which is executed frequently may be invoked simply by typing in a single command. The user first defines the macro by entering the entire sequence of commands which he wants to execute. He then names the macro and stores it for future use. He executes the macro by typing its name and passing up to ten parameters to the commands in the macro. Macros may be saved on a disk file for use in subsequent debugging sessions.

Compound commands provide conditional execution of commands (IF), and execution of commands until a condition is met or until they have been executed a specified number of times (COUNT, REPEAT).

Compound commands and macros may be nested any number of times.
MEMORY MAPPING

Memory for the user system can be resident in the user system or "borrowed" from the Intellec System through the ICE-86A emulator's mapping capability. The speed of run emulation by the ICE-86A module depends on which mapping options are being used.

The ICE-86A emulator allows the memory which is addressed by the 8086 to be mapped in 1K-byte blocks to:

1. Physical memory in the user's system, which provides 100 percent real-time emulation at the user-system clock rate (up to 5 MHz) with no wait states.
2. Either of two 1K-byte blocks of ICE-86A module high-speed memory, which allow nearly full-speed emulation (with two additional wait states per 8086-controlled bus cycle).
3. Intellec System memory, which provides emulation at approximately 0.02 percent of real-time with a 5 MHz clock.
4. A random-access diskette file, with emulation speed comparable to Intellec System memory, except the emulation must wait when a new page is accessed on the diskette.

The user can also designate a block of memory as non-existent. The ICE-86A module issues an error message when any such "guarded" memory is addressed by the user program.

As the user prototype progresses to include memory, emulation becomes real time.

OPERATION MODES

The ICE-86A software is a RAM-based program that provides the user with easy-to-use commands for initiating emulation, defining breakpoints, controlling trace data collection, and displaying and controlling system parameters. ICE-86A commands are configured with a broad range of modifiers which provide the user with maximum flexibility in describing the operation to be performed.

Emulation

Emulation commands to the ICE-86A emulator control the process of setting up, running and halting an emulation of the user's iAPX 86 System. Breakpoints and tracepoints enable the ICE-86A module to halt emulation and provide a detailed trace of execution in any part of the user's program. A summary of the emulation commands is shown in Table 1.

Table 1. Summary of ICE-86A™ Emulation Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>GO</td>
<td>Initializes emulation and allows the user to specify the starting point and breakpoints. Example: GO FROM .START TILL .DELAY EXECUTED where START and DELAY are statement labels.</td>
</tr>
<tr>
<td>STEP</td>
<td>Allows the user to single-step through the program.</td>
</tr>
</tbody>
</table>

Breakpoints: The ICE-86A module has two breakpoint registers that allow the user to halt emulation when a specified condition is met. The breakpoint registers may be set up for execution or non-execution breaking. An execution breakpoint consists of a single address which causes a break whenever the 8086 executes from its queue an instruction byte which was obtained from the address. A non-execution breakpoint causes an emulation break when a specified condition other than an instruction execution occurs. A non-execution breakpoint condition, using one or both breakpoint registers, may be specified by any one of or a combination of:

1. A set of address values. Break on a set of address values has three valuable features:
   a. Break on a single address.
   b. The ability to set any number of breakpoints within a limited range (1024 bytes maximum) of memory.
   c. The ability to break in an unlimited range. Execution is halted on any memory access to an address greater than (or less than) any 20-bit breakpoint address.
2. A particular status of the 8086 bus (one or more of: memory or I/O read or write, instruction fetch, halt, or interrupt acknowledge).
3. A set of data values (features comparable to break on a set of address values, explained in point one).
4. A segment register (break occurs when the register is used in an effective address calculation).
Emulation break can also be set to occur on an external signal condition. An external breakpoint match output and emulation status lines are provided on the buffer box. These allow synchronization of other test equipment when a break occurs or when emulation is begun.

Tracepoints: The ICE-86A module has two tracepoint registers which establish match conditions to conditionally start and stop trace collection. The trace information is gathered at least twice per bus cycle, first when the address signals are valid and second when the data signals are valid. If the 8086 execution queue is otherwise active, additional frames of trace are collected.

Each trace frame contains the 20 address/data lines and detailed information on the status of the 8086. The trace memory can store 1,023 frames, or an average of about 300 bus cycles, providing ample data for determining how the 8086 was reacting prior to emulation break. The trace memory contains the last 1,023 frames of trace data collected, even if this spans several separate emulations. The user has the option of displaying each frame of the trace data or displaying by instruction in actual ASM-86 Assembler mnemonics. Unless the user chooses to disable trace, the trace information is always available after an emulation.

Interrogation and Utility

Interrogation and utility commands give the user convenient access to detailed information about the user program and the state of the 8086 that is useful in debugging hardware and software. Changes can be made in both memory and the 8086 registers, flags, input pins, and I/O ports. Commands are also provided for various utility operations such as loading and saving program files, defining symbols and macros, displaying trace data, setting up the memory map, and returning control to ISIS-II. A summary of the basic interrogation and utility commands is shown in Table 2.

| Table 2. Selected ICE-86A™ Module Interrogation and Utility Commands |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| **Memory/Register Commands** | **RQ/GT** | **Set or display the status of the Request/Grant facility which enables the ICE-86A module to share the system bus with coprocessors.** |
| | **BUS** | **Display which device in the user's iAPX 86 system is currently master of the system bus.** |
| | **CAUSE** | **Display the cause of the most recent emulation break.** |
| | **PRINT** | **Display the specified portion of the trace memory.** |
| | **LOAD** | **Fetch user symbol table and object code from the input file.** |
| | **EVALUATE** | **Display the value of an expression in binary, octal, decimal, hexadecimal, and ASCII.** |
| | **CLOCK** | **Select the internal (ICE-86A module provided, for standalone mode only) or an external (user-provided) system clock.** |
| | **RWTIMEOUT** | **Allows the user to time out READ/WRITE command signals based on the time taken by the 8086 to access Intellec memory or diskette memory.** |
| | **ENABLE/DISABLE RDY** | **Enable or disable logical AND of ICE-86A emulator Ready with the user Ready signal for accessing Intellec memory, ICE memory, or diskette memory.** |
iAPX 86/20 DEBUGGING

The ICE-86A module has the extended capabilities to debug iAPX 86/20 microsystems which contain both the 8086 microprocessor and the 8087 Numeric Processor Extension (NPX). An iAPX 86/20 system is configured in the 8086's "maximum" mode and communication between the processors is accomplished through the RQ/GT signals. Debugging can be done either using the 8087 chip itself (in which case the 8086 ESCAPE instruction is interpreted as a floating point instruction) or using the 8087 software emulator E8087 (where the 8086 INTERRUPT instruction is interpreted as a floating point instruction). Three new data types are defined to use the NPX:

- REAL (4 byte Short Real)
- DREAL (8 byte Long Real)
- TREAL (10 byte Temporary Real)

While the 8087 NPX is not a programmable part, it does interact closely with the 8086 and can execute instructions in parallel with it. The ICE-86A module provides information about the relative timing of instruction execution in each processor so that the complete system can be debugged. Other debugging capabilities available through the ICE-86A module are: symbolically disassemble NPX call instructions from memory or trace history; display or change the control, status and flag values of the NPX; display the NPX stack either in disassembled form; and display the last instruction address, last operand, and last operand address.

iAPX 86/11 DEBUGGING

The 8089 Real-Time Breakpoint Facility (RBF-89) is an extension of the ICE-86A emulator that aids in testing and trouble-shooting iAPX 86/11 systems designed around a combination of the 8086 CPU and the 8089 Input/Output Processor (IOP). RBF-89 interrogates 8089 registers, sets breakpoints in 8089 programs, and performs other functions by preparing special control blocks in application system memory. It then issues input/output channel-attention commands to the 8089 in the user's system to perform these functions. While using the RBF-89 extension, the user can also enter and execute the other standard ICE-86A emulator commands.

RBF-89 allows the user to load his application (channel) program from diskette into 8089 IOP memory and execute it in real time. The program can reside in either local (system) RAM (accessible by both the 8086 and 8089 microprocessors), or remote RAM (accessible by the 8089 IOP only). The user may request execution to begin at any location and continue until normal termination, a specified breakpoint is reached, or the program is otherwise aborted. If a program is modified during a debugging session, RBF-89 can save the latest version by copying it from application system memory to a diskette file.

Breakpoints

RBF-89 supports setting up to twelve breakpoints (six per 8089 channel) in the user program. RBF-89 implements each breakpoint by inserting a HALT instruction at the breakpoint location, while saving the overwritten instruction in temporary storage. When a breakpoint is reached during program execution the program halts. At this point the user can examine 8089 registers, flags, and memory, and optionally resume program execution. The invoked breakpoint address is recorded in one of two breakpoint registers—one register for each 8089 channel. Through simple RBF-89 commands the user can display or change the contents of these registers.

Symbolic Debugging

As in the ICE-86A emulator, the RBF-89 extension accepts symbolic references for variables and labels, including symbols in the symbol table generated by the ASM-89 assembler.

Through RBF-89, the user can display and change the contents of:

- memory, which can be displayed as either numeric data or disassembled (8089 assembly-language mnemonic) code.
- all 8089 registers except the channel control pointer (CCP) and status flags.

Multiprocessor Operation

The ICE-86A emulator and RBF-89 support 8089 configurations in both local and remote modes. The ICE-86A emulator may be operating either in minimum or maximum mode. In maximum mode, the 8086 RQ/GT lines are employed. This is required for the 8089 local mode configuration to provide local bus arbitration between the two processors. Using RBF-89, the user can:
Set RO/GT to operate for a local or remote configuration.

Display status to determine which processor controls the system bus.

Start and halt 8089 channel programs.

RBF-89 permits the 8089 and emulated 8086 to run simultaneously as well as sequentially. The user can specify breakpoints and begin program execution in three operating sequences:

Set breakpoints, start the 8089, and return control to the console until a breakpoint is reached or the program runs to completion or is aborted. Use this sequence when the 8086 and 8089 programs do not need to be executed simultaneously.

Set breakpoints, start the 8089, return control to the console, and start the 8086. This sequence lets both microprocessors run simultaneously.

Set breakpoints, start the 8086, and allow that program to drive the 8089 program in a master/slave relationship. This sequence would be used, for instance, to verify the 8086 communication driver program.

RBF-89 System Components

RBF-89 is furnished as a superset of the ICE-86A emulator software. Its main components are:

A HOST PROGRAM that resides in Intellec development system RAM, where it serves as an extension of the ICE-86A emulator's software driver. This program, executed by the development system, translates the user's keyboard input into low-level directives that can be processed by the RBF-89 control program (described below), and converts information supplied by the control program into easily understood display output.

A CONTROL PROGRAM that resides in ICE-86A emulator memory. Running on the emulator's 8086 microprocessor, the control program monitors such operations as preparing program control blocks for communication with the 8089 microprocessor; issuing commands to the 8089 to start, terminate, and continue the 8089 task program; and directing the 8089 to start execution of the RBF-89 utility program (described below).

A UTILITY PROGRAM that resides in the 8089 RAM in the user's prototype application system. This program, running on the 8089, reads and writes data to and from 8089 memory and registers, and sets and removes breakpoints in the user's task program.

The 200 bytes of RAM required by the utility program must be accessible to both the ICE-86A emulator and the 8089.

DC CHARACTERISTICS OF THE ICE-86A™ MODULE USER CABLE

1. Output Low Voltages [$V_{OL}(\text{Max})=0.4V$]

<table>
<thead>
<tr>
<th>Port</th>
<th>$I_{OL}(\text{Min})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD0-AD15</td>
<td>12 mA</td>
</tr>
<tr>
<td>A16/S3-A19/S7, BHE/S7, RD, LOCK, QS0, QS1, S0, S1, S2, WR, M/I, DT/R, DEN, ALE, INTA</td>
<td>(24 mA @ 0.5V)</td>
</tr>
<tr>
<td>HLDA</td>
<td>7 mA</td>
</tr>
<tr>
<td>RO/GT</td>
<td>16 mA</td>
</tr>
</tbody>
</table>

2. Output High Voltages [$V_{OH}(\text{Min})=2.4V$]

<table>
<thead>
<tr>
<th>Port</th>
<th>$I_{OH}(\text{Min})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD0-AD15</td>
<td>-3 mA</td>
</tr>
<tr>
<td>A16/S3-A19/S7, BHE/S7, RD, LOCK, QS0, QS1, S0, S1, S2, WR, M/I, DT/R, DEN, ALE, INTA, HLDA</td>
<td>-2.6 mA</td>
</tr>
<tr>
<td>RO/GT</td>
<td>250 mA</td>
</tr>
</tbody>
</table>

3. Input Low Voltages [$V_{IL}(\text{Max})=0.8V$]

<table>
<thead>
<tr>
<th>Port</th>
<th>$I_{IL}(\text{Max})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD0-AD15</td>
<td>-0.2 mA</td>
</tr>
<tr>
<td>NMI, CLK</td>
<td>-0.4 mA</td>
</tr>
<tr>
<td>READY</td>
<td>-0.8 mA</td>
</tr>
<tr>
<td>INTR, HOLD, TEST, RESET</td>
<td>-1.4 mA</td>
</tr>
<tr>
<td>MN/MX (0.1 $\mu$F to GND)</td>
<td>-3.3 mA</td>
</tr>
</tbody>
</table>

4. Input High Voltages [$V_{IH}(\text{Min})=2.0V$]

<table>
<thead>
<tr>
<th>Port</th>
<th>$I_{IH}(\text{Max})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD0-AD15</td>
<td>80 $\mu$A</td>
</tr>
<tr>
<td>NMI, CLK</td>
<td>20 $\mu$A</td>
</tr>
<tr>
<td>READY</td>
<td>40 $\mu$A</td>
</tr>
<tr>
<td>INTR, HOLD, TEST, RESET</td>
<td>-0.4 mA</td>
</tr>
<tr>
<td>MN/MX (0.1 $\mu$F to GND)</td>
<td>-1.1 mA</td>
</tr>
</tbody>
</table>

5. No current is taken from the user circuit at $V_{CC}$ pin.
SPECIFICATIONS

ICE-86A Operating Environment

REQUIRED HARDWARE
Intellec microcomputer development system with:
1. Three adjacent slots for the ICE-86A module.
2. 64K bytes of Intellec memory. If user prototype program memory is desired, additional memory above the basic 64K is required.

System console
Intellec diskette operating system
ICE-86A module

REQUIRED SOFTWARE
System Monitor
ISIS-II, version 3.4 or subsequent
ICE-86A software

Equipment Supplied
Printed circuit boards (3)
Interface cable and emulation buffer module
Operator's manual
ICE-86A software, diskette-based

Emulation Clock
User system clock up to 5 MHz or 2 MHz ICE-86A internal clock in stand-alone mode

Physical Characteristics

PRINTED CIRCUIT BOARDS
Width: 12.00 in (30.48 cm)
Height: 6.75 in (17.15 cm)
Depth: 0.50 in (1.27 cm)
Packaged Weight: 9.00 lb (4.10 kg)

Electrical Characteristics

DC POWER
\[ V_{CC} = +5V \pm 5\% - 1\% \]
\[ I_{CC} = 17A \text{ maximum; } 11A \text{ typical} \]
\[ V_{DD} = +12V \pm 5\% \]
\[ I_{DD} = 120 mA \text{ maximum; } 80 mA \text{ typical} \]
\[ V_{BB} = -10V \pm 5\% \text{ or } -12V \pm 5\% \text{ (optional)} \]
\[ I_{BB} = 25 mA \text{ maximum; } 12 mA \text{ typical} \]

Environmental Characteristics

OPERATING TEMPERATURE
0° to 40°C

OPERATING HUMIDITY
Up to 95% relative humidity without condensation.

ORDERING INFORMATION

Part Number    Description
MDS*-86A-ICE    iAPX 86 microsystem in-circuit emulator, cable assembly, and interactive software
MDS*-86U-ICE    Upgrade kit to convert ICE-86 emulators to ICE-86A emulator capabilities.

*MDS is an ordering code only and is not used as a product name or trademark. MDS* is a registered trademark of Mohawk Data Sciences Corporation.
ICE-88™
8088 IN-CIRCUIT EMULATOR

- Hardware In-Circuit Emulation
- Full Symbolic Debugging
- Breakpoints to Halt Emulation on a Wide Variety of Conditions
- Comprehensive Trace of Program Execution, Both Conditional and Unconditional
- Disassembly of Trace or Memory from Object Code into Assembler Mnemonics
- 2K Bytes of High Speed ICE-88™ Mapped Memory
- Software Debugging with or without User System
- Handles Full 1 Megabyte Addressability of 8088
- Compound Commands
- Command Macros

The ICE-88 module provides In-Circuit Emulation for the 8088 microprocessor. It includes three circuit boards which reside in Intellec® Microcomputer Development Systems. A cable and buffer box connect the Intellec system to the user system by replacing the user’s 8088. Powerful Intellec debug functions are thus extended into the user system. Using the ICE-88 module, the designer can execute prototype software in continuous or single-step mode and can substitute blocks of Intellec system memory for user equivalents. Breakpoints allow the user to stop emulation on user-specified conditions, and the trace capability gives a detailed history of the program execution prior to the break. All user access to the prototype system software may be done symbolically by referring to the source program variables and labels.
INTEGRATED HARDWARE/SOFTWARE DEVELOPMENT

The ICE-88 emulator allows hardware and software development to proceed interactively. This is more effective than the traditional method of independent hardware and software development followed by system integration. With the ICE-88 module, prototype hardware can be added to the system as it is designed. Software and hardware testing occurs while the product is being developed.

Conceptually, the ICE-88 emulator assists three stages of development:

1. It can be operated without being connected to the user’s system, so ICE-88 debugging capabilities can be used to facilitate program development before any of the user’s hardware is available.
2. Integration of software and hardware can begin when any functional element of the user system hardware is connected to the 8088 socket. Through ICE-88 mapping capabilities, Intellec memory, ICE memory, or diskette memory can be substituted for missing prototype memory. Time-critical program modules are debugged before hardware implementation by using the 2K-bytes of high-speed ICE-resident memory. As each section of the user’s hardware is completed, it is added to the prototype. Thus each section of the hardware and software is “system” tested as it becomes available.
3. When the user’s prototype is complete, it is tested with the final version of the user system software. The ICE-88 module is then used for real time emulation of the 8088 to debug the system as a completed unit.

Thus the ICE-88 module provides the user with the ability to debug a prototype or production system at any stage in its development without introducing extraneous hardware or software test tools.

SYMBOLIC DEBUGGING

Symbols and PL/M statement numbers may be substituted for numeric values in any of the ICE-88 commands. This allows the user to make symbolic references to I/O ports, memory addresses, and data in the user program. Thus the user need not remember the addresses of variables or program subroutines.

Symbols can be used to reference variables, procedures, program labels, and source statements. A variable can be displayed or changed by referring to it by name rather than by its absolute location in memory. Using symbols for statement labels, program labels, and procedure names simplifies both tracing and breakpoint setting. Disassembly of a section of code from either trace or program memory into its assembly mnemonics is readily accomplished.

Furthermore, each symbol may have associated with it one of the data types BYTE, WORD, INTEGER, SINTEGER (for short, 8-bit integer) or POINTER. Thus the user need not remember the type of a source program variable when examining or modifying it. For example, the command “!VAR” displays the value in memory of variable VAR in a format appropriate to its type, while the command “!VAR = !VAR + 1” increments the value of the variable.

The user symbol table generated along with the object file during a PL/M-86 compilation or an ASM-86 assembly is loaded into memory along with the user program which is to be emulated. The user may add to this symbol table any additional symbolic values for memory addresses, constants, or variables that are found useful during system debugging.

The ICE-88 module provides access through symbolic definition to all of the 8088 registers and flags. The READY, NMI, TEST, HOLD, RESET, INTR, and MN/MX pins of the 8088 can also be read. Symbolic references to key ICE-88 emulation information are also provided.

---

**Figure 1. ICE-88™ Emulator Block Diagram**
MACROS AND COMPOUND COMMANDS

The ICE-88 module provides a programmable diagnostic facility which allows the user to tailor its operation using macro commands and compound commands.

A macro is a set of ICE-88 commands which is given a single name. Thus, a sequence of commands which is executed frequently may be invoked simply by typing in a single command. The user first defines the macro by entering the entire sequence of commands which he wants to execute. He then names the macro and stores it for future use. He executes the macro by typing its name and passing up to ten parameters to the commands in the macro. Macros may be saved on a disk file for use in subsequent debugging sessions.

Compound commands provide conditional execution of commands (IF), and execution of commands until a condition is met or until they have been executed a specified number of times (COUNT, REPEAT).

Compound commands and macros may be nested any number of times.

MEMORY MAPPING

Memory for the user system can be resident in the user system or "borrowed" from the Intellec System through ICE-88’s mapping capability.

The ICE-88 emulator allows the memory which is addressed by the 8088 to be mapped in 1K-byte blocks to:
1. Physical memory in the user’s system,
2. Either of two 1K-byte blocks of ICE-88 high-speed memory,
3. Intellec memory,

The user can also designate a block of memory as non-existent. The ICE-88 module issues an error message when any such “guarded” memory is addressed by the user program.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GO</td>
<td>Initializes emulation and allows the user to specify the starting point and breakpoints. Example: GO FROM .START TILL .DELAY EXECUTED where START and DELAY are statement labels.</td>
</tr>
<tr>
<td>STEP</td>
<td>Allows the user to single-step through the program.</td>
</tr>
</tbody>
</table>

Table 1. Summary of ICE-88 Emulation Commands.

OPERATION MODES

The ICE-88 software is a RAM-based program that provides the user with easy-to-use commands for initiating emulation, defining breakpoints, controlling trace data collection, and displaying and controlling system parameters. ICE-88 commands are configured with a broad range of modifiers which provide the user with maximum flexibility in describing the operation to be performed.

Emulation

Emulation commands to the ICE-88 emulator control the process of setting up, running and halting an emulation of the user’s 8088. Breakpoints and tracepoints enable ICE-88 to halt emulation and provide a detailed trace of execution in any part of the user’s program. A summary of the emulation commands is shown in Table 1.

Breakpoints — The ICE-88 module has two breakpoint registers that allow the user to halt emulation when a
specified condition is met. The breakpoint registers may be set up for execution or non-execution breaking. An execution breakpoint consists of a single address which causes a break whenever the 8088 executes from its queue an instruction byte which was obtained from the address. A non-execution breakpoint causes an emulation break when a specified condition other than an instruction execution occurs. A non-execution breakpoint condition, using one or both breakpoint registers, may be specified by any one of or a combination of:

1. A set of address values. Break on a set of address values has three valuable features:
   a. Break on a single address.
   b. The ability to set any number of breakpoints within a limited range (1024 bytes maximum) of memory.
   c. The ability to break in an unlimited range. Execution is halted on any memory access to an address greater than (or less than) any 20-bit breakpoint address.

2. A particular status of the 8088 bus (one or more of: memory or I/O read or write, instruction fetch, halt, or interrupt acknowledge).

3. A set of data values (features comparable to break on a set of address values, explained in point one).

4. A segment register (break occurs when the register is used in an effective address calculation).

An external breakpoint match output for user access is provided on the buffer box. This allows synchronization of other test equipment when a break occurs.

Tracepoints — The ICE-88 module has two tracepoint registers which establish match conditions to conditionally start and stop trace collection. The trace information is gathered at least twice per bus cycle, first when the address signals are valid and second when the data signals are valid. If the 8088 execution queue is otherwise active, additional frames of trace are collected.

Each trace frame contains the 20 address/data lines and detailed information on the status of the 8088. The trace memory can store 1,023 frames, or an average of about 300 bus cycles, providing ample data for determining how the 8088 was reacting prior to emulation break. The trace memory contains the last 1,023 frames of data collected, even if this spans several separate emulations. The user has the option of displaying each frame of the trace data or displaying by instruction in actual ASM-86 Assembler mnemonics. Unless the user chooses to disable trace, the trace information is always available after an emulation.

**Interrogation and Utility**

Interrogation and utility commands give the user convenient access to detailed information about the user program and the state of the 8088 that is useful in debugging hardware and software. Changes can be made in both memory and the 8088 registers, flags, input pins, and I/O ports. Commands are also provided for various utility operations such as loading and saving program files, defining symbols and macros, displaying trace data, setting up the memory map, and returning control to the ISIS-II operating system. A summary of the basic interrogation and utility commands is shown in Table 2.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Display or change the contents of:</strong></td>
<td>Display or change the contents of:</td>
</tr>
<tr>
<td>Memory</td>
<td>Memory</td>
</tr>
<tr>
<td>8088 Registers</td>
<td>8088 Registers</td>
</tr>
<tr>
<td>8088 Status flags</td>
<td>8088 Status flags</td>
</tr>
<tr>
<td>8088 Input pins</td>
<td>8088 Input pins</td>
</tr>
<tr>
<td>8088 I/O ports</td>
<td>8088 I/O ports</td>
</tr>
<tr>
<td>ICE-88 Pseudo-Registers</td>
<td>ICE-88 Pseudo-Registers (e.g. emulation timer)</td>
</tr>
</tbody>
</table>

**Memory Mapping Commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display, declare, set, or reset the ICE-88 memory mapping.</td>
<td>Memory, set, or reset the ICE-88 memory mapping.</td>
</tr>
</tbody>
</table>

**Symbol Manipulation Commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display any or all symbols, program modules, and program line numbers and their associated values (locations in memory).</td>
<td>Display symbols, program modules, and program line numbers</td>
</tr>
<tr>
<td>Set the domain (choose the particular program module) for the line numbers.</td>
<td>Set the domain (choose the particular program module)</td>
</tr>
<tr>
<td>Define new symbols as they are needed in debugging.</td>
<td>Define symbols as needed</td>
</tr>
<tr>
<td>Remove any or all symbols, modules, and program statements.</td>
<td>Remove symbols, modules, and program statements</td>
</tr>
<tr>
<td>Change the value of any symbol.</td>
<td>Change the value of any symbol</td>
</tr>
</tbody>
</table>

**TYPE**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assign or change the type of any symbol in the symbol table.</td>
<td>Assign or change the type of any symbol</td>
</tr>
</tbody>
</table>

**ASM**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disassemble user program memory into ASM-86 Assembler mnemonics.</td>
<td>Disassemble user program memory</td>
</tr>
</tbody>
</table>

**PRINT**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display the specified portion of the trace memory.</td>
<td>Display the trace memory</td>
</tr>
</tbody>
</table>

**LOAD**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetch user symbol table and object code from the input file.</td>
<td>Fetch symbol table and object code</td>
</tr>
</tbody>
</table>

**SAVE**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Send user symbol table and object code to the output file.</td>
<td>Send symbol table and object code</td>
</tr>
</tbody>
</table>

**LIST**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Send a copy of all output (including prompts, input line echoes, and error messages) to the chosen output device (e.g. disk, printer) as well as the console.</td>
<td>Send output</td>
</tr>
</tbody>
</table>

**EVALUATE**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display the value of an expression in binary, octal, decimal, hexadecimal, and ASCII.</td>
<td>Display values</td>
</tr>
</tbody>
</table>

**SUFFIX/BASE**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish the default base for numeric values in input text/output display (binary, octal, decimal, or hexadecimal).</td>
<td>Establish bases</td>
</tr>
</tbody>
</table>

**CLOCK**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select the internal (ICE-88 provided, for stand-alone mode only) or an external (user-provided) system clock.</td>
<td>Select clock</td>
</tr>
</tbody>
</table>

**RWTIMEOUT**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allows the user to time out READ/WRITE command signals based on the time taken by the 8088 to access Intellic memory or diskette memory.</td>
<td>Allow timeouts</td>
</tr>
</tbody>
</table>

**ENABLE/DISABLE RDY**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable or disable logical AND of ICE-88 Ready with the user Ready signal for accessing Intellic memory, ICE memory, or diskette memory.</td>
<td>Enable or disable ready signal</td>
</tr>
</tbody>
</table>

Table 2. Summary of Basic ICE-88 Interrogation and Utility Commands.
DIFFERENCES BETWEEN ICE-88™ EMULATION AND THE 8088 MICROPROCESSOR

The ICE-88 module emulates the actual operation of the 8088 microprocessor with the following exceptions:

- The ICE-88 module will not respond to a user system NMI or RESET signal when it is out of emulation.
- Trap is ignored in single step mode and on the first instruction step of an emulation.
- The MIN/MAX line, which chooses the "minimum" or "maximum" configuration of the 8088, must not change dynamically in the user system.
- In the "minimum" mode, the user HOLD signal must remain active until HLDA is output by the ICE-88 emulator.
- The RO/GT lines in the "maximum" configuration are not supported.

The speed of run emulation by the ICE-88 module depends on where the user has mapped his memory. As the user prototype progresses to include memory, emulation becomes real time.

<table>
<thead>
<tr>
<th>Memory Mapped To</th>
<th>Estimated Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>User System</td>
<td>100% of real time*, up to 5 MHz clock</td>
</tr>
<tr>
<td>ICE</td>
<td>2 wait states per 8088-controlled bus cycle</td>
</tr>
<tr>
<td>Intellec</td>
<td>Approximately 0.02% of real time at 5 MHz clock</td>
</tr>
<tr>
<td>Diskette</td>
<td>**</td>
</tr>
</tbody>
</table>

* 100% of real time is emulation at the user system clock rate with no wait states.
** The emulation speed from diskette is comparable to Intellec memory, but emulation must wait when a new page is accessed on the diskette.

DC CHARACTERISTICS OF ICE-88™ USER CABLE

1. Output Low Voltages \([V_{OL}(Max) = 0.4V]\) \(I_{OL}(Min)\)

<table>
<thead>
<tr>
<th>Outputs</th>
<th>(I_{OL}(Min))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0-A7, A8-A15, S0, S1, S2, WR, M/I/O, DT/R, DEN, ALE, INTA</td>
<td>8mA</td>
</tr>
<tr>
<td>HLD, MATCH0 OR MATCH1 (on buffer box)</td>
<td>5mA</td>
</tr>
</tbody>
</table>

2. Output High Voltages \([V_{OH}(Min) = 2.4V]\) \(I_{OH}(Min)\)

<table>
<thead>
<tr>
<th>Outputs</th>
<th>(I_{OH}(Min))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0-A7, A8-A15, A16/S3-A19/S7, S0, RD, LOCK, QSO, QSI, S0, S1, S2, WR, M/I/O, DT/R, DEN, ALE, INTA</td>
<td>-2.0mA</td>
</tr>
<tr>
<td>HLD, MATCH0 OR MATCH1 (on buffer box)</td>
<td>-3.0mA</td>
</tr>
</tbody>
</table>

3. Input Low Voltages \([V_{IL}(Max) = 0.8V]\) \(I_{IL}(Max)\)

<table>
<thead>
<tr>
<th>Inputs</th>
<th>(I_{IL}(Max))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0-A7, NMI, CLK, READY, INTR, HOLD, TEST, RESET, MN/MX (0.1(\mu)F to GND)</td>
<td>-0.2mA</td>
</tr>
</tbody>
</table>

4. Input High Voltages \([V_{IH}(Min) = 2.0V]\) \(I_{IH}(Max)\)

<table>
<thead>
<tr>
<th>Inputs</th>
<th>(I_{IH}(Max))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0-A7, NMI, CLK, READY, INTR, HOLD, TEST, RESET, MN/MX (0.1(\mu)F to GND)</td>
<td>80(\mu)A</td>
</tr>
</tbody>
</table>

5. RO/GT0, RO/GT1 are pulled up to +5V through a 5.6K ohm resistor. No current is taken from user circuit at Vcc pin.
**ICE-88™ IN-CIRCUIT EMULATOR**

**SPECIFICATIONS**

**Operating Environment**

**Required Hardware**
Intellic microcomputer development system with:
1. Three adjacent slots for the ICE-88 module. (Series II requires Model 201 Expansion Chassis).
2. 64K bytes of Intellec memory. If user prototype program memory is desired, additional memory above the basic 64K is required.

System console
Intellec diskette operating system
ICE-88 module

**Required Software**
System monitor
ISIS-II, version 3.4 or subsequent
ICE-88 software

**Equipment Supplied**
Printed circuit boards (3)
Interface cable and emulation buffer module
Operator's manual
ICE-88 software, diskette-based

**Emulation Clock**
User system clock up to 5 MHz or 2 MHz ICE-88 internal clock in stand-alone mode

**Physical Characteristics**

**Printed Circuit Boards**
Width: 12.00 in (30.48 cm)
Height: 6.75 in (17.15 cm)
Depth: 0.50 in (1.27 cm)
Packaged Weight: 9.00 lb (4.10 kg)

**Electrical Characteristics**

**DC Power**

\[ V_{CC} = +5V \pm 5\% - 1\% \]

\[ I_{CC} = 1A \text{ maximum; } 11A \text{ typical} \]

\[ V_{DD} = +12V \pm 5\% \]

\[ I_{DD} = 120mA \text{ maximum; } 80mA \text{ typical} \]

\[ V_{BB} = -10V \pm 5\% \text{ or } -12V \pm 5\% \text{ (optional)} \]

\[ I_{BB} = 25mA \text{ maximum; } 12mA \text{ typical} \]

**Environmental Characteristics**

**Operating Temperature:** 0 °C to 40 °C

**Operating Humidity:** Up to 95% relative humidity without condensation.

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS-88-ICE*</td>
<td>8088 CPU in-circuit emulator</td>
</tr>
</tbody>
</table>

* MDS is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Science Corporation.
Prototype
Microcomputer Kits
SDK-C86
MCS-86™ SYSTEM DESIGN KIT
SOFTWARE AND CABLE INTERFACE TO
INTELEC® DEVELOPMENT SYSTEM

- Provides the Software and Hardware Communications Link Between an Intelec® Development System and the SDK-86
- Intelec® System Files can be Accessed and Down-Loaded to the SDK-86 Resident Memory
- Data in SDK-86 Memory can be Uploaded and Saved in Intelec® System Files
- Enhances and Extends the Power and Usefulness of the SDK-86
- Allows the SDK-86 to Become an Execution Vehicle for ISIS-II Developed 8086 Object Code Using the Series II 8086/8088 Software Development Packages
- All SDK-86 Serial Port Mode Commands Become Available at Console of the Intelec® System

The SDK-C86 product provides the software and hardware link for using the SDK-86 monitor in conjunction with an Intelec® Development System while adding features of data transfer between SDK-86 memory and Intelec® System files. The user may enter programs and data into the SDK-86 and then save them on a diskette. Also, programs and data may be created on the Intelec® System using the Series II 8086/8088 Software Development Packages, then loaded into the SDK-86 for testing and checkout. This provides a real time execution environment of the SDK-86 as a peripheral to the Intelec® System.
HARDWARE
There are two serial ports on the Intellec® System back panel, TTY and CRT. Assuming that one of the ports is used for the Intellec® console, the SDK-C86 cable can plug into the unused port. The SDK-86 is jumper selectable to accept either the CRT (RS232) or TTY (20mA current loop) signals.

The edge connector on the SDK-86 has the MULTIBUS™ form factor. No signals are connected to the fingers except the power supply traces. Therefore, the SDK-86 can plug directly into the Intellec® motherboard to obtain power while using the SDK-C86 cable as the communication link.

SOFTWARE
Two programs must be invoked to operate in the SDK-86 slave mode. One program runs on the SDK-86, and another runs in any ISIS-II environment that includes a diskette drive.

The serial I/O monitor is installed on the SDK-86 and operates as though it was talking to a terminal. The software in the Intellec® allows the Intellec®, with a console device, to behave as if it were a terminal to the SDK-86.

The SDK-C86 software program in the Intellec reads the console input device, then passes the character to the SDK-86 through the serial port. It also receives the characters from the SDK-86 and displays them at the console output device. Besides the basic transfer function, this program also recognizes and performs the Upload and Download functions.

COMMAND Modes
- Transparent: In this mode, the SDK-C86 software passes all characters through without any processing. All the commands of the SDK-86 monitor (except paper tape commands) are available and will function in exactly the same manner as if the terminal were attached directly to the serial port of the SDK-86.

- Upload/Download: In this mode the SDK-C86 software, in the Intellec®, recognizes the mnemonic for Upload or Download from the terminal. It "translates" the Download command to an R (Read hexadecimal tape) command and the Upload command to a W (Write hexadecimal tape). The R and W commands are then passed on to the SDK-86 monitor. Using these paper tape commands allows for a checksummed transfer of data between the Intellec® and the SDK-86 memory.

COMMAND SUMMARY
- Reset — starts the SDK-86 monitor.

- Execute with Breakpoint (G) — Allows you to execute a user program and cause it to halt at a predetermined program step — useful for debugging.

- Single Step (N) — allows you to execute a user program one instruction at a time — useful for debugging.

- Substitute Memory (S, SW) — allows you to examine and modify memory locations in byte or word mode.

- Examine Register (X) — allows you to examine and modify the 8086's register contents.

- Block Move (M) — allows you to relocate program and data portions in memory.

- Input or Output (I, IW, O, OW) — allows direct control of the SDK-86's I/O facilities in byte or word mode.

- Display Memory (D) — allows you to print or display large blocks of memory information in HEX format.

- Load (L) — allows you to load hex format object files into SDK-86 memory from an Intellec.

- Transfer (T) — allows you to save contents of SDK-86 memory in a hex format object file in the Intellec.

---

SDK-86/Intellec® Slave Mode Configuration
SDK-86
MCS-86™ SYSTEM DESIGN KIT

- Complete Single Board Microcomputer System Including CPU, Memory, and I/O
- Easy to Assemble Kit Form
- High Performance 8086 16-Bit CPU
- Interfaces Directly with TTY or CRT
- Interactive LED Display and Keyboard
- Wire Wrap Area for Custom Interfaces
- Extensive System Monitor Software in ROM
- Comprehensive Design Library Included

The SDK-86 MCS-86 System Design Kit is a complete single board 8086 microcomputer system in kit form. It contains all necessary components to complete construction of the kit, including LED display, keyboard, resistors, caps, crystal, and miscellaneous hardware. Included are preprogrammed ROMs containing a system monitor for general software utilities and system diagnostics. The complete kit includes an 8-digit LED display and a mnemonic 24-key keyboard for direct insertion, examination, and execution of a user’s program. In addition, it can be directly interfaced with a teletype terminal, CRT terminal, or the serial port of an Intellec system. The SDK-86 is a high performance prototype system with designed-in flexibility for simple interface to the user’s application.
FUNCTIONAL DESCRIPTION

The SDK-86 is a complete MCS-86 microcomputer system on a single board, in kit form. It contains all necessary components to build a useful, functional system. Such items as resistors, caps, and sockets are included. Assembly time varies from 4 to 10 hours, depending on the skill of the user. The SDK-86 functional block diagram is shown in Figure 1.

8086 Processor

The SDK-86 is designed around Intel's 8086 microprocessor. The Intel 8086 is a new generation, high performance microprocessor implemented in N-channel, depletion load, silicon gate technology (HMOS), and packaged in a 40-pin CerDIP package. The processor features attributes of both 8-bit and 16-bit microprocessors in that it addresses memory as a sequence of 8-bit bytes, but has a 16-bit wide physical path to memory for high performance. Additional features of the 8086 include the following:

- Direct addressing capability to one megabyte of memory
- Assembly language compatibility with 8080/8085
- 14 word x 16-bit register set with symmetrical operations
- 24 operand addressing modes
- Bit, byte, word, and block operations
- 8 and 16-byte signed and unsigned arithmetic in binary or decimal mode, including multiply and divide
- 4 or 5 or 8 MHz clock rate

A block diagram of the 8086 microprocessor is shown in Figure 2.

System Monitor

A compact but powerful system monitor is supplied with the SDK-86 to provide general software utilities and system diagnostics. It comes in preprogrammed read only memories (ROMs).

Communications Interface

The SDK-86 communicates with the outside world through either the on-board light emitting diode (LED) display/keyboard combination or the user’s TTY or CRT terminal (jumper selectable), or by means of a special mode in which an Intellec development system transports finished programs to and from the SDK-86. Memory may be easily expanded by simply soldering in additional devices in locations provided for this purpose. A large area of the board (22 square inches) is laid out as general purpose wire-wrap for the user's custom interfaces.

Assembly

Only a few simple tools are required for assembly: soldering iron, cutters, screwdriver, etc. The SDK-86 assembly manual contains step-by-step instructions for easy assembly with a minimum of mistakes. Once construction is complete, the user connects his kit to a power supply and the SDK-86 is ready to go. The monitor starts immediately upon power-on or reset.

Commands — Keyboard mode commands, serial port commands, and Intellec slave mode commands are summarized in Table 1, Table 2, and Table 3, respectively. The SDK-86 keyboard is shown in Figure 3.

![Figure 1. SDK-86 System Design Kit Functional Block Diagram](image-url)
Documentation

In addition to detailed information on using the monitors, the SDK-86 user's manual provides circuit diagrams, a monitor listing, and a description of how the system works. The complete design library for the SDK-86 is shown in Figure 4 and listed in the specifications section under Reference Manuals.

Figure 2. 8086 Microprocessor Block Diagram

Table 1. Keyboard Mode Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reset</td>
<td>Starts monitor.</td>
</tr>
<tr>
<td>Go</td>
<td>Allows user to execute user program, and causes it to halt at predetermined program stop. Useful for debugging.</td>
</tr>
<tr>
<td>Single step</td>
<td>Allows user to execute user program one instruction at a time. Useful for debugging.</td>
</tr>
<tr>
<td>Substitute memory</td>
<td>Allows user to examine and modify memory locations in byte or word mode.</td>
</tr>
<tr>
<td>Examine register</td>
<td>Allows user to examine and modify 8086 register contents.</td>
</tr>
<tr>
<td>Block move</td>
<td>Allows user to relocate program and data portions in memory.</td>
</tr>
<tr>
<td>Input or output</td>
<td>Allows direct control of SDK-86 I/O facilities in byte or mode.</td>
</tr>
</tbody>
</table>

Table 2. Serial Mode Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dump memory</td>
<td>Allows user to print or display large blocks of memory information in hex format than amount visible on terminal's CRT display.</td>
</tr>
<tr>
<td>Start/continue display</td>
<td>Allows user to display blocks of memory information larger than amount visible on terminal's CRT display.</td>
</tr>
<tr>
<td>Punch/read paper tape</td>
<td>Allows user to transmit finished programs into and out of SDK-86 via TTY paper tape punch.</td>
</tr>
<tr>
<td>Mnemonic and Description</td>
<td>Instruction Code</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Data Transfer</td>
<td></td>
</tr>
<tr>
<td>MOV - Move</td>
<td></td>
</tr>
<tr>
<td>Register/memory to/from memory</td>
<td></td>
</tr>
<tr>
<td>Immediate to register/memory</td>
<td></td>
</tr>
<tr>
<td>Memory to accumulator</td>
<td></td>
</tr>
<tr>
<td>Accumulator to memory</td>
<td></td>
</tr>
<tr>
<td>Register/memory to segment register</td>
<td></td>
</tr>
<tr>
<td>Segment register to memory/register</td>
<td></td>
</tr>
<tr>
<td>PUSH - Push</td>
<td></td>
</tr>
<tr>
<td>Register/memory</td>
<td></td>
</tr>
<tr>
<td>Register</td>
<td></td>
</tr>
<tr>
<td>Segment register</td>
<td></td>
</tr>
<tr>
<td>POP - Pop</td>
<td></td>
</tr>
<tr>
<td>Register/memory</td>
<td></td>
</tr>
<tr>
<td>Register</td>
<td></td>
</tr>
<tr>
<td>Segment register</td>
<td></td>
</tr>
<tr>
<td>XCHG - Exchange</td>
<td></td>
</tr>
<tr>
<td>Register/memory with register/memory</td>
<td></td>
</tr>
<tr>
<td>Register with accumulator</td>
<td></td>
</tr>
<tr>
<td>IN - Input</td>
<td></td>
</tr>
<tr>
<td>Fixed port</td>
<td></td>
</tr>
<tr>
<td>Variable port</td>
<td></td>
</tr>
<tr>
<td>OUT - Output</td>
<td></td>
</tr>
<tr>
<td>Fixed port</td>
<td></td>
</tr>
<tr>
<td>Variable port</td>
<td></td>
</tr>
<tr>
<td>LAT-Load a byte to AL</td>
<td></td>
</tr>
<tr>
<td>LDA-Load EA to register</td>
<td></td>
</tr>
<tr>
<td>LDB-Load pointer to DS</td>
<td></td>
</tr>
<tr>
<td>LBS-Load pointer to ES</td>
<td></td>
</tr>
<tr>
<td>LARP-Load AH with flags</td>
<td></td>
</tr>
<tr>
<td>BSW-Store AH into flags</td>
<td></td>
</tr>
<tr>
<td>PBW-Push flags</td>
<td></td>
</tr>
<tr>
<td>PRR-Ptr flags</td>
<td></td>
</tr>
<tr>
<td>Arithmetic</td>
<td></td>
</tr>
<tr>
<td>ADD - Add</td>
<td></td>
</tr>
<tr>
<td>Reg/memory with register to either/memory to register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate to accumulator</td>
<td></td>
</tr>
<tr>
<td>ADC - Add with carry</td>
<td></td>
</tr>
<tr>
<td>Reg/memory with register to either/memory to register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate to accumulator</td>
<td></td>
</tr>
<tr>
<td>INC - Increment</td>
<td></td>
</tr>
<tr>
<td>Register/memory</td>
<td></td>
</tr>
<tr>
<td>Register</td>
<td></td>
</tr>
<tr>
<td>AAA-ASCII adjust for add</td>
<td></td>
</tr>
<tr>
<td>DAA-Decimal adjust for add</td>
<td></td>
</tr>
<tr>
<td>SUB - Subtract</td>
<td></td>
</tr>
<tr>
<td>Reg/memory with register to either/memory to register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate from accumulator</td>
<td></td>
</tr>
<tr>
<td>SBB - Subtract with borrow</td>
<td></td>
</tr>
<tr>
<td>Reg/memory and register to either/memory to register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate from accumulator</td>
<td></td>
</tr>
<tr>
<td>DEC - Decrement</td>
<td></td>
</tr>
<tr>
<td>Register/memory</td>
<td></td>
</tr>
<tr>
<td>Register</td>
<td></td>
</tr>
<tr>
<td>NEB-Change sign</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4. 8086 Instruction Set Summary

<table>
<thead>
<tr>
<th>Mnemonic and Description</th>
<th>Instruction Code</th>
<th>Mnemonic and Description</th>
<th>Instruction Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMP - Compare</td>
<td></td>
<td>CMP - Compare</td>
<td></td>
</tr>
<tr>
<td>Register/memory and register/memory to/from register/memory</td>
<td></td>
<td>Register/memory and register/memory to/from register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate with register/memory</td>
<td></td>
<td>Immediate with register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate with accumulator</td>
<td></td>
<td>Immediate with accumulator</td>
<td></td>
</tr>
<tr>
<td>AAA-ASCII adjust for subtract</td>
<td></td>
<td>AAA-ASCII adjust for subtract</td>
<td></td>
</tr>
<tr>
<td>DAA-Decimal adjust for subtract</td>
<td></td>
<td>DAA-Decimal adjust for subtract</td>
<td></td>
</tr>
<tr>
<td>MUL - Multiply (unsigned)</td>
<td></td>
<td>MUL - Multiply (unsigned)</td>
<td></td>
</tr>
<tr>
<td>MUL-Immediate multiply (signed)</td>
<td></td>
<td>MUL-Immediate multiply (signed)</td>
<td></td>
</tr>
<tr>
<td>AND-ASCII (256) adjust for multiply</td>
<td></td>
<td>AND-ASCII (256) adjust for multiply</td>
<td></td>
</tr>
<tr>
<td>DIV - Divide (unsigned)</td>
<td></td>
<td>DIV - Divide (unsigned)</td>
<td></td>
</tr>
<tr>
<td>DIV-Immediate divide (signed)</td>
<td></td>
<td>DIV-Immediate divide (signed)</td>
<td></td>
</tr>
<tr>
<td>AND-ASCII (256) adjust for divide</td>
<td></td>
<td>AND-ASCII (256) adjust for divide</td>
<td></td>
</tr>
<tr>
<td>CBW - Convert byte to word</td>
<td></td>
<td>CBW - Convert byte to word</td>
<td></td>
</tr>
<tr>
<td>CBW-Convert word to double word</td>
<td></td>
<td>CBW-Convert word to double word</td>
<td></td>
</tr>
<tr>
<td>Logic</td>
<td></td>
<td>Logic</td>
<td></td>
</tr>
<tr>
<td>MOVT-Insert</td>
<td></td>
<td>MOVT-Insert</td>
<td></td>
</tr>
<tr>
<td>SUBL-Shift logical/arithm logical left</td>
<td></td>
<td>SUBL-Shift logical/arithm logical left</td>
<td></td>
</tr>
<tr>
<td>SABR-Shift logical right</td>
<td></td>
<td>SABR-Shift logical right</td>
<td></td>
</tr>
<tr>
<td>SABR-Shift arithmetic</td>
<td></td>
<td>SABR-Shift arithmetic</td>
<td></td>
</tr>
<tr>
<td>ROL-Rotate left</td>
<td></td>
<td>ROL-Rotate left</td>
<td></td>
</tr>
<tr>
<td>ROR-Rotate right</td>
<td></td>
<td>ROR-Rotate right</td>
<td></td>
</tr>
<tr>
<td>RCR-Rotate through carry flag left</td>
<td></td>
<td>RCR-Rotate through carry flag left</td>
<td></td>
</tr>
<tr>
<td>RCR-Rotate through carry right</td>
<td></td>
<td>RCR-Rotate through carry right</td>
<td></td>
</tr>
<tr>
<td>AND - And</td>
<td></td>
<td>AND - And</td>
<td></td>
</tr>
<tr>
<td>Reg/memory and register to either/memory to register/memory</td>
<td></td>
<td>Reg/memory and register to either/memory to register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate from accumulator</td>
<td></td>
<td>Immediate from accumulator</td>
<td></td>
</tr>
<tr>
<td>TEST - And function to flags</td>
<td></td>
<td>TEST - And function to flags</td>
<td></td>
</tr>
<tr>
<td>Reg/memory and register to either/memory to register/memory</td>
<td></td>
<td>Reg/memory and register to either/memory to register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate from accumulator</td>
<td></td>
<td>Immediate from accumulator</td>
<td></td>
</tr>
<tr>
<td>OR - Or</td>
<td></td>
<td>OR - Or</td>
<td></td>
</tr>
<tr>
<td>Reg/memory and register to either/memory to register/memory</td>
<td></td>
<td>Reg/memory and register to either/memory to register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate from accumulator</td>
<td></td>
<td>Immediate from accumulator</td>
<td></td>
</tr>
<tr>
<td>XOR - Exclusive or</td>
<td></td>
<td>XOR - Exclusive or</td>
<td></td>
</tr>
<tr>
<td>Reg/memory and register to either/memory to register/memory</td>
<td></td>
<td>Reg/memory and register to either/memory to register/memory</td>
<td></td>
</tr>
<tr>
<td>Immediate from accumulator</td>
<td></td>
<td>Immediate from accumulator</td>
<td></td>
</tr>
<tr>
<td>String Manipulation</td>
<td></td>
<td>String Manipulation</td>
<td></td>
</tr>
<tr>
<td>MOVX - Move byteword</td>
<td></td>
<td>MOVX - Move byteword</td>
<td></td>
</tr>
<tr>
<td>CMPX - Compare byteword</td>
<td></td>
<td>CMPX - Compare byteword</td>
<td></td>
</tr>
<tr>
<td>SCAS - Scan byteword</td>
<td></td>
<td>SCAS - Scan byteword</td>
<td></td>
</tr>
<tr>
<td>LODS - Load byteword to AL</td>
<td></td>
<td>LODS - Load byteword to AL</td>
<td></td>
</tr>
<tr>
<td>STDS - Store byteword to AL</td>
<td></td>
<td>STDS - Store byteword to AL</td>
<td></td>
</tr>
<tr>
<td>Control Transfer</td>
<td></td>
<td>Control Transfer</td>
<td></td>
</tr>
<tr>
<td>CALL - Call</td>
<td></td>
<td>CALL - Call</td>
<td></td>
</tr>
<tr>
<td>Direct within segment</td>
<td></td>
<td>Direct within segment</td>
<td></td>
</tr>
<tr>
<td>Indirect within segment</td>
<td></td>
<td>Indirect within segment</td>
<td></td>
</tr>
<tr>
<td>Direct segment</td>
<td></td>
<td>Direct segment</td>
<td></td>
</tr>
<tr>
<td>Indirect segment</td>
<td></td>
<td>Indirect segment</td>
<td></td>
</tr>
</tbody>
</table>

---

continued
### SPECIFICATIONS

**Central Processor**

CPU — 8086 (5 MHz clock rate)

Note

May be operated at 2.5 MHz or 5 MHz, jumper selectable, for use with 8086.

**Memory**

ROM — 8K bytes 2316/2716

RAM — 2K bytes (expandable to 4K bytes) 2142

### Addressing

- **ROM** — FE000-FFFF
- **RAM** — 0-7FF (800-FFF available with additional 2142's)

Note

The wire-wrap area of the SDK-86 PC board may be used for additional custom memory expansion.

### Input/Output

- **Parallel** — 48 lines (two 8255A's)
- **Serial** — RS232 or current loop (8251A)

### Baud Rate

— selectable from 110 to 4800 baud
SDK-86

Interfaces
Bus — All signals TTL compatible
Parallel I/O — All signals TTL compatible
Serial I/O — 20 mA current loop TTY or RS232

Note
The user has access to all bus signals which enable him to design custom system expansions into the kit's wire-wrap area.

Interrupts (256 vectored)
Maskable
Non-maskable
TRAP

DMA
Hold Request — Jumper selectable. TTL compatible input.

Software
System Monitor — Preprogrammed 2716 or 2316 ROMs
Addresses — FE000-FFFF
Monitor I/O — Keyboard/display or TTY or CRT (serial I/O)

Physical Characteristics
Width — 13.5 in. (34.3 cm)
Height — 12 in. (30.5 cm)
Depth — 1.75 in. (4.45 cm)
Weight — approx. 24 oz. (3.3 kg)

Electrical Characteristics
DC Power Requirement
(Power supply not included in kit)

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC5V ± 5%</td>
<td>3.5A</td>
</tr>
<tr>
<td>VTTY - 12V ± 10%</td>
<td>0.3A</td>
</tr>
</tbody>
</table>

TTY required only if teletype is connected.

Environmental Characteristics
Operating Temperature — 0-50°C

Reference Manuals
9800697A — SDK-86 MCS-86 System Design Kit Assembly Manual
9800640A — 8086 Assembly Language Programming Manual
8086 Assembly Language Reference Card

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDK-86</td>
<td>MCS-86 system design kit</td>
</tr>
</tbody>
</table>
SDK-85
MCS-85™ SYSTEM DESIGN KIT

- Complete Single Board Microcomputer System Including CPU, Memory, and I/O
- Easy to Assemble, Low Cost, Kit Form
- Extensive System Monitor Software in ROM
- Interactive LED Display and Keyboard
- Large Wire-Wrap Area for Custom Interfaces
- Popular 8080A Instruction Set
- Interfaces Directly with TTY
- High Performance 3 MHz 8085A CPU (1.3 μs Instruction Cycle)
- Comprehensive Design Library Included

The SDK-85 MCS-85 System Design Kit is a complete single board microcomputer system in kit form. It contains all components required to complete construction of the kit, including LED display, keyboard, resistors, caps, crystal, and miscellaneous hardware. Included is a preprogrammed ROM containing a system monitor for general software utilities and system diagnostics. The complete kit includes a 6-digit LED display and a 24-key keyboard for a direct insertion, examination, and execution of a user's program. In addition, it can be directly interfaced with a teletype terminal. The SDK-85 is an inexpensive, high performance prototype system that has designed-in flexibility for simple interface to the user's application.
FUNCTIONAL DESCRIPTION

The SDK-85 is a complete 8085A microcomputer system on a single board, in kit form. It contains all necessary components to build a useful, functional system. Such items as resistors, capacitors, and sockets are included. Assembly time varies from three to five hours, depending on the skill of the user. The SDK-85 functional block diagram is shown in Figure 1.

8085A Processor

The SDK-85 is designed around Intel's 8085A microprocessor. The Intel 8085A is a new generation, complete 8-bit parallel central processing unit (CPU). Its instruction set is 100% software upward compatible with the 8080A microprocessor, and it is designed to improve the present 8080A's performance by higher system speed. Its high level of system integration allows a minimum system of three IC's: 8085A (CPU), 8156 (RAM), and 8355/8755 (ROM/PROM). A block diagram of the 8085A microprocessor is shown in Figure 2.

System Integration — The 8085A incorporates all of the features that the 8224 (clock generator) and 8228 (system controller) provided for the 8080A, thereby offering a high level of system integration.

Addressing — The 8085A uses a multiplexed data bus. The 16-bit address is split between the 8-bit address bus and the 8-bit address/data bus. The on-chip address latches of 8155/8156/8355/8755 memory products allows a direct interface with the 8085A.

System Monitor

A compact but powerful system monitor is supplied with the SDK-85 to provide general software utilities and system diagnostics. It comes in a pre-programmed ROM.

Communications Interface

The SDK-85 communicates with the outside world through either the on-board LED display/keyboard combination, or the user's TTY terminal (jumper selectable).

Figure 1. SDK-85 System Design Kit Functional Block Diagram
INSIDE THE 8085:

Both memory and I/O can be easily expanded by simply soldering in additional devices in locations provided for this purpose. A large area of the board (45 sq. in.) is laid out as general purpose wire-wrap for the user's custom interfaces.

Assembly

Only a few simple tools are required for assembly; soldering iron, cutters, screwdriver, etc. The SDK-85 user's manual contains step-by-step instructions for easy assembly without mistakes. Once construction is complete, the user connects his kit to a power supply and the SDK-85 is ready to go. The monitor starts immediately upon power-on or reset.

Table 1. Keyboard Monitor Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reset</td>
<td>Starts monitor. Allows user to execute user program.</td>
</tr>
<tr>
<td>Go</td>
<td>Allows user to execute user program one instruction at a time—useful for debugging.</td>
</tr>
<tr>
<td>Single step</td>
<td>Allows user to examine and modify memory locations.</td>
</tr>
<tr>
<td>Substitute memory</td>
<td>Allows user to examine and modify 8085A's register contents.</td>
</tr>
<tr>
<td>Examine register</td>
<td>Allows user to examine and modify 8085A's register contents.</td>
</tr>
<tr>
<td>Vector interrupt</td>
<td>Serves as user interrupt button.</td>
</tr>
</tbody>
</table>

Table 2. Teletype Monitor Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display memory</td>
<td>Displays multiple memory locations.</td>
</tr>
<tr>
<td>Substitute memory</td>
<td>Allows user to examine and modify memory locations one at a time.</td>
</tr>
<tr>
<td>Insert instructions</td>
<td>Allows user to store multiple bytes in memory.</td>
</tr>
<tr>
<td>Move memory</td>
<td>Allows user to move blocks of data in memory.</td>
</tr>
<tr>
<td>Examine register</td>
<td>Allows user to examine and modify the 8085A's register contents.</td>
</tr>
<tr>
<td>Go</td>
<td>Allows user to execute user programs.</td>
</tr>
</tbody>
</table>

Documentation

In addition to detailed information on using the monitors, the SDK-85 user's manual provides circuit diagrams, a monitor listing, and a description of how the system works. The complete design library for the SDK-85 is shown in Figure 7-11 and listed in the Specifications section under Reference Manuals.
Figure 3. SDK-85 Design Library

8085A INSTRUCTION SET

Table 3 contains a summary of processor instructions used for the 8085A microprocessor.

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Description</th>
<th>Instruction Code</th>
<th>Clock Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOVE, LOAD, AND STORE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOV 11/2</td>
<td>Move register to register</td>
<td>0 1 0 0 0 0 0 0</td>
<td>1</td>
</tr>
<tr>
<td>MOV M/L</td>
<td>Move register to memory</td>
<td>0 1 0 0 0 0 0 0</td>
<td>7</td>
</tr>
<tr>
<td>MOV M/L</td>
<td>Move register to register</td>
<td>0 1 0 0 0 0 0 0</td>
<td>7</td>
</tr>
<tr>
<td>MVI r</td>
<td>Move immediate register</td>
<td>0 0 0 1 0 0 0 0</td>
<td>7</td>
</tr>
<tr>
<td>MVI M</td>
<td>Move immediate memory</td>
<td>0 0 0 1 0 0 0 0</td>
<td>10</td>
</tr>
<tr>
<td>LXI B</td>
<td>Load immediate register</td>
<td>0 0 0 0 0 0 0 0</td>
<td>10</td>
</tr>
<tr>
<td>LXI D</td>
<td>Load immediate register</td>
<td>0 0 0 0 0 0 0 0</td>
<td>10</td>
</tr>
<tr>
<td>LXI H</td>
<td>Load immediate register</td>
<td>0 0 0 0 0 0 0 0</td>
<td>10</td>
</tr>
<tr>
<td>STAX B</td>
<td>Store A indirect</td>
<td>0 0 0 0 0 0 0 0</td>
<td>7</td>
</tr>
<tr>
<td>STAX D</td>
<td>Store A indirect</td>
<td>0 0 0 0 0 0 0 0</td>
<td>7</td>
</tr>
<tr>
<td>LDAX B</td>
<td>Load A indirect</td>
<td>0 0 0 0 0 0 0 0</td>
<td>7</td>
</tr>
<tr>
<td>LDAX D</td>
<td>Load A indirect</td>
<td>0 0 0 0 0 0 0 0</td>
<td>7</td>
</tr>
<tr>
<td>STA</td>
<td>Store A direct</td>
<td>0 0 1 1 0 0 0 0</td>
<td>13</td>
</tr>
<tr>
<td>LDA</td>
<td>Load A direct</td>
<td>0 0 1 1 0 0 0 0</td>
<td>13</td>
</tr>
<tr>
<td>SHLD</td>
<td>Store H &amp; L direct</td>
<td>0 0 1 1 0 0 0 0</td>
<td>16</td>
</tr>
<tr>
<td>LHL</td>
<td>Load H &amp; L direct</td>
<td>0 0 1 1 0 0 0 0</td>
<td>16</td>
</tr>
<tr>
<td>XCHG</td>
<td>Exchange D &amp; E, H &amp; L registers</td>
<td>1 1 0 0 1 0 0 0</td>
<td>4</td>
</tr>
<tr>
<td>STACK OPS</td>
<td>Push B</td>
<td>Push register pair B &amp; C on stack</td>
<td>1 1 0 0 0 0 1 0</td>
</tr>
<tr>
<td>Push D</td>
<td>Push register pair D &amp; E on stack</td>
<td>1 1 0 0 0 0 1 0</td>
<td>12</td>
</tr>
<tr>
<td>Push H</td>
<td>Push register pair H &amp; L on stack</td>
<td>1 1 0 0 0 0 1 0</td>
<td>12</td>
</tr>
<tr>
<td>Push PSW</td>
<td>Push A and flags on stack</td>
<td>1 1 1 1 0 1 0 0</td>
<td>12</td>
</tr>
<tr>
<td>POP B</td>
<td>Pop register pair B &amp; C off stack</td>
<td>1 1 0 0 0 0 0 1</td>
<td>10</td>
</tr>
<tr>
<td>POP D</td>
<td>Pop register pair D &amp; E off stack</td>
<td>1 1 0 0 0 0 0 1</td>
<td>10</td>
</tr>
<tr>
<td>POP H</td>
<td>Pop register pair H &amp; L off stack</td>
<td>1 1 1 1 0 0 0 0</td>
<td>10</td>
</tr>
<tr>
<td>POP PSW</td>
<td>Pop A and flags off stack</td>
<td>1 1 1 1 1 0 0 0</td>
<td>10</td>
</tr>
<tr>
<td>XTHL</td>
<td>Exchange top of stack</td>
<td>1 1 1 1 0 0 0 1</td>
<td>16</td>
</tr>
<tr>
<td>SPHL</td>
<td>H &amp; L to stack pointer</td>
<td>1 1 1 1 1 0 0 1</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Description</th>
<th>Instruction Code</th>
<th>Clock Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>LXI SP</td>
<td>Load immediate stack pointer</td>
<td>0 0 1 1 0 0 0 0</td>
<td>10</td>
</tr>
<tr>
<td>INX SP</td>
<td>Increment stack pointer</td>
<td>0 0 1 1 0 0 0 0</td>
<td>6</td>
</tr>
<tr>
<td>DCX SP</td>
<td>Decrement stack pointer</td>
<td>0 0 1 1 1 0 0 0</td>
<td>6</td>
</tr>
<tr>
<td>JUMP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JMP</td>
<td>Jump unconditional</td>
<td>1 1 0 0 0 0 0 0</td>
<td>10</td>
</tr>
<tr>
<td>JNC</td>
<td>Jump on no carry</td>
<td>1 1 1 0 0 0 0 0</td>
<td>7/10</td>
</tr>
<tr>
<td>JNZ</td>
<td>Jump on no zero</td>
<td>1 1 0 0 0 0 0 0</td>
<td>7/10</td>
</tr>
<tr>
<td>JP</td>
<td>Jump on positive</td>
<td>1 1 1 0 0 0 0 0</td>
<td>7/10</td>
</tr>
<tr>
<td>JM</td>
<td>Jump on minus</td>
<td>1 1 1 0 0 0 0 0</td>
<td>7/10</td>
</tr>
<tr>
<td>JPE</td>
<td>Jump on parity even</td>
<td>1 1 1 0 0 0 0 0</td>
<td>7/10</td>
</tr>
<tr>
<td>JPO</td>
<td>Jump on parity odd</td>
<td>1 1 1 0 0 0 0 0</td>
<td>7/10</td>
</tr>
<tr>
<td>PCHL</td>
<td>H &amp; L to program counter</td>
<td>1 1 1 0 0 0 0 0</td>
<td>6</td>
</tr>
<tr>
<td>CALL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CALL</td>
<td>Call unconditional</td>
<td>1 1 0 0 0 0 0 0</td>
<td>18</td>
</tr>
<tr>
<td>CC</td>
<td>Call on carry</td>
<td>1 1 1 0 0 0 0 0</td>
<td>9/16</td>
</tr>
<tr>
<td>CNC</td>
<td>Call on no carry</td>
<td>1 1 1 0 0 0 0 0</td>
<td>9/16</td>
</tr>
<tr>
<td>CZ</td>
<td>Call on zero</td>
<td>1 1 0 0 0 0 0 0</td>
<td>9/16</td>
</tr>
<tr>
<td>CNZ</td>
<td>Call on no zero</td>
<td>1 1 0 0 0 0 0 0</td>
<td>9/16</td>
</tr>
<tr>
<td>CP</td>
<td>Call on positive</td>
<td>1 1 1 0 0 0 0 0</td>
<td>9/16</td>
</tr>
<tr>
<td>CM</td>
<td>Call on minus</td>
<td>1 1 1 0 0 0 0 0</td>
<td>9/16</td>
</tr>
<tr>
<td>CPE</td>
<td>Call on parity even</td>
<td>1 1 1 0 0 0 0 0</td>
<td>9/16</td>
</tr>
<tr>
<td>CPO</td>
<td>Call on parity odd</td>
<td>1 1 1 0 0 0 0 0</td>
<td>9/16</td>
</tr>
<tr>
<td>RETURN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RET</td>
<td>Return</td>
<td>1 1 0 0 0 0 0 0</td>
<td>10</td>
</tr>
<tr>
<td>RC</td>
<td>Return on carry</td>
<td>1 1 0 0 0 0 0 0</td>
<td>6/12</td>
</tr>
<tr>
<td>RNC</td>
<td>Return on no carry</td>
<td>1 1 0 0 0 0 0 0</td>
<td>6/12</td>
</tr>
<tr>
<td>RZ</td>
<td>Return on zero</td>
<td>1 1 0 0 0 0 0 0</td>
<td>6/12</td>
</tr>
<tr>
<td>RNZ</td>
<td>Return on no zero</td>
<td>1 1 0 0 0 0 0 0</td>
<td>6/12</td>
</tr>
<tr>
<td>RP</td>
<td>Return on positive</td>
<td>1 1 1 0 0 0 0 0</td>
<td>6/12</td>
</tr>
<tr>
<td>RM</td>
<td>Return on minus</td>
<td>1 1 1 0 0 0 0 0</td>
<td>6/12</td>
</tr>
</tbody>
</table>

17-12

continued
Table 3. Summary of 8085A Processor Instructions (Continued)

<table>
<thead>
<tr>
<th>Mnemonic 1</th>
<th>Description</th>
<th>Instruction Code 2</th>
<th>Clock 3 Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPE</td>
<td>Return on parity even</td>
<td>1 1 1 0 1 0 0 0</td>
<td>6/12</td>
</tr>
<tr>
<td>RPO</td>
<td>Return on parity odd</td>
<td>1 1 1 0 0 0 0 0</td>
<td>6/12</td>
</tr>
<tr>
<td>RESTART</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RST</td>
<td>Restart</td>
<td>1 1 A A A 1 1 1</td>
<td>12</td>
</tr>
<tr>
<td>INCRTN AND DECREMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INR r</td>
<td>Increment register</td>
<td>0 0 D D D 1 0 0</td>
<td>4</td>
</tr>
<tr>
<td>DCR r</td>
<td>Decrement memory</td>
<td>0 0 D D D 1 0 1</td>
<td>4</td>
</tr>
<tr>
<td>INR M</td>
<td>Increment memory</td>
<td>0 0 1 1 0 1 0 0</td>
<td>10</td>
</tr>
<tr>
<td>DCR M</td>
<td>Decrement memory</td>
<td>0 0 1 1 0 1 0 1</td>
<td>10</td>
</tr>
<tr>
<td>INX B</td>
<td>Increment B &amp; C registers</td>
<td>0 0 0 0 0 0 0 1 1</td>
<td>6</td>
</tr>
<tr>
<td>INX D</td>
<td>Increment D &amp; E registers</td>
<td>0 0 0 1 0 0 0 1 1</td>
<td>6</td>
</tr>
<tr>
<td>INX H</td>
<td>Increment H &amp; L registers</td>
<td>0 0 1 0 0 0 1 1 6</td>
<td></td>
</tr>
<tr>
<td>DCX B</td>
<td>Decrease B &amp; C</td>
<td>0 0 0 0 1 0 0 1 1</td>
<td></td>
</tr>
<tr>
<td>DCX D</td>
<td>Decrease D &amp; E</td>
<td>0 0 0 1 1 0 0 1 1</td>
<td></td>
</tr>
<tr>
<td>DCX H</td>
<td>Decrease H &amp; L</td>
<td>0 0 1 0 1 0 0 1 6</td>
<td></td>
</tr>
<tr>
<td>ADD r</td>
<td>Add register to A</td>
<td>1 0 0 0 0 0 S S</td>
<td>4</td>
</tr>
<tr>
<td>ADC r</td>
<td>Add register to A with carry</td>
<td>1 0 0 0 0 1 S S</td>
<td>4</td>
</tr>
<tr>
<td>ADD M</td>
<td>Add memory to A</td>
<td>1 0 0 0 0 0 1 1 0</td>
<td>7</td>
</tr>
<tr>
<td>ADC M</td>
<td>Add memory to A with carry</td>
<td>1 0 0 0 0 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>ADI</td>
<td>Add immediate to A</td>
<td>1 1 0 0 0 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>ACI</td>
<td>Add immediate to A</td>
<td>1 1 0 0 1 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>DAD B</td>
<td>Add B &amp; C to H &amp; L</td>
<td>0 0 0 0 1 0 0 1 10</td>
<td></td>
</tr>
<tr>
<td>DAD D</td>
<td>Add D &amp; E to H &amp; L</td>
<td>0 0 0 1 1 0 0 1 10</td>
<td></td>
</tr>
<tr>
<td>DAD H</td>
<td>Add H &amp; L to H &amp; L</td>
<td>0 0 1 0 1 0 0 1 10</td>
<td></td>
</tr>
<tr>
<td>DAD SP</td>
<td>Add stack pointer to H &amp; L</td>
<td>0 0 1 1 1 0 0 1 10</td>
<td></td>
</tr>
<tr>
<td>SUB r</td>
<td>Subtract register from A</td>
<td>1 0 0 1 0 0 S S</td>
<td>4</td>
</tr>
<tr>
<td>SBB r</td>
<td>Subtract register from A</td>
<td>1 0 0 1 1 1 S S</td>
<td>4</td>
</tr>
<tr>
<td>SUB M</td>
<td>Subtract memory from A</td>
<td>1 0 0 1 0 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>SBB M</td>
<td>Subtract memory from A</td>
<td>1 0 0 1 1 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>SUI</td>
<td>Subtract Immediate from A</td>
<td>1 1 0 1 0 1 1 1 0</td>
<td></td>
</tr>
<tr>
<td>SBI</td>
<td>Subtract Immediate from A</td>
<td>1 1 0 1 1 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>LOGICAL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANA r</td>
<td>And register with A</td>
<td>1 0 1 0 0 S S S</td>
<td>4</td>
</tr>
<tr>
<td>XRA r</td>
<td>Exclusive Or register with A</td>
<td>1 0 1 0 1 S S S</td>
<td>4</td>
</tr>
<tr>
<td>ORA r</td>
<td>Or register with A</td>
<td>1 0 1 1 0 S S S</td>
<td>4</td>
</tr>
<tr>
<td>CMP r</td>
<td>Compare register with A</td>
<td>1 0 1 1 1 S S S</td>
<td>4</td>
</tr>
<tr>
<td>ANA M</td>
<td>And memory with A</td>
<td>1 0 1 0 0 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>XRA M</td>
<td>Exclusive Or memory with A</td>
<td>1 0 1 0 1 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>ORA M</td>
<td>Or memory with A</td>
<td>1 0 1 1 0 1 1 0 7</td>
<td></td>
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<tr>
<td>CMP M</td>
<td>Compare memory with A</td>
<td>1 0 1 1 1 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>ANI</td>
<td>And immediate with A</td>
<td>1 1 1 0 0 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>XRI</td>
<td>Exclusive Or immediate A</td>
<td>1 1 1 0 1 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>ORI</td>
<td>Or immediate with A</td>
<td>1 1 1 1 0 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>CPI</td>
<td>Compare immediate with A</td>
<td>1 1 1 1 1 1 1 0 7</td>
<td></td>
</tr>
<tr>
<td>ROTATE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLC</td>
<td>Rotate A left</td>
<td>0 0 0 0 0 0 1 1 1</td>
<td>4</td>
</tr>
<tr>
<td>RRC</td>
<td>Rotate A right</td>
<td>0 0 0 0 1 1 1 1 4</td>
<td></td>
</tr>
<tr>
<td>RAL</td>
<td>Rotate A left through carry</td>
<td>0 0 0 1 0 1 1 1 4</td>
<td></td>
</tr>
<tr>
<td>RAR</td>
<td>Rotate A right through carry</td>
<td>0 0 0 1 1 1 1 1 4</td>
<td></td>
</tr>
<tr>
<td>SPECIALS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMA</td>
<td>Complement A</td>
<td>0 0 1 0 1 1 1 1 4</td>
<td></td>
</tr>
<tr>
<td>STC</td>
<td>Set carry</td>
<td>0 0 1 1 1 1 1 1 4</td>
<td></td>
</tr>
<tr>
<td>CMC</td>
<td>Complement carry</td>
<td>0 0 1 1 1 1 1 1 4</td>
<td></td>
</tr>
<tr>
<td>DAA</td>
<td>Decimal adjust A</td>
<td>0 0 1 0 0 1 1 1 4</td>
<td></td>
</tr>
<tr>
<td>INPUT/OUTPUT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN</td>
<td>Input</td>
<td>1 1 0 1 1 1 0 1</td>
<td>10</td>
</tr>
<tr>
<td>OUT</td>
<td>Output</td>
<td>1 1 0 1 0 0 1 1</td>
<td>10</td>
</tr>
<tr>
<td>CONTROL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EI</td>
<td>Enable interrupts</td>
<td>1 1 1 1 1 1 0 1</td>
<td>4</td>
</tr>
<tr>
<td>DI</td>
<td>Disable interrupts</td>
<td>1 1 1 1 0 0 1 1</td>
<td>4</td>
</tr>
<tr>
<td>NOP</td>
<td>No-operation</td>
<td>0 0 0 0 0 0 0 0</td>
<td>4</td>
</tr>
<tr>
<td>HLT</td>
<td>Halt</td>
<td>0 1 1 1 1 1 0 1</td>
<td>5</td>
</tr>
<tr>
<td>NEW 8085 INSTRUCTIONS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIM</td>
<td>Read interrupt mask</td>
<td>0 0 1 0 0 0 0 0</td>
<td>4</td>
</tr>
<tr>
<td>SIM</td>
<td>Set interrupt mask</td>
<td>0 0 1 1 0 0 0 0</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes
1. All mnemonics copyright © Intel Corporation 1977.
2. DDD or SSS: B = 000, C = 001, D = 010, E = 011, H = 100, L = 101, Memory = 110, A = 111.
3. Two possible cycle times. (6/12) indicates instruction cycles dependent on condition flags.

SPECIFICATIONS

Central Processor
CPU — 8085A
Instruction Cycle — 1.3 μs
Tcy — 330 ns

Memory
ROM — 2K bytes (expandable to 4K bytes) 8355/8755A
RAM — 256 bytes (expandable to 512 bytes) 8155

Addressing
ROM — 0000–07FF (expandable to 0FFF with an additional 8355/8755A)
RAM — 2000–20FF (2800–28FF available with an additional 8155)

Note
The wire-wrap area of the SDK-85 PC board may be used for additional custom memory expansion up to the 64K-byte addressing limit of the 8085A.
SDK-85

Input/Output
Parallel — 38 lines (expandable to 76 lines)
Serial — Through SID/SOD ports of 8085A. Software generated baud rate.
Baud Rate — 110

Interfaces
Bus — All signals TTL compatible
Parallel I/O — All signals TTL compatible
Serial I/O — 20 mA current loop TTY

Note
By populating the buffer area of the board, the user has access to all bus signals that enable him to design custom system expansions into the kit’s wire-wrap area.

Interrupts
Three Levels
(RST 7.5) — Keyboard interrupt
(RST 6.5) — TTL input
(INTR) — TTL input

DMA
Hold Request — Jumper selectable. TTL compatible input.

Software
System Monitor — Pre-programmed 8755A or 8355 ROM Addresses — 0000–07FF
Monitor I/O — Keyboard/display or TTY (serial I/O)

Physical Characteristics
Width — 12.0 in. (30.5 cm)
Height — 10 in. (25.4 cm)
Depth — 0.50 in. (1.27 cm)
Weight — approx. 12 oz

Electrical Characteristics
DC Power Requirement (power supply not included in kit)

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC 5V ± 5%</td>
<td>1.3A</td>
</tr>
<tr>
<td>VTTY 10V ± 10%</td>
<td>0.3A</td>
</tr>
</tbody>
</table>

(VTTY required only if teletype is connected)

Environmental Characteristics
Operating Temperature — 0–55°C

Reference Manuals
9800451 — SDK-85 User’s Manual (SUPPLIED)
9800366 — MCS-85 User’s Manual (SUPPLIED)
9800301 — 8080/8085 Assembly Language Programming Manual (SUPPLIED)
8085/8080 Assembly Language Reference Card (SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDK-85</td>
<td>MCS-85 system design kit</td>
</tr>
</tbody>
</table>

17-14
The SDK-51 MCS-51 System Design Kit contains all of the components required to assemble a complete single-board microcomputer based on Intel's high-performance 8051 single-chip microcomputer. SDK-51 uses the external ROM version of the 8051 (8031). Once you have assembled the kit and supplied +5V power, you can enter programs in MCS-51 assembly language mnemonics, translate them into MCS-51 object code, and run them under control of the system monitor. The kit supports optional memory and interface configurations, including a serial terminal link, audio cassette storage, EPROM program memory, and Intellec® development system upload and download capability.
FUNCTIONAL DESCRIPTION
The SDK-51 is a kit which includes hardware and software components to assemble a complete MCS-51 family single-board microcomputer. Only common laboratory tools and test equipment are required to assemble the kit. Assembly generally requires 5 to 10 hours, depending on the experience of the user.

The MCS-51 Microcomputer Series
MCS-51 is a series of high-performance single-chip microcomputers for use in sophisticated real-time applications such as instrumentation, industrial control and intelligent computer peripherals. The 8031, 8051, and 8751 microcomputers belong to the 8051 family, which is the first family in the MCS-51 series.

In addition to their advanced features for control applications, MCS-51 family devices have a microprocessor bus and arithmetic capability such as hardware multiply and divide instructions, which make the SDK-51 a versatile stand-alone microcomputer board.

The 8031, 8051, and 8751 CPUs
The 8031, 8051, and 8751 CPUs each combine, on a single chip, a 128 x 8 data RAM; 32 input/output lines; two 16-bit timer/event counters; a five-source, two-level nested interrupt structure; a serial I/O port; and on-chip oscillator and clock circuits. An 8051 block diagram is shown in Figure 1. The 8031, the SDK-51's CPU, is a CPU without on-chip program memory. The 8031 can address 64K bytes of external program memory in addition to 64K bytes of external data memory. For systems requiring extra capability, each member of the 8051 family can be expanded using standard memories and the byte-oriented MCS-80 and MCS-85 peripherals. The 8051 is an 8031 with the lower 4K bytes of program memory filled with on-chip mask-programmable ROM while the 8751 has 4K bytes of ultraviolet light-erasable, electrically programmable ROM (EPROM).

The 8031 CPU operates at a 12 MHz clock rate, resulting in 4 μs multiply and divide and other instructions of 1 μs and 2 μs.

For additional information on the 8051 family, see the 8051 User's Manual or MCS-51 Macroassembler User's Guide.

Figure 1. 8051 Block Diagram
System Software
A compact but powerful system monitor is contained in 8K bytes of pre-programmed ROM. The monitor includes system utilities such as command interpretation, user program debugging, and interface controls. Table 1 summarizes the SDK-51 monitor commands.

The ROM devices also include a single-line assembler and disassembler. The assembler lets you enter programs in MCS-51 assembly language mnemonics directly from the ASCII keyboard. The disassembler supports debugging by letting you look at MCS-51 instructions in mnemonic form during system interrogation.

Memory
The two 64K external memory spaces are combined into a single memory space which you can configure between program memory and data memory. The kit includes 1K-byte of static RAM. The board has space and printed circuitry for an additional 15K bytes of RAM and 8K bytes of ROM.

User Interface
The kit includes a typewriter-format, ASCII-subset keyboard and a 24-character, alpha-numeric LED

Table 1. SDK-51 Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set breakpoint</td>
<td>Define addresses for breaking execution.</td>
</tr>
<tr>
<td>Display cause</td>
<td>Ask the system why execution stopped.</td>
</tr>
<tr>
<td>Upload, download</td>
<td>Transfer files to and from Intellect development system.</td>
</tr>
<tr>
<td>Save, load</td>
<td>Transfer files to and from optional cassette interface.</td>
</tr>
<tr>
<td>Set top of program memory</td>
<td>Define partition between program memory and data memory.</td>
</tr>
<tr>
<td>Set baud</td>
<td>Define baud rate value of serial port.</td>
</tr>
<tr>
<td>Display memory</td>
<td>Examine and change program memory or data locations.</td>
</tr>
<tr>
<td>Assemble</td>
<td>Translate an MCS-51 assembly mnemonic into object code.</td>
</tr>
<tr>
<td>Disassemble</td>
<td>Translate program memory into MCS-51 assembly language mnemonics.</td>
</tr>
<tr>
<td>Go</td>
<td>Start execution between a selected pair of addresses.</td>
</tr>
<tr>
<td>Step</td>
<td>Execute a specified number of instructions.</td>
</tr>
</tbody>
</table>

Figure 2. Block Diagram of SDK-51 System Design Kit
display. The standard keyboard and display provide full access to all of the SDK-51's capabilities. All of the SDK-51 interfaces are controlled by a pre-programmed Intel 8041 Universal Peripheral Interface.

A 3 x 4 matrix keyboard can be jumpered to port 1 of the 8031.

Optional Interfaces

TERMINAL
An RS-232-compatible CRT or printing terminal or a current-loop-interface terminal may be used as a listing device by connecting it to the board's serial interface connector and supplying +12 and -12 volts to the board.

AUDIO CASSETTE
The kit includes hardware, software, and user's guide instructions to connect and operate an audio cassette tape recorder for low-cost program and data storage.

INTELLEC SYSTEM
An SDK-51 and an Intellec Model 800 or Series II development system with ISIS-II can upload and download files through the serial interface without adding any software to the Intellec system.

Parallel I/O
The kit includes an Intel 8155 parallel I/O device which expands the 8031 I/O capability by providing 22 dedicated parallel lines. Three 40-pin headers between the 8031 and 8155 devices and the wire-wrap area facilitate interconnections with the user's custom circuitry.

Debugging
Hardware breakpoint logic in the SDK-51 checks the address of a program or external data-memory access against values defined by the user and stops execution when it sees a "break" condition. After a breakpoint, you can examine and modify registers, memory locations, and other points in the system. A step command lets you execute instructions in a single-step mode.

Assembly and Test
The SDK-51 assembly manual describes hardware assembly in a step-by-step process that includes checking each hardware subsystem as it is installed. Building the system requires only a few common tools and standard laboratory instruments.

Figure 3. SDK-51 Assembled with Additional RAM and ROM Devices Installed

SPECIFICATIONS

Control Processor
Intel 8031 microcomputer 12 MHz clock rate

Memory
RAM — 1K-byte static, expandable in 1K segments to 16K-byte with 2114 RAM devices; user-configurable as program or data memory.
ROM — Printed circuitry for 8K bytes of program memory in 4K segments using 2732A EPROM devices.

Interfaces
Keyboard — 51-key, ASCII subset, typewriter format, 12-key (3 x 4) matrix
Display — 24-character, alpha-numeric
Serial — RS-232 with user-selectable baud rate. Printed circuitry for 110 baud 20 mA current loop interface. 8031 serial port.
Parallel — 22 lines, TTL compatible
Cassette — Audio cassette tape storage interface
SDK-51

Software
System monitor preprogrammed in on-board ROM
MCS-51 assembler and disassembler preprogrammed in on-board ROM
Interface control software preprogrammed in 8041’s on-chip ROM

Assembly and Test Equipment Required
Needle-nose pliers
Small Phillips screwdriver
Small diagonal wire cutters
Soldering pencil, ±30 watts, 1/16” diameter tip
Rosin-core, 60-40 solder, 0.05” diameter
Volt-Ohm-Milliammeter, 1 meg-ohm input impedance
Oscilloscope, 1 volt/division vertical sensitivity, 200 µs/division sweep rate, single trace, internal and external triggering

Physical Characteristics
Length — 13.5 in. (34.29 cm)
Width — 12 in. (30.48 cm)
Height — 4 in. (10.16 cm)
Weight — 3 lb (1.36 kg)

Electrical Characteristics
DC Power Requirement (supplied by user, cable included with kit)

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 5V ± 5%</td>
<td>3A</td>
</tr>
<tr>
<td>+ 12V ± 5%*</td>
<td>100 mA</td>
</tr>
<tr>
<td>− 12V ± 5%*</td>
<td>100 mA</td>
</tr>
</tbody>
</table>

*± 12 volts required only for operation with serial interface.

Environmental Characteristics
Operating Temperature — 0 to 40°C
Relative Humidity — 10% to 90%, non-condensing

Reference Manuals
SDK-51 User’s Manual
SDK-51 Assembly Manual
SDK-51 Monitor Listing
MCS-51 Macro Assembler User’s Guide
MCS-51 Macro Assembly Language Pocket Reference

ORDERING INFORMATION
Part Number       Description
MCI-51-SDK         MCS-51 System Design Kit
The SDK-2920 contains all of the components required to assemble a complete single board microcomputer system for programming and evaluation of the 2920 Analog Signal Processor. The 8085/8041A microcomputer-based program development section allows you to immediately enter programs in 2920 assembly mnemonics, translate them to 2920 object code, and program the on-board 2920 EPROM. The kit supports basic filing options such as up/down loading to/from an Intellec, audio cassette, and line printer. The SDK-2920 also provides the user with a 2920 run mode section allowing real-time execution of a programmed 2920. This section comes complete with BNC connectors and Intel's 2912 PCM line filters required for one input and one output network. The kit supports optional input and output circuitry on the run mode section.
FUNCTIONAL DESCRIPTION
The SDK-2920 is a kit which includes all the necessary hardware and software components to assemble, using common laboratory tools and test equipment, a complete single board 2920 programming and evaluation aid. Assembly generally requires 4 to 8 hours, depending on the experience of the user.

The 2920 Signal Processor
The Intel® 2920 Signal Processor is a programmable, single chip analog and digital signal processor specifically designed to replace analog subsystems in real-time processing applications. Its instruction set plus the high precision (25 bits) digital arithmetic logic unit provides the capability to implement very complex subsystems. Typical functions performed by the 2920 include: lowpass and bandpass filters with up to 20 complex pole and/or zero pairs; threshold detectors; limiters; rectifiers; up to 25-bit multiplication and division; approximations to nonlinear functions such as square law and logarithm; logical operations; input and output multiplexing of signals; logical outputs for decision type processing; and analog outputs for multifrequency oscillators, waveform generators, etc. In addition, several 2920's may be cascaded for very complex processing applications with no loss in throughput rate.

Tables 1 and 2 show the 2920 instruction set and op codes.

Table 1. Shift Op Codes

<table>
<thead>
<tr>
<th>Operation</th>
<th>Mnemonic</th>
<th>Op Code</th>
<th>Scale Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift Right 13 Bits</td>
<td>R13</td>
<td>1 1 0 0</td>
<td>$2^{-13}$</td>
</tr>
<tr>
<td>Shift Right 12 Bits</td>
<td>R12</td>
<td>1 0 1 1</td>
<td>$2^{-12}$</td>
</tr>
<tr>
<td>No Shift</td>
<td>R00</td>
<td>1 1 1 1</td>
<td>1</td>
</tr>
<tr>
<td>Shift Left 1 Bit</td>
<td>L01</td>
<td>1 1 1 0</td>
<td>2</td>
</tr>
<tr>
<td>Shift Left 2 Bits</td>
<td>L02</td>
<td>1 1 0 1</td>
<td>4</td>
</tr>
</tbody>
</table>

System Software
A compact but powerful system monitor is contained in 6K bytes of preprogrammed ROM. The monitor includes system utilities such as command interpretation, user program debugging, and interface controls.

The monitor ROM devices also include a single-line assembler and disassembler. The assembler lets you enter programs in 2920 assembly language mnemonics. The disassembler supports debugging by letting you look at or change either hexadecimal values or 2920 instructions during program interrogation.

![Figure 1. 2920 Function Block Diagram (Run Mode)](image-url)
Table 2. Instruction Set and Op Codes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Instructions</td>
<td></td>
<td></td>
<td>2,1,0</td>
<td>1,0</td>
<td>2,1,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADD</td>
<td>110</td>
<td>(A × 2^N) + B − B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUB</td>
<td>101</td>
<td>B − (A × 2^N) − B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDA</td>
<td>111</td>
<td>(A × 2^N) + 0 − B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XOR</td>
<td>000</td>
<td>(A × 2^N) ⊕ B − B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AND</td>
<td>001</td>
<td>(A × 2^N) × B − B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABA[11]</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIM</td>
<td>010</td>
<td>Sign(A) − ± F.S. − B[4]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADD CND( )[2]</td>
<td>110</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUB CND( )[2,8]</td>
<td>101</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDA CND( )[2]</td>
<td>111</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XOR CND( )[9]</td>
<td>000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Analog Instructions**

<table>
<thead>
<tr>
<th>IN(K)</th>
<th>OUT(K)</th>
<th>CVTS</th>
<th>CVT(K)</th>
<th>EOP</th>
<th>NOP</th>
<th>CND(K)</th>
<th>CNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>10</td>
<td>00</td>
<td>01</td>
<td>00</td>
<td>00</td>
<td>11</td>
<td>00</td>
</tr>
</tbody>
</table>

**Notes:**

1. Op codes ALU and ADF are in binary notation, ADK is in decimal notation and represents the value "K" when appropriate.
2. CND( ) can be either CND(K) or CNDS testing amplitude bits or the sign bit of the DAR respectively.
3. Determined by analog instructions below.
4. B is set to full scale (F.S.) amplitude with the same sign as the "A" port operand.
5. The previous carry bit (CY) is tested to determine the operation. The present carry bit (CY) is loaded into the Kth bit location of the DAR. "Present carry (CY) is generated independent of overflow. It will represent the carry (CY) of a calculated 28-bit result."
6. EOP will also enable overflow correction if it was disabled during a program pass. The EOP must occur in ROM location 188.
7. Determined by digital instructions above.
8. For SUB CNDS Operation CY − DAR(S).
9. Does not affect DAR. In this case, CND is used with XOR/ABA to enable/disable the ALU overflow saturation algorithm. Use of either instruction causes the ALU output to roll over rather than go to full scale with sign bit preserved. An EOP instruction will also enable the ALU overflow saturation algorithm.
10. Clarification of CY OUT sense for certain operations. For LDA, XOR, AND, ABS; CYOUT = 0.

**Memory**

The kit contains 1.25K bytes of RAM for 2920 program development. The RAM is used as 2920 program memory for up to a 192-instruction 2920 program. The RAM space is also used for a symbol table up to 40 user defined symbols.

**User Interface**

The kit includes a function and hex keyboard and a formatted 24-character, 18-segment display for easy 2920 code entry. The interactive keyboard and display enables the system monitor to step the user through a command entry sequence with
the friendliness of a menu-driven operating system.

**Optional Interfaces**

An RS-232 or 20 mA current loop compatible CRT or printer may be used as a listing or file storage device by connecting it to the board's serial interface connector and supplying +12 and -12 volts to the board. In addition, the kit provides an audio cassette interface, allowing the use of an audio cassette as a mass storage device.

**Debugging**

Program development is made easy by use of interactive error messages that will inform the user of illegal entries at the time of program development. Syntax errors are checked for at time of EPROM programming, giving the user the option to continue the programming or not.

The run-mode section allows the user to execute a programmed 2920 in real time, with his own input stimulus and output circuit or instrumentation. The kit is supplied with the 2920-18 and a 5 MHz crystal (800 ns instructions). However, the kit will support the 2920-16 (600 ns instructions) with a 6.67 MHz crystal or clock.

**Assembly and Test**

The SDK-2920 assembly manual describes assembly in a step-by-step process that includes checking segments of hardware as they are installed. Building the system requires only a few common tools and standard instruments.

---

**Figure 2. Keyboard Arrangement**

**Figure 3. Assembled SDK-2920**

**Figure 4. Display Layout**

**Figure 5. SDK-2920 Functional Block Diagram**
Table 3. SDK-2920 Control Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESET</td>
<td>Sets the monitor to its initialization program and responds to the selection of one of the four modes. The display will prompt the user with EDIT? LOAD? LIST? CONV?.</td>
</tr>
<tr>
<td>SHIFT</td>
<td>Selects the upper case characters or functions.</td>
</tr>
<tr>
<td>EDIT</td>
<td>Selects the edit mode, allowing for 2920 program entry and/or modification. The commands available in the edit mode are shown below in Table 4.</td>
</tr>
<tr>
<td>LOAD</td>
<td>Selects the load mode, providing for up/down loading to/from the RS-232, cassette, or the 20 mA current loop interfaces. It also provides for 2920 EPROM read, program and verify.</td>
</tr>
<tr>
<td>LIST</td>
<td>Selects the list mode, providing for listing the 2920 program source code, symbol table, and 2920 hex code to a line printer via the RS-232 interface.</td>
</tr>
<tr>
<td>CONV</td>
<td>Selects the decimal-to-binary-to-decimal conversion program.</td>
</tr>
</tbody>
</table>

Table 4. Edit Mode Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>→</td>
<td>Cursor Right</td>
</tr>
<tr>
<td>←</td>
<td>Cursor Left</td>
</tr>
<tr>
<td>NEXT</td>
<td>Next Instruction</td>
</tr>
<tr>
<td>PREV</td>
<td>Previous Instruction</td>
</tr>
<tr>
<td>LIST</td>
<td>List Memory</td>
</tr>
<tr>
<td>HEX/ASM</td>
<td>Mode Toggle</td>
</tr>
<tr>
<td>INSRT</td>
<td>Insert Instruction</td>
</tr>
<tr>
<td>DEL</td>
<td>Delete Instruction</td>
</tr>
</tbody>
</table>

Figure 6. Load Command and Display Tree
SPECIFICATIONS

Control Processor
Intel 8085A microprocessor
6.144 MHz clock rate

Memory
RAM — 1.25K-byte static
ROM — 6K-byte

Interfaces
Keyboard — 28-key with shift, providing 54 functions and characters
Display — 24-character, 18-segment LED
Serial — RS-232 with user-selectable baud rate and 20 mA current loop
Cassette — Hardware and software for audio cassette tape storage interface

Software
System monitor preprogrammed in ROM
2920 assembler and disassembler preprogrammed in ROM
Interface control software preprogrammed in 8041 on-chip ROM

Assembly and Test Equipment Required
• Needle-nose pliers
• Small Phillips screwdriver
• Small flat-blade screwdriver
• Small diagonal wire cutters
• Soldering pencil, <30 watts, 1/16" diameter tip
• Rosin-core, 60-40 solder, 0.05" diameter
• Volt-ohm-millimeter, 1 meg ohm input impedance
• Oscilloscope, 1 volt/division vertical sensitivity, 200 μs/division sweep rate, single trace, internal and external triggering

Physical Characteristics
Length — 16 in. (40.64 cm)
Width — 10 in. (25.40 cm)
Height — 4 in. (10.16 cm)
Weight — 3 lb (1.36 kg)

Electrical Characteristics
DC Power Requirements (supplied by user, cables included with the kit)

Program Development Section:
Voltage | Current | Comments
--- | --- | ---
+5V ± 5%  | 1.0A  | Required for program development
+12V ± 5% | 100 mA | Required for 2920 EPROM programming and RS-232 interface
-12V ± 5% | 100 mA | Required for RS-232 interface

Run Mode Section:
Voltage | Current | Comments
--- | --- | ---
+5V ± 5% | 300 mA | Required for operation as supplied
200 mA | Required for each additional 2912/74LS324 pair
-5V ± 5% | 250 mA | Required for operation as supplied
200 mA | Required for each additional 2912/74LS324 pair

Environmental Characteristics
Operating Temperature — 0 to 40°C
Relative Humidity — 10% to 90% non-condensing

Reference Manuals
SDK-2920 System Design Kit User's Guide
SDK-2920 System Design Kit Assembly Manual
2920 Analog Signal Processor Design Handbook

ORDERING INFORMATION

Part Number | Description
--- | ---
MCI-20-SDK | 2920 System Design Kit
INTELLEC PROMPT 48
MCS-48 MICROCOMPUTER DESIGN AID

Complete low cost design aid and EPROM programmer for revolutionary MCS-48 single component computers

Simplifies microcomputing, allowing user to enter, run, debug, and save machine language programs with calculator-like ease

Utilizes two removable 8-bit MCS-48 CPUs
- 8748 CPU with erasable, reprogrammable on-chip program memory
- 8035 CPU with off-chip program memory

1K-byte erasable, reprogrammable on-chip (8748), expandable program memory, 1K-byte RAM in PROMPT system

64 bytes RAM on-chip, expandable register memory

256 bytes expandable RAM data memory in PROMPT system

27 on-chip TTL compatible expandable I/O lines

On-chip clock, internal timer/event counter, two vectored interrupts, eight level stack control

Single +5V DC system power requirement

Integral keyboard and displays (no teletypewriter or CRT terminal required)

Extensive PROMPT 48 monitor, allowing system I/O, bus, and memory expansion

Includes comprehensive design library

The Intellec Prompt 48 MCS-48 Microcomputer Design Aid is a low cost, fully-assembled design aid for the revolutionary 8748 single component microcomputer. PROMPT 48 simplifies the programming of MCS-48 systems — programs may be entered and debugged with calculator-like ease on the large, informative display and keyboard panel. The comprehensive design library with tutorial manual is ideal for newcomers to microcomputing. PROMPT 48's panel connector allows easy access to I/O ports and system bus. Thus users can expand program memory beyond the 1K bytes provided internally.
FEATURES

Single Component Computer
The 8748 is the first microcomputer fully integrated on one component. All elements of a computing system are provided, including CPU, RAM, I/O, timer, interrupts, and erasable, reprogrammable nonvolatile program memory.

Programming Socket
PROMPT's programming socket programs this revolutionary "smart PROM"—the 8748—in a highly reliable, convenient manner. A fail-safe interlock ensures the device is properly inserted before applying programming pulses. Each location may be individually programmed, one byte at a time. A read-before-write programming algorithm prevents device damage by inadvertently programming unerased memory.

MCS-48 Processors
The execution socket accepts either an 8035 or an 8748 MCS-48 processor. Both are supplied with each PROMPT 48, and either can serve as heart of the PROMPT system. There are no processors within the PROMPT 48 mainframe, which instead contains monitor ROM and RAM, user RAM, peripherals, drivers, and sophisticated control circuitry. Once a processor is seated in the execution socket and power is applied, the PROMPT system comes to life. Various access modes may be selected such as program execution from PROMPT system RAM, or from on-chip PROM. Thus programs may first be executed from PROMPT RAM with the 8035 processor. When debugging is complete, the 8035 (execution socket) processor can program the 8748 (programming socket) processor. Finally, a programmed 8748 processor may be exercised by itself from the execution socket. The execution socket processor runs either monitor or user programs.

System Monitor
The system reset command initializes the PROMPT system and enters the monitor. The monitor interrupt command exits a user program gracefully, preserving system status and entering the monitor. The user interrupt command causes an interrupt only if the PROMPT system is running a user program. A comprehensive system monitor resides in four 1K-byte read only memories. It drives the PROMPT keyboard and displays and responds to commands and functions. The top 16 bytes of on-chip program memory must be used by the PROMPT system to switch between monitor and user programs. It requires one level of the MCS-48 eight-level stack.

Commands
PROMPT 48's commands are grouped and color-coded to simplify access to the 8748's separate program and data memory. Registers, data memory, or program memory, may be examined and modified with the examine and modify commands. Then either the next or previous register and memory locations may be accessed with one keystroke. Programs may be exercised in three modes. The go no break (GO NO BREAK) runs in real time. The go with break (GO WITH BREAK) mode is not real time — after each instruction the MCS-48 program counter is compared against pending breakpoints. If no break is encountered, execution resumes. The go single step (GO SINGLE STEP) mode exercises one instruction at a time. Commands are like sentences, with parameters separated by \texttt{NEXT}. Each command ends with \texttt{EXECUTE/END}. In addition to the PROMPT basic commands, thirteen functions simplify programming. Each is started merely by pressing a hex data/function key and entering parameters as required, as shown in Table 1.
Cable Interface

An optional cable, PROMPT-SER, directly connects the PROMPT system to virtually any terminal via a rear access slot.

<table>
<thead>
<tr>
<th>Key</th>
<th>Function</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Port 2 map</td>
<td>Allows specification of direction of each pin on port 2. Port 2 is multiplexed to address external program memory and expand I/O. Thus it must be buffered; the P2 map command establishes the direction of buffering.</td>
</tr>
<tr>
<td>3</td>
<td>Program EPROM</td>
<td>Programs 8748 EPROMs.</td>
</tr>
<tr>
<td>4</td>
<td>Byte search (with optional mask)</td>
<td>Sweeps through register, data, or program memory searching for byte matches. Starting and ending memory addresses are specified.</td>
</tr>
<tr>
<td>5</td>
<td>Word search (with optional mask)</td>
<td>Sweeps through register, data, or program memory searching for word matches. Starting and ending memory addresses are specified.</td>
</tr>
<tr>
<td>6</td>
<td>Hex calculator</td>
<td>Computes hexadecimal sums and differences.</td>
</tr>
<tr>
<td>7</td>
<td>8748 program for debug</td>
<td>Similar to program EPROM, but ensures that the top of program memory contains monitor re-entry code for debugging.</td>
</tr>
<tr>
<td>8</td>
<td>Compare</td>
<td>Verifies any portions of EPROM program memory against PROMPT memory.</td>
</tr>
<tr>
<td>9</td>
<td>Move memory</td>
<td>Allows blocks of register, data, or program memory to be moved.</td>
</tr>
<tr>
<td>A</td>
<td>Access</td>
<td>Specifies one of six access modes for PROMPT 48. For example EPROM, PROMPT RAM, or external program memory, and a variety of input/output options may be selected.</td>
</tr>
<tr>
<td>B</td>
<td>Breakpoint</td>
<td>Allows any or all of the eight breakpoints to be set and cleared.</td>
</tr>
<tr>
<td>C</td>
<td>Clear</td>
<td>Clears portions of register, data, or program memory.</td>
</tr>
<tr>
<td>D</td>
<td>Dump</td>
<td>Dumps register, data, or program memory to PROMPT's serial channel: for example, a teletypewriter paper tape punch.</td>
</tr>
<tr>
<td>E</td>
<td>Enter</td>
<td>Enters (reads) register, data, or program memory from PROMPT's serial channel.</td>
</tr>
<tr>
<td>F</td>
<td>Fetch</td>
<td>Fetches programs from EPROM to PROMPT RAM.</td>
</tr>
</tbody>
</table>

Table 1. PROMPT 48 Commands and Functions

Access

Easy access to the pins of the executing processor is provided via the I/O ports and bus connector. Only the EA external access, SS single step, and X1, X2 clock inputs are reserved for the PROMPT system.

Expansion

Program or data memory may be expanded beyond that provided on-chip or in the PROMPT system. I/O ports may be expanded, as with the 8243, or peripheral controllers may be memory-mapped. The I/O ports and Bus connector allows the execution socket processor to be directly interfaced to prototype systems, yet be controlled from the PROMPT panel.

Control

The command/function group panel keyboard and displays completely control PROMPT 48—a teletypewriter or CRT terminal is not needed. A hyphen prompting character appears whenever a command or function can be entered. Addresses and data are shown whenever examining registers and memory. Parameters for commands and functions are also shown.
FUNCTIONAL DESCRIPTION

"PROMPT" stands for PROgramming Tool. It is a programmer for 8748 EPROMs, and a versatile aid for debugging MCS-48 programs. Programs can be entered via its integral panel keyboard, programming socket, or serial channel. Almost any terminal can be interfaced to the serial channel, including a teletypewriter, CRT, or an Intellec microcomputer development system. Intellec PROMPT 48 simplifies the programming of MCS-48 systems. Like the 8748 it is radically new, highly integrated, and expandable. Like the MCS-48 family, it is low cost, and ideal for small applications and programs. It is a design aid, not a development system with sophisticated software and peripherals.

MCS-48 Processors

PROMPT 48 comes complete with two of Intel's revolutionary MCS-48 processors: an 8748-4 Single Component 8-Bit Microcomputer and an 8035-4 Single Component 8-Bit Microcomputer. Advances in n-channel MOS technology allow Intel, for the first time to integrate into one 40-pin component all computer functions: 8-bit CPU 1K x 8-bit EPROM/ROM program memory 64 x 8-bit RAM data memory 27 input/output lines 8-bit timer/event counter

Performance — More than 90 instructions — each one or two cycles — make the single chip MCS-48 equal in performance to most multi-chip microprocessors. The MCS-48 is an efficient controller and arithmetic processor, with extensive bit handling, binary, and BCD arithmetic instructions. These are encoded for minimum program length; 70% are single byte operation codes, and none is more than two bytes.

Flexibility — Three interchangeable, pin-compatible devices offer flexibility and low cost in development and production, as follows:

8748 — with user-programmable and erasable EPROM program memory for prototype and pre-productions systems.
8048 — with factory-programmed mask ROM memory for low-cost, high volume production.
8035 — without program memory, for use with external program memories.

Circuitry — Each MCS-48 processor operates on a single +5V supply, with internal oscillator and clock driver, and circuitry for interrupts and resets. Extra circuitry is in the 8048 ROM processor to allow low power standby operation. The 64 x 8 RAM data memory can be independently powered.

Compatibility — For systems requiring additional compatibility, the MCS-48 can be expanded with the new 8243 I/O expander, 8155 I/O and 256-byte RAM, 8755 I/O and 2K-byte EPROM, or 8355 I/O and 2K ROM devices. MCS-48 processors readily interface to MCS-80/85 peripherals and standard memories.

Memory Capacity

PROMPT 48 is a complete, fully assembled and powered microcomputer system including program memory, data memory, I/O, and system monitor beyond that available on MCS-48 single component computers. 1K bytes of PROMPT system RAM serve as "writable program memory" — a ROM simulator for the program memory on each MCS-48 computer. 256 bytes of PROMPT system RAM serve as "external data memory," beyond the 64 register bytes on each MCS-48 computer. Users may further expand program or data memory via the panel I/O ports and bus connector.

Programming

Programs written first in assembly language, are entered in machine language and debugged with calculator-like ease on the large, informative display and keyboard panel. Most MCS-48 operations can be specified with only two keystrokes. Once entered, routines can be exercised one instruction (single step) or many instructions at a time. The principal MCS-48 register — the accumulator — is displayed while single stepping. Programs can be executed in real time (GO NO BREAK) or with as many as eight different breakpoints (GO WITH BREAK).

Control

PROMPT 48 can be fully controlled either by the panel keyboard and displays, or remotely by a serial channel. Thus a teletypewriter or CRT can be used but neither is required.

Access

The PROMPT panel I/O ports and bus connector allow easy access to all MCS-48 pins except those reserved for control by the PROMPT system, namely EA external access, SS single step, and X1, X2 clock inputs.

Optional Expansion

PROMPT 48 may be expanded beyond the resources on both the MCS-48 single component computer and the PROMPT system. External program and data memory may be interfaced and input/output ports added with the 8243 I/O expander.
INTELLEC PROMPT 48

Documentation
The PROMPT 48 manual includes chapters for the reader with little or no programming experience. Topics treated range from number systems to microcomputer hardware design. A novel, unifying set of tutorial diagrams — MICROMAPS — simplify microcomputer concepts. PROMPT’s handy, pocket-sized reference cardlet can be affixed to the mainframe. Programming pads aid in the organization and documentation of programs. These features, plus a comprehensive design library of manuals, articles, and application notes, make the Intellec PROMPT 48 ideal for the newcomer to microcomputing.

SPECIFICATIONS
Timing
Basic Instruction — 2.5 μs
Cycle Time — tCY = 2.5 μs
Clock — 6 MHz ± 0.1%

Memory Bytes
The 8748 contains 64 bytes of register memory, no external data memory, and 1024 bytes of RAM program memory. The PROMPT system provides 256 bytes of external data memory, and 1024 bytes of RAM program memory. PROMPT RAM program memory can be used in place of the on-chip EPROM program memory; thus programs less than 1024 bytes may be designed. For larger programs additional memory can be directly interfaced to the MCS-48 bus via the PROMPT panel I/O ports and bus connector.

Memory Configuration

<table>
<thead>
<tr>
<th>Memory</th>
<th>Maximum</th>
<th>On Chip</th>
<th>In PROMPT 48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register</td>
<td>64</td>
<td>64</td>
<td>0</td>
</tr>
<tr>
<td>Data</td>
<td>3328</td>
<td>0</td>
<td>256</td>
</tr>
<tr>
<td>Program</td>
<td>4096</td>
<td>1024 EPROM</td>
<td>1024 RAM</td>
</tr>
</tbody>
</table>

I/O Ports
All MCS-48 I/O ports are accessible on the PROMPT panel connector.

Bus — A true bidirectional 8-bit port with associated strobes. If the bidirectional feature is not needed, bus can serve as either a statically latched output port or a non-latching input port. Input and output lines cannot be mixed.

Ports 1 and 2 — Data written to these 8-bit ports is latched and remains unchanged until written. As inputs these lines are not latching. The lines of ports 1 and 2 are called quasidirectional. A special output structure allows each line of port 1 and half of port 2 to serve as an input, an output, or both. Any mix of input, output, and both lines is allowed.

T0, T1, and INT — Three pins that can serve as inputs. T0 can be designated as a clock output. Input/output can be expanded via the PROMPT panel connector with a special I/O expander (8243) or standard peripherals.

Reset and Interrupts
Reset — initializes the PROMPT system and enters the monitor.
Monitor Interrupt — exits a user program gracefully, preserving system status and entering the monitor.

User Interrupt — causes an interrupt only if the PROMPT system is running a user program.

The processor traps to location 316. The MCS-48 timer/event counter is not used by the PROMPT system and is available to the user. Either timer flag or interrupt will signal when overflow has occurred. The timer interrupt can be used only in the go-no-break (real time) mode.

EPROM Programming
PROMPT 48 provides a programming socket to directly program 8748s. Programs are loaded into the PROMPT RAM program memory via keyboard. EPROM, teletype-writer, or other serial interface. A fail-safe interlock ensures programming pulses are applied only if the device is properly inserted. Inadvertent reprogramming is prevented by a read-before-write programming algorithm. Each location may be individually programmed, one byte at a time.

Panel I/O Ports and Bus Connectors
All MCS-48 pins, except five, are accessible on the I/O ports and bus connector. The five reserved for PROMPT system control are EA external access, SS single step, X1, X2 crystal inputs, and 5V. Due to internal buffering of the MCS-48 bus, access times will be negligibly degraded by the PROMPT system. Since MCS-48 processors do not communicate internal address gate status, bus data must be driven out if neither PSEN nor RD is asserted.

System Devices
Both user programs and the PROMPT monitor enjoy access to system devices: serial I/O, panel displays, and keyboard. These are memory-mapped to program memory addresses beyond 2K.

Serial I/O — The serial I/O port (data 82016, control 82116) is defined by software and jumpers for 110 baud, 20 mA current loop, but can easily be jumpered for other baud rates and RS232C levels. Asynchronous or synchronous transmission, data format, control characters, and parity can be programmed.

Panel Displays — Eight display ports (data 810-81716) allow each of the panel displays to be written from user programs. Data written on a display device will time out after a fixed interval. Displays must be refreshed on a polled or interrupt-driven basis. User programs can call software drivers which provide this capability.
Keyboard — Software is used to debounce the panel keyboard (data 810, 16). The monitor's input routines (see Software Drivers) provide this debouncing and can be called from user programs.

Commands

- Single step
- With break
- No break
- Register
- Data
- Program
- Memory
- Open previous/clear/entry
- Next
- Execute/End

Examining/modify
- Port 2 map
- Program EPROM (8748)
- Search (R, D or P)* memory for 1 byte, optional mask
- Search (R, D or P) memory for 2 bytes, optional mask
- Hexadecimal calculator +, -
- 8748 program EPROM for debug
- Compare EPROM with memory
- Move memory (R, D or P)
- Access
- Breakpoint
- Clear memory (R, D or P)
- Dump memory (R, D or P)
- Enter (read) memory (R, D or P)
- Fetch EPROM program memory

Note
* R, D, or P is register, data, or program.

Software Drivers

Panel Keyboard In — KBIN, KDBIN
Panel Display Out — DGS6, DGOUT, HXOUT, BLK, REFS, ENREF
Serial Channel — CI, CO, RI, PO, CSTS

Connectors

Serial I/O — 3M 3462-0001 Flat Crimp/AMP 88106-1 Flat Crimp/ TI H312113 Solder/AMP 1-583485-5 Solder.

Panel I/O ports and Bus Connector — 3M 3425 Flat Crimp. A complete cable set including wirewrap header for prototyping is included with each PROMPT.

Equipment Supplied

PROMPT 48 mainframe with two MCS-48 processors (8748, 8305), display/keyboard, EPROM programmer, power supply, cabinet, and ROM-based monitor.

- 110 V AC power cable
- 110 or 220 V AC
- Fuse
- Panel I/O ports
- Bus connector cable set

Physical Characteristics

- Height — 5.3 in. (13.5 cm) max
- Width — 17 in. (43.2 cm)
- Depth — 17 in. (43.2 cm) max
- Weight — 21 lb. (9.6 kg)

Electrical Characteristics

- Power Requirements — either 115 or 230V AC (± 10%) may be switch selected on the mainframe. 1.8 amps max current (at 125 V AC).
- Frequency — 47-63 Hz

Environmental Characteristics

- Operating Temperature — 0°C to +40°C
- Non-Operating Temperature — 20°C to +65°C

Reference Manuals

9800402 — Intellec PROMPT 48 User's Manual (SUPPLIED)
9800270 — MCS-48 User's Manual (SUPPLIED)
9800255 — MCS-48 and UPI-41 Assembly Language Programming Manual (SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROMPT-48</td>
<td>Intellec PROMPT 48 MCS-48 microcomputer design aid. Complete with two MCS-48 processors (8748 and 8305), EPROM programmer, integral keyboard, displays, and system monitor in ROM.</td>
</tr>
<tr>
<td>PROMPT-48-220V</td>
<td></td>
</tr>
<tr>
<td>PROMPT-SER</td>
<td>Serial cable for connecting PROMPT to TTY, CRT</td>
</tr>
</tbody>
</table>

18-6
The HSE-49™ emulator is a fully-assembled stand-alone development tool with on-board 33-key keypad, 8-character display, two 8039 microcontrollers, 2K bytes of user-program RAM, a serial port and cable, and a ROM-based monitor which supervises the emulator operation and user interface. The emulator provides a means for executing and debugging programs for the 8048/8049 family of microcontrollers at speeds up to 11 MHz. It interfaces to a user-designed system through an emulation cable and 40-pin plug, which replaces the MCS-48™ device in the user’s system. Using the HSE-49 keypad, a designer can run programs in real-time or single-step modes, set up to 8000 breakpoint flags, and display or change the contents of user program memory, internal and external data memory, and internal MCS-48 hardware registers. When linked to a host Intellec® development system, the HSE-49 emulator system-debugging capabilities, with the development system program assembly and storage facilities, provide the tools required for total product development.
FUNCTIONAL DESCRIPTION

The HSE-49 High-Speed Emulator is a stand-alone execution and debugging tool for 8048/8049 family microcontroller-based systems which are designed to run at speeds up to 11 MHz. It may be used alone or with other Intel microcomputer development system products to facilitate system integration early in the product development cycle, in parallel with hardware and software development. The convenient two-way debugging which early integration permits results in reduced total development time and cost.

System Development

SOFTWARE DEVELOPMENT

After an application program has been written in MCS-48 assembly language, the HSE-49 emulator may be used to debug software even if prototype hardware is not yet available.

Stand-alone Mode

The designer first hand assembles the source code from ASM-48 mnemonics into hex code, and then loads the program into the HSE-49 emulator user-program RAM through the on-board hex keypad, or through the serial port from a hex file stored on a user-supplied peripheral device. The emulator may then be used to execute the user program in a variety of debugging modes, and to alter the program as necessary. The altered program may then be uploaded to a user-supplied storage device.

Development System Mode

With an Intellec development system, the designer assembles the source code using the MCS-48 macroassembler and downloads the resulting hex file through the serial port and cable to the HSE-49 emulator user-program RAM. The emulator is then used to execute and debug the program as above. Finally, the resulting program is uploaded to the development system and stored in a disk file.

HARDWARE/SOFTWARE INTEGRATION

Prototype hardware may be developed off-board or on the wire-wrap area provided on the HSE-49 emulator board. The HSE-49 emulator interfaces to the user-system hardware through the supplied emulation cable, which plugs into the MCS-48 device socket in the user system. With the plug in place, the emulator executes code from the user-program memory and exercises the prototype hardware. Additional hardware is added as it becomes available, and the system is debugged using the emulator's capabilities to break emulation and to examine and change the user program and processor status values. The completed system may be final tested prior to ROM-code entry by replacing the HSE-49 emulation plug with a programmed 874X device in the user-system MCS-48 device socket, and running the system (with crystal input and power supplied) at full speed. Figure 1 shows a typical development configuration utilizing a host Intellec development system and the HSE-49 emulator, with the emulation cable interface to a user-designed system.

For enhanced system debugging capabilities the designer may elect to use Intel's ICE-49™ in-circuit emulator. The ICE-49 module permits real-time emulation of the user system up to 6 MHz, and offers the added benefits of symbolic debugging, 255 instruction-cycle real-time trace, and full emulation without the stack, interrupt or I/O limitations to which the HSE-49 emulator is subject (see discussion under "Limitations" heading). For further information on the ICE-49 emulator, refer to the ICE-49™ In-Circuit Emulator Data Sheet (order number 305200).

Emulator Overview

EMULATION AND MASTER PROCESSORS

The user’s program is emulated by an 8039 microprocessor, the emulation processor (EP), which executes code that is stored in 2K bytes of external RAM for ease of program development. Additional RAM may be added by the user in the provided sockets to expand program and external data memory to 4K bytes each.

A second microcontroller — an 8039 with off-chip ROM program memory — is used to scan the on-board keypad and display, interpret and imple-
ment commands, drive serial interfaces, etc. In general, this master processor (MP) is used to interface the emulation processor's memory spaces with the outside world and control the operation of the EP. Figure 2 shows how the two processors interrelate with the rest of the system. Figure 3 shows the layout of the 33-key keypad through which the user interfaces to the emulator.

**MP MONITOR**

The monitor program executed by the MP includes commands for filling, reading, or writing the various memory spaces, including the execution processor's program RAM, external ("MOVX") data RAM, accumulator, PSW, PC, timer/counter, working registers, and internal RAM; executing the user's program from arbitrary addresses in various debugging modes; and uploading or downloading object or data files from diskettes using a host development system. No special software is needed for the Intellec system other than ISIS II Version 3.4 or later. The data format is compatible with the standard Intel hex file format produced by ASM-48; the baud rate may be altered from 110 baud (default state) up to 1200 baud from the on-board keypad. Blocks of data may be transmitted to a CRT or printer and displayed in a tabular format.
INTERPROCESSOR COMMUNICATION

An 8212 8-bit latch is used to communicate data and commands between the master and emulation processors. Under control of the MP, this register, call the “Link” register, may be logically mapped into either the program or data RAM address spaces. When this is done, the RAM in the respective memory space is disabled and the link responds to all accesses regardless of address.

When the MP detects that the EP has been halted by the breakpoint hardware, or when the operator presses a key while the program is executing, the program break sequence is initiated. The low-order 23 bytes of user-program memory is read into a buffer within the internal RAM of the MP. A short program for reading and transmitting internal EP status is written into the low-order user-program memory. (This is one of several “mini-monitors” overlayed on the user-program area.) The link register is mapped logically into the user-program memory, and loaded with the 8049 machine code for a “CALL” instruction to the mini-monitor program area. The EP is then allowed to fetch a single instruction from the link, forcing the “CALL” to the mini-monitor onto the EP data bus.

The link register is then mapped to the external data RAM address space. A block diagram of the system at this point is shown in Figure 4.

From this point on, the EP executes code contained in the mini-monitor which makes the EP accumulator, timer/counter and PSW values available to the MP (through “MOVX” instructions to the link register) so that the EP internal status may be saved in the MP internal data RAM. The MP then loads a different mini-monitor into the same EP program RAM area which allows it to read and save the internal RAM of the EP.

At this point, the HSE-49 emulator may be interrogated or given instructions by the operator from the hex keypad. The emulator operation remains transparent to the user, who need not be concerned, for example, with the actual (altered) location of the EP low-order program RAM or internal data RAM.

In order to resume user-program execution, a status restoration mini-monitor is overlayed. This restores the EP internal status using a scheme analogous to the one in which the status was originally saved. The final step of the last mini-monitor is an “RETR” instruction, after which the EP is again halted. The low-order program memory saved earlier is rewritten into the appropriate area, the break logic is configured for the desired execution mode, and the EP is released to run at full speed until the next break situation is encountered.

Operation Modes

The HSE-49 firmware is a ROM-based program that provides the user with simple key-stroke commands for initiating emulation, defining breakpoints, and displaying and controlling system parameters. A summary of the HSE-49 emulator commands is given in Table 1.

SIX EMULATION MODES are provided by the HSE-49 emulator to aid in hardware and software debugging. The user may single-step through a program or have the emulator automatically step through the program with a user-defined idle time between steps. Three real-time emulation commands allow 1) real-time emulation with breakpoints not enabled (a user-accessible pulse is generated each time a breakpoint is encountered, however, facilitating user-defined logic analysis), 2) real-time emulation with breakpoints enabled, and 3) real-time emulation with automatic breakpointing, whereby the emulator executes in real time between breakpoints, and pauses at each breakpoint for a user-defined time before automatically resuming real-time emulation. A final command initiates real-time execution, beginning emulation at user-program location 000H, from the Emulator Processor hardware reset state.

BREAKPOINTS may be set at any combination of program memory and external data memory address locations from 000H to FFFH. This unlimited capability to specify breakpoints for all possible combinations of addresses complements the somewhat different breakpointing features available with the ICE-49 emulator.

The ICE-49 emulator permits the symbolic specification of breakpoints on program memory and external data memory addresses, or external data memory address reads or writes individually, and upon the input of an external synchronization signal.

INTERROGATION AND UTILITY commands are provided by the HSE-49 emulator which allow the user to examine, change or fill the various emulator memory spaces. Additional commands are provided to upload or download the contents of the memory spaces to or from a host Intellic development system, or other peripheral device, through the HSE-49 emulator serial port.
### Table 1. HSE-49 Emulator Command Description

<table>
<thead>
<tr>
<th>Command</th>
<th>Command Modifier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GO</td>
<td></td>
<td>Begins emulation:</td>
</tr>
<tr>
<td></td>
<td>NO BRK</td>
<td>Real-time breakpoints not enabled</td>
</tr>
<tr>
<td></td>
<td>W/BRK</td>
<td>Real-time breakpoints enabled</td>
</tr>
<tr>
<td></td>
<td>SING STP</td>
<td>Steps program one instruction</td>
</tr>
<tr>
<td></td>
<td>AUTO STP</td>
<td>Automatically steps/pauses/steps/...</td>
</tr>
<tr>
<td></td>
<td>AUTO BRK</td>
<td>Automatically emulates real-time/pauses at breakpoint/emulates real-time/...</td>
</tr>
<tr>
<td>GO/RESET</td>
<td>(NONE)</td>
<td>Begins real-time emulation from EP hardware reset state, beginning at program location 000H</td>
</tr>
<tr>
<td>B, C</td>
<td>(PROG MEM, DATA MEM)</td>
<td>Sets (B) or Clears (C) breakpoint at specified address within Program or External Data memory</td>
</tr>
<tr>
<td>SYS RST</td>
<td>(NONE)</td>
<td>Resets emulation and master processors and clears all breakpoints</td>
</tr>
<tr>
<td>EXAM/CHA</td>
<td></td>
<td>Examine/Change memory location</td>
</tr>
<tr>
<td>FILL</td>
<td></td>
<td>Fill range of memory addresses with a single data value</td>
</tr>
<tr>
<td>LIST</td>
<td></td>
<td>List memory to output device through HSE-49 serial port</td>
</tr>
<tr>
<td>DNLOAD</td>
<td></td>
<td>Download hex-file format memory to HSE-49 emulator through HSE-49 serial port</td>
</tr>
<tr>
<td>UPLOAD</td>
<td></td>
<td>Upload memory within a range of addresses through HSE-49 serial port</td>
</tr>
<tr>
<td></td>
<td></td>
<td>to Intellec Development System or external peripheral device</td>
</tr>
</tbody>
</table>

*: Memory types allowed for above commands:

- PROG MEM: User-program memory
- DATA MEM: External data memory (if installed)
- PROG BRK: User-program breakpoint memory
- DATA BRK: External data breakpoint memory
- REGISTER: Register memory and internal data memory
- HARD REG: Hardware registers/system control parameters
Limitations

The HSE-49 emulator was not designed to have the same capabilities that Intel's ICE™ in-circuit emulators have, and certain features have been deleted to keep the circuitry relatively simple. As a result, the following limitations exist and should be taken into account when using the system:

1. As explained previously, user-program execution is terminated by forcing the EP to execute a "CALL" instruction to the mini-monitor. Because this requires one level of the EP subroutine stack, the user program can be using a maximum of seven levels of stack when a break is initiated.

2. Because program execution is initiated by forcing the EP to execute an "RETR" instruction, the EP interrupt-in-progress flip-flop will be cleared. Therefore, if interrupts are enabled, emulation should not be resumed from an address within an interrupt servicing routine; if it is, the EP may incorrectly recognize an interrupt request which should be ignored.

3. The I/O status of ports P0 and P22–P23 with respect to user-supplied hardware is determined by the HSE-49 emulator hardware configuration rather than by software. Therefore the I/O modes of these ports may not be altered while a program is executing. These ports may be configured as is inputs, latched outputs or bidirectional ports by changing socketed HSE-49 emulator hardware.

4. The "ANL BUS, #nn" and "ORL BUS, #nn" instructions may not be used in the user program, as external hardware cannot properly restore these functions.

Several other minor limitations with the HSE-49 emulator operation are explained in the Operating Instructions.

SPECIFICATIONS

Equipment Supplied

Printed Circuit Board with Integral Keypad, Display, ROM Monitor, (2) 8039 microprocessors and 2K bytes user program RAM
Emulation Cable and Plug
Serial-Link Cable
Power Pick-up Card with Cable
Power Cable

Emulation Clock

11 MHz supplied, or user supplied crystal for 3.6 MHz to 11 MHz clock

Serial I/O

20 mA Current Loop or RS232 (jumper selectable)

Physical Characteristics

Width: 14.0 in (35.6 cm)
Length: 10.0 in. (25.4 cm)
Height: 0.5 in. (1.27 cm)
Packaged Weight: 4.0 lb (1.8 kg)

D.C. Electrical Characteristics

\[ V_{CC} = +5V \pm 5\% \]
\[ I_{CC} = 2.0A \text{ max}; 1.5A \text{ typical} \]
\[ V_{RS232} = +12V \pm 5\%; -12V \pm 5\% \]
\[ I_{RS232} = 0.020A \text{ max}; 0.015A \text{ typical} \]
(V_{RS232} required only if using RS232 mode of serial port)

Environmental Characteristics

Operating Temperature: 0° to 55°C
Operating Humidity: Up to 90% relative humidity without condensation

ORDERING INFORMATION

Part Number   Description
MCI-49-HSE   8048/8049 family CPU high-speed (11 MHz) emulator, cable assembly and ROM firmware
ICE-49
MCS-48 IN-CIRCUIT EMULATOR

Emulates 8049, 8048, 8748, 8039, 8035, and 8021* Microcomputers

Extends Intellec microcomputer development system debug power to user configured system via external cable and 40-pin plug, replacing system MCS-48 device

Emulates user system MCS-48 device in real time

Shares static RAM memory with user system for program debug

Provides hardware comparators for user designated break conditions

Eliminates need for extraneous debugging tools residing in user system

Collects bus, register, and MCS-48 status information on instructions emulated

Provides capability to examine and alter MCS-48 registers, memory, and flag values, and to examine pin and port values

Integrates hardware and software efforts early to save development time

The ICE-49 MCS-48 In-Circuit Emulator module is an Intellec-resident module that interfaces with any MCS-48 system. The MCS-48 family consists of the 8049, 8048, 8748, 8039, 8035, and 8021 microcomputers. The ICE-49 module interfaces with an MCS-48 system through a cable terminating in an MCS-48 pin-compatible plug which replaces the MCS-48 device in the system. With the ICE-49 plug in place, the designer has the capability to execute the system in real time while collecting up to 255 instruction cycles of real-time trace data. In addition, he can single step the system program to monitor more closely the program logic during execution. Static RAM memory is available through the ICE-49 module to emulate MCS-48 program and data memory. The designer can display and alter the contents of data and replacement RAM control memory, internal MCS-48 registers and flags and I/O ports. Powerful debug capability is extended into the MCS-48 system while ICE-49 debug hardware and software remain inside the Intellec system. Symbolic reference capability allows the designer to use meaningful symbols rather than absolute values when examining and modifying memory, registers, flags, and I/O ports in this system.

*EM1 emulator board is also required.
FUNCTIONAL DESCRIPTION

Debug Capability Inside User System
The ICE-49 module provides the user with the ability to debug a full prototype or production system without introducing extraneous hardware or software test tools. The module connects to the user system through the socket provided for the MCS-48 device in the user system. Intellec memory is used for the execution of the ICE-49 software. The Intellec console and file handling capabilities provide the designer with the ability to communicate with the ICE-49 module and display information on the operation of the prototype system. The ICE-49 module block diagram is shown in Figure 1.

Batch Testing
In conjunction with the ISIS-II diskette operating system, the ICE-49 module can run extensive system diagnostics without operator intervention. The designer or test engineer can define a complete diagnostic exercise, which is stored in a file on the diskette. When activated with an ISIS-II submit command, this file can instruct the ICE-49 module to execute the diagnostic routine and store the results in another file on the diskette. Results are available to the designer at his convenience. In this way, routine diagnostics and long-term testing may be done without tying up valuable manpower.

Integrated Hardware/Software Development
The user prototype need consist of no more than an MCS-48 socket and timing logic to begin integration of software and hardware development efforts. Through the ICE-49 module mapping capabilities, Intellec system resources can be accessed to replace prototype memory. Hardware designs can be tested using the system software to drive the final product. Thus, the system integration phase, which can be costly when attempting to mesh completed hardware and software products, becomes a convenient two-way debug tool when begun early in the design cycle.

Real-Time Trace
The ICE-49 module captures trace information while the designer is executing programs in real time. The instructions executed, program counter, port values for bus 0, port 1 and port 2, and the values of selected MCS-48 status lines are stored for the last 255 instruction cycles executed. When retrieved for display, code is disassembled for user convenience. This provides data for determining how the user system was reacting prior to emulation break, and is available whether the break was user initiated or the result of an error condition. For more detailed information on the actions of internal registers, flags, or other system operations, the user may operate in single or multiple step sequences tailored to system debug needs.

Figure 1. ICE-49 Module Block Diagram
Memory Mapping

The 8049, 8748 and 8048 contain internal program and data memory. Both program and data memory can be expanded using external memory devices.

Internal Memory — When the MCS-48 microcomputer is replaced by the ICE-49 socket in a system, the ICE-49 module supplies static RAM memory as a replacement for the internal microcomputer memory. The ICE-49 module has enough RAM memory available to emulate up to the total 4K control memory capability of the system. The ICE-49 module also provides for up to 384 bytes of data memory.

External Memory — The ICE-49 module separates replacement control memory into sixteen 256-byte blocks. Replacement external data memory consists of one 256-byte block. Each block of memory can be defined separately as supplied by the user system or supplied by the ICE-49 module. The user may assign ICE-49 equivalent memory to take the place of external memory not yet supplied in his system.

Symbolic Debugging

ICE-49 software provides symbolic definition of all MCS-48 registers, flags, and selected MCS-48 pins. Symbolically defined pseudo registers provide access to the sense of MCS-48 flip flops which enable time, counter, interrupt, and flag-0/flag-1 options. In addition, the user may reference locations in program and data memory, or their contents, symbolically. The user symbol table generated along with the object file during a program assembly may be loaded to Intellec memory for access during emulation. The user is encouraged to add to this symbol table any additional symbolic values for memory addresses, constants, or variables he may find useful during system debugging. Symbols may be substituted for numeric values in any of the ICE-49 commands. Symbolic reference is a great advantage to the system designer. He is no longer burdened with the need to recall or look up those addresses of key locations in his program that can change with each assembly. Meaningful symbols from his source program may be used instead. For example, the command:

  GO FROM .START TILL XDATA. RSLT WRITTEN

begins execution of the program at the address referenced by the label START in the designers assembly program. A breakpoint is set to occur the first time the microprocessor writes to the external data memory location referenced by RSLT. The designer does not have to be concerned with the physical locations of START and RSLT. The ICE-49 software driver supplies them automatically from information stored in the symbol table.

Hardware

The ICE-49 module is a microcomputer system utilizing Intel's 8049 or 8048/8748 microcomputer as its nucleus. The 8049 provides the 8049, 8039 emulation characteristics. The 8048/8748 provides the 8749/8048/8035/8021 emulation characteristics. The ICE-49 module uses an Intel 8080 to communicate with the Intellec host processor via a common memory space. The 8080 also controls an internal ICE-49 bus for intramodule communication. ICE-49 hardware consists of two PC boards, the controller board, and the emulator board, all of which reside in the Intellec chassis. A cable interfaces the ICE-49 boards to the MCS-48 system. The cable terminates in a MCS-48 pin compatible plug which replaces any MCS-48 device in the user system. The ICE-49 module block diagram is shown in Figure 1.

Real-Time Trace

Trace Buffer — While the ICE-49 module is executing the user program, it is monitoring port, program counter, data, and status lines. Values for each instruction cycle executed are stored in a 255 x 44 real-time RAM trace buffer. A resettable timer resident on the controller board counts instruction cycles.

Controller Board

The ICE-49 module talks to the Intellec system as a peripheral device. The controller board receives commands from the Intellec system and responds through the parameter block. Three 15-bit hardware breakpoint registers are available for loading by the user. While in emulation mode, a hardware comparator is constantly monitoring address and status lines for a match to terminate an emulation. The breakpoint registers provide a signal when a match is detected. The user may disable the emulation break capability and use the signal to synchronize other debug tools. The controller board returns real-time trace data, MCS-48 register, flag, and pin values, and ICE-49 status information, to a control block in the Intellec system when emulation is terminated. This information is available to the user through the ICE-49 interrogation commands. Error conditions, when present, are automatically displayed on the Intellec system console. The controller board also contains static RAM memory, which can be used to emulate MCS-48 program and data memory in real time. 4K of memory is available in sixteen 256-byte pages to emulate MCS-48 PROM or PROM program memory. A 256-byte page of data memory is available to access in place of MCS-48 external data memory. The controller board address map directs the ICE-49 module to access either replacement ICE-49 memory or actual user system external memory in 256-byte segments based on information provided by the user.

Emulator Board

The emulator board contains the 8049* and peripheral logic required to emulate the MCS-48 device in the user system. A software selectable 6 MHz or 3 MHz clock drives the emulated MCS-48 device. This clock can be disabled and replaced with a user supplied TTL clock in the user system.

*Use 8048 with internal monitor program when emulating 8748/8048/8035/8021.
Cable Card
The cable card is included for cable driving. It transmits address and data bus information to the user system through a 40-pin connector which plugs into the user system in the socket designed for the MCS-48 device.

Software
The ICE-49 software driver is a RAM-based program which provides the user with an easy to use command language (see Table 1, Table 2, and Table 3) for defining breakpoints, initiating real-time emulation or single step operation, and interrogating and altering user system status recorded during emulation. The ICE-49 command language contains a broad range of modifiers to provide the user with maximum flexibility in defining the operation to be performed. The ICE-49 software driver is available on diskette and operates in 32K of Intellec RAM memory.

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable</td>
<td>Activates breakpoint and display registers for use with go and step commands.</td>
</tr>
<tr>
<td>Go</td>
<td>Initiates real-time emulation and allows user to specify breakpoints and data retrieval.</td>
</tr>
<tr>
<td>Step</td>
<td>Initiates emulation in single instruction increments. Each step is followed by register dump. User may optionally tailor other diagnostic activity to his needs.</td>
</tr>
<tr>
<td>Interrupt</td>
<td>Emulates user system interrupt.</td>
</tr>
</tbody>
</table>

Table 1. ICE-49 Emulation Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>Prints contents of memory, MCS-48 device registers, I/O ports, flags, pins, real-time trace data, symbol table, or other diagnostic data on list device.</td>
</tr>
<tr>
<td>Change</td>
<td>Alters contents of memory, register, output port, or flag. Sets or alters breakpoints and display registers.</td>
</tr>
<tr>
<td>Map</td>
<td>Defines memory status.</td>
</tr>
<tr>
<td>Base</td>
<td>Establishes mode of display for output data.</td>
</tr>
<tr>
<td>Suffix</td>
<td>Establishes mode of display input data.</td>
</tr>
</tbody>
</table>

Table 2. ICE-49 Interrogation Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load</td>
<td>Fetches user symbol table and object code from input device.</td>
</tr>
<tr>
<td>Save</td>
<td>Sends user symbol table and object code to output device.</td>
</tr>
<tr>
<td>Define</td>
<td>Enters symbol name and value to user symbol table.</td>
</tr>
<tr>
<td>Move</td>
<td>Moves block of memory data to another area of memory.</td>
</tr>
<tr>
<td>List</td>
<td>Defines list device.</td>
</tr>
<tr>
<td>Exit</td>
<td>Returns program control to ISIS-II.</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Converts expression to equivalent values in binary, octal, decimal, and hex.</td>
</tr>
<tr>
<td>Remove</td>
<td>Deletes symbols from symbol table.</td>
</tr>
<tr>
<td>Reset</td>
<td>Reinitializes ICE-49 hardware.</td>
</tr>
</tbody>
</table>

Table 3. ICE-49 Utility Commands

SPECIFICATIONS
ICE-49 Operating Environment

Required Hardware
Intellec microcomputer development system
System console
Intellec diskette operating system
ICE-49 Module

Required Software
System monitor
ISIS-II

Equipment Supplied
Printed circuit boards (control board, emulator board)
Interface cables and buffer module
ICE-49 software, diskette-based version (single density or double density)
8048 with internal monitor program

System Clock
Crystal controlled 6.0 MHz internal, 3.0 MHz internal or user supplied TTL external: software selectable.

Physical Characteristics

- Width — 12.00 in. (30.48 cm)
- Height — 6.75 in. (17.15 cm)
- Depth — 0.50 in. (1.27 cm)
- Weight — 8.00 lb. (3.64 kg)

Electrical Characteristics

DC Power Requirements

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC</td>
<td>+5V ±5%</td>
</tr>
<tr>
<td>Icc</td>
<td>10A max; 7.0A typ</td>
</tr>
<tr>
<td>VDD</td>
<td>+12V ±5%</td>
</tr>
<tr>
<td>IDD</td>
<td>79 mA max; 45 mA typ</td>
</tr>
<tr>
<td>VBB</td>
<td>-10V ±5%</td>
</tr>
<tr>
<td>IBB</td>
<td>20 mA max</td>
</tr>
</tbody>
</table>

18-16
Input Impedance — @ICE-49 user socket pins:
- $V_{IL} = 0.8V$ (max), $I_{IL} = -1.6\ mA$,
- $V_{IH} = 2.0V$ (min), $I_{IH} = 40\ \mu A$

For Bus:
- $V_{IL} = 0.8V$ (max), $I_{IL} = -250\ \mu A$
- $V_{IH} = 2.0V$ (min), $I_{IH} = 20\ \mu A$

Output Impedance — @ICE-49 user socket pins:
P1, P2:
- $V_{OL} = 0.5V$ (max), $I_{OL} = 16\ mA$
- $V_{OH} = V_{CC}$ (10K pullup)

For Bus:
- $V_{OL} = 0.5V$ (max), $I_{OL} = 25\ mA$
- $V_{OH} = 3.65V$ (min), $I_{OH} = -1\ mA$

Others:
- $V_{OL} = 0.5V$ (max), $I_{OL} = 16\ mA$
- $V_{OH} = 2.4V$ (max), $I_{OH} = -400\ \mu A$

Environmental Characteristics

Operating Temperature — 0°C to 40°C (Room Temperature)

Operating Humidity — Up to 95% relative humidity without condensation

Reference Manuals

9800632 — ICE-49 Operator's Manual (SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS-49-ICE</td>
<td>8049, 8048, 8039, 8748, 8035, 8021 CPU in-circuit emulator. Cable assembly and interactive diskette software included</td>
</tr>
</tbody>
</table>
EM1
8021 EMULATION BOARD

EPROM functional equivalent of 8021 — single component 8-bit microcomputer

Connects to prototype system through 8021 pin compatible plug

Based on 8748 — user programmable/erasable EPROM 8-bit computer

On-card 3.0 MHz or external TTL driven clock

Operates with ICE-49™ module to provide full in-circuit debugging of 8021 prototype system

Portable 4” x 7” microcomputer circuit assembly

The EM1 emulator board is a ready-to-use 4” x 7” microcomputer circuit assembly that emulates the Intel 8021 microcomputer. A 12-inch flat-cable assembly connects the board to the 8021 socket in a prototype system. The board is designed so that it can be mounted either as a stand-alone unit, or within the prototype assembly.

The 8021 microcomputer has 1K x 8 mask-programmable ROM program memory and 64 by 8 RAM data memory. The EM1 is controlled by an Intel 8748, with 1K of EPROM program memory and a 64 byte data memory. The EPROM can be programmed and erased repeatedly during hardware and software development. The EM1 has several ancillary circuits that perform the following functions which are specific to the 8021:

- Zero crossing detector
- Crystal controlled clock/buffer
- Port 0 simulator

For prototype debugging, the 8748 can be removed from its socket and replaced with a cable to an ICE-49 module. When used with the EM1, ICE-49 module emulates the 8021 in real-time, or single-steps the 8021 program at the user's command. A full range of capabilities for examining and modifying 8021 memory and status are supplied through ICE-49 module.
HARDWARE

The EM1 emulation board uses the 8748 to perform the emulation.

P0 Simulator

Port 0 of the 8021 is a quasi*-bidirectional port. The P0 simulator converts the data bus of the 8748 into a quasi-bidirectional port.

Crystal Control Clock Buffer

The EM1 allows user to select an on-board oscillator or a TTL clock driven from the 8021 user's prototype system via a Cambion Suitcase jumper.

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Position</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>A — B</td>
<td>On-Board</td>
</tr>
<tr>
<td></td>
<td>C — D</td>
<td>External</td>
</tr>
</tbody>
</table>

*TTL clock

*A bidirectional port which serves as an input port, output port, or both even though outputs are statically latched.

Zero Cross Detection Simulator

The zero cross detection simulator enables the 8748's T1 input to detect zero-crossings. The circuitry provides a high level signal on a positive crossing and a low level signal on a negative crossing of zero to the T1 input of the 8748.

Reset Buffer

The 8021 resets on a logic HIGH level signal. However, the 8748 resets on a logic LOW level, thus an inverter is provided on the EM1 to make the two chips compatible.

Optional Pull-Ups

Resistors are provided to simulate the optional pull-up resistors on T1 input and Port 0 of the 8021. A removable resistor pack is used on Port 0. The T1 input pull up can be installed by soldering in a 50K resistor.

Software

When emulating the 8021 with EM1, the user must observe the 8021 instruction set.
SPECIFICATIONS

Operating Environment

Stand-Alone
Required Hardware:
EM1 emulation board

In-Circuit Emulation
Required Hardware:
EM1 emulation board
Intellec Microcomputer Development System configured with ICE-49 module

Equipment Supplied

EM1 printed circuit board
12" long flat cable terminating in 28-pin plug, pin compatible with 8021
EM1 Operator's Manual

System Clock

Crystal controlled 3.0 MHz on board or user supplied TTL external clock; hardware jumper selectable.

Physical Characteristics

Width: 7.0 in (17.78 cm)
Height: 4.0 in. (10.16 cm)
Depth: 0.75 in. (1.91 cm)
Weight: < 1.0 lbs. (0.45 kg)

Electrical Characteristics

DC Power:
\[ V_{CC} \, 5V \pm 5\%
\[ I_{CC} \, 300 \, mA \, (max.)

Environmental Characteristics

Operating Temperature: 0 — 55°C
Operating Humidity: up to 95% relative humidity without condensation

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS-EM1</td>
<td>8021 Emulation Board</td>
</tr>
</tbody>
</table>
EM2
8022 EMULATION BOARD

Portable 4.25” x 2.75” microcomputer circuit assembly

Connects directly into prototype system through Intel® 8022* pin compatible socket

Provides Intel® 8755A — 2K x 8 EPROM

EPROM functional and electrical equivalent of Intel® 8022 — single component 8-bit computer

The EM2 emulator board is a ready-to-use 4.25” x 2.75” microcomputer circuit assembly that emulates the Intel® 8022 single chip microcomputer. The emulator board is designed to plug directly into the 8022 socket. No interfacing and interconnection cables are necessary. Power is obtained from the user’s system.

The EM2 emulator board provides the user a full EPROM functional and electrical equivalent of the 8022 single component 8-bit microcomputer.

The EM2 emulator board consists of an Intel® 8022 emulator chip and an Intel® 8755A, providing the EM2 emulator board with a 2K x 8 EPROM program memory which can be programmed and erased repeatedly during hardware and software development.

The 8022E emulator chip is a modified version of the 8022 intended for use in design support systems. Instead of using resident ROM memory as the 8022, the 8022E uses an external 2K EPROM 8755A memory for program storage, allowing easy program modification.

*See Intel® 8022 Data Sheet.
40-PIN SOCKET CONFIGURATION

EM2 BLOCK DIAGRAM

<table>
<thead>
<tr>
<th>Designation</th>
<th>Pin #</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vss</td>
<td>20</td>
<td>Circuit GND potential.</td>
</tr>
<tr>
<td>Vcc</td>
<td>40</td>
<td>+5V circuit power supply.</td>
</tr>
<tr>
<td>Prog</td>
<td>37</td>
<td>Output strobe for Intel® 8243 I/O expander.</td>
</tr>
<tr>
<td>P00-P07</td>
<td>10-17</td>
<td>8-bit open-drain port with comparator inputs. The switching threshold is set externally by Vth. Optional pull-up resistors may be added via ROM mask selection. (The emulator board has switch selection of this option.)</td>
</tr>
<tr>
<td>Vth</td>
<td>9</td>
<td>Port 0 threshold reference pin.</td>
</tr>
<tr>
<td>P10-P17</td>
<td>25-32</td>
<td>8-bit quasi-bidirectional port.</td>
</tr>
<tr>
<td>P20-P27</td>
<td>33-36</td>
<td>8-bit quasi-bidirectional port.</td>
</tr>
<tr>
<td>T0</td>
<td>8</td>
<td>Interrupt input and input pin testable using the conditional transfer instructions JTO and JNTO. Initiates an interrupt following a low level input if interrupt is enabled. Interrupt is disabled after a reset.</td>
</tr>
<tr>
<td>T1</td>
<td>19</td>
<td>Input pin testable using the JT1 and JNT1 conditional transfer instructions. Can be designated the timer/event counter input using the STRT CNT instruction. Also serves as the zero-cross detection input to allow zero-crossover sensing of slowly moving AC inputs. Optional pull-up resistor may be added via ROM mask selection.</td>
</tr>
</tbody>
</table>

Designation  Pin #  Function
RESET        24   Input used to initialize the processor by clearing status flip-flops and setting the program counter to zero.
Aves         7    A/D converter GND potential. Also establishes the lower limit of the conversion range.
Vcc          3    A/D +5V power supply.
Subst        21   Substrate pin used with a bypass capacitor to stabilize the substrate voltage and improve A/D accuracy.
Varef        4    A/D converter reference voltage. Establishes the upper limit of the conversion range.
Ano, AN1     6,5   Analog inputs to A/D converter. Software selectable on-chip via SEL AN0 and SEL AN1 instructions.
A1e          18   Address Latch Enable. Signal occurring once every 30 input clocks (once every single cycle instruction), used as an output clock.
Xtal1        22   One side of crystal, inductor, or resistor input for internal oscillator. Also input for external frequency source. (Not TTL compatible.)
Xtal2        23   Other side of timing control element. This pin is not connected when an external frequency source is used.
On the EM2 Board:

The Intel® 8755A EPROM can be programmed using any of the modules listed in Table 1.

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPP-103</td>
<td>Universal PROM Programmer. Requires UPP-955, which includes 8755A Personality Card with 40-pin adapter socket.</td>
</tr>
<tr>
<td>PROMPT-80/85</td>
<td>Intellic® 8080/8085 Microcomputer Design Aid. Requires PROMPT-975 Programming Adapter.</td>
</tr>
</tbody>
</table>

Table 1. 8755A Programming Module

SPECIFICATIONS

Operating Environment
Intel® 8755A EPROM Programming

<table>
<thead>
<tr>
<th>Equipment Supplied</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM2 Printed Circuit Board</td>
</tr>
<tr>
<td>EM2 Reference Manual</td>
</tr>
</tbody>
</table>

Physical Characteristics

Width: 2.75 in. (6.98 cm)
Height: 4.25 in. (10.79 cm)
Depth: 1.5 in. (3.81 cm)
Weight: 0.5 lb (0.23 kg)

Electrical Characteristics

DC Power

$V_{CC} = 5V \pm 5\%$

$I_{CC} = 300 mA$ (maximum)

Environmental Characteristics

Operating Temperature — 0 to 55°C
Operating Humidity — Up to 95% relative humidity without condensation

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS-EM2</td>
<td>8022 Emulation Board</td>
</tr>
</tbody>
</table>
ICE-22™
8022 IN-CIRCUIT EMULATOR

- Single-line assembler allows mnemonic program instruction changes
- Full symbolic debugging
- ICE™-resident user-program RAM for real-time execution
- Examine and alter 8022 registers, memory, and digital port values, and examine analog port data
- Two user-specified breakpoint registers
- 500 instruction cycle trace
  - conditionally triggered
  - 16 user-definable trace probes
  - symbolic groupings and display
- 32-bit half-microsecond emulation timer
- HELP facility summarizes ICE-22™ command syntax at the console
- User confidence test of ICE-22™ hardware

The ICE-22 module resides in the Intellec® Microcomputer Development System and interfaces to any user-designed 8022 system through a cable terminating in an 8022 emulator microprocessor and a pin-compatible plug. The emulator processor, together with 2K bytes of user-program RAM located in the ICE-22 buffer box, replaces the 8022 device in the user system while maintaining the 8022 electrical and timing characteristics. Powerful Intellec debugging functions are thus extended into the user system. Using the ICE-22 module, the designer can emulate the system's 8022, including full A/D converter function, in real-time or single-step mode. Breakpoints allow the user to stop emulation on user-specified conditions, and a trace qualifier feature allows the conditional collection of 500 instruction cycles of trace data. The ICE-22 trace includes 8022 status information and, through ICE-22 external logic probes, can provide data on up to 16 signal nodes in the user-system peripheral circuitry. For the first time in any ICE module, the designer may alter program memory using ASM-48 mnemonics and symbolic references without returning to ISIS II control. In addition, user-created peripheral chip analyzer routines may be applied to the logic probe data, thereby expanding the in-circuit emulation function to the entire system.
FUNCTIONAL DESCRIPTION

Integrated Hardware/Software Development

The ICE-22 emulator allows hardware and software development to proceed interactively. This is more effective than the traditional method of independent hardware and software development followed by system integration. With the ICE-22 module, prototype hardware can be added to the system as it is designed. Software and hardware testing occur while the product is being developed.

Conceptually, the ICE-22 emulator assists three stages of development:

1. It can be operated without being connected to the user's system, so ICE-22 debugging capabilities can be used in conjunction with the Intellic text editor and MCS-48™ macro-assembler to facilitate program development before any of the user's hardware is available.

2. Integration of software and hardware can begin when any functional element of the user system hardware is connected to the 8022 socket. As each section of the user's hardware is completed, it is added to the prototype. Thus, each section of the hardware and software is "system" tested as it becomes available.

3. When the user's prototype is complete, it is tested with the final version of the user system software. The ICE-22 module is then used for real-time emulation of the 8022 to debug the system as a completed unit, and verify system performance before any ROM codes are entered. A final product verification test may be performed prior to ROM code entry by using the separately available EM-2 8022 emulation board (8022 EPROM equivalent) within the eventual product package.

Thus, the ICE-22 module provides the user with the ability to debug a prototype or production system at any stage in its development without introducing extraneous hardware or software test tools.

Symbolic Debugging

The ICE-22 emulator permits the user to define and use symbolic rather than absolute references to program and data memory addresses; additional symbols are predefined by the ICE-22 software for referencing registers, flags, and input/output ports. Thus, the user need not become involved with machine code, or recall or look up the addresses of key locations in his program as they change with each assembly.

For each symbol that is used for memory reference in an ICE-22 emulator command, the emulator supplies the symbol value location as stored in the ICE-22 emulator symbol table. This table can be loaded with the symbol table produced by the assembler during application program assembly. Furthermore, the user can interactively modify the emulator symbol table by adding new symbols or changing or deleting old ones. This feature provides great flexibility in debugging and minimizes the need to work with hexadecimal values.

Through symbolic references in combination with other features of the emulator, the user can easily:

- Disassemble program memory to mnemonics
- Assemble mnemonic instructions into executable code.
- Examine or modify 8022 internal registers, data memory, or digital port contents.
- Examine analog port data
- Symbolically define groups of user probes, and use these groups to symbolically specify breakpoints and trace qualifiers, or to format external trace data output.

Operation Modes

The ICE-22 software is a RAM-based program that provides the user with easy-to-use commands for initiating emulation, defining breakpoints, controlling trace data collection, and displaying and controlling system parameters. ICE-22 commands are configured with a broad range of modifiers which provide the user with maximum flexibility in describing the operation to be performed.

EMULATION

The ICE-22 module can emulate the operation of a prototype 8022 system, including full emulation of the 8022 analog to digital converter, at real-time speed (0.6 to 3.6 MHz) or in single or multiple steps. Emulation commands to the ICE-22 module control the process of setting up, running, and halting an emulation of the user's 8022-based system. Breakpoints, comparison registers, and tracepoints enable the ICE-22 emulator to halt emulation and provide a detailed trace of execution in any part of the user's program. A summary of the emulation commands is shown in Table 1.

Breakpoints

The ICE-22 hardware includes two breakpoint registers that allow the user to halt emulation when specified conditions are met. The emulator continuously compares the values stored on the breakpoint registers with the status of specified
data, addresses, and/or external logic probes, and halts emulation when this comparison is satisfied. When an instruction initiates a break, that instruction is executed completely before the break takes place. The ICE-22 emulator then regains control of the console and enters the Interrogation Mode. With the breakpoint feature, the user can request an emulation break when his program:

• Executes an instruction at a specific address or within a range of addresses
• Executes a particular opcode
• Receives a specific signal on a logic probe, digital port pin, or group of probes or pins
• Fetches a particular data value from the user program memory

Breakpoints can be composed of conditions on 22 channels which reflect internal 8022 activities, plus the 16 external logic probe channels; all but one of the channels may be specified as "Don't Care" channels. Address ranges must be specified as a range of pages (r00H) to sFFH), a range of 16-byte paragraphs within a page (pr0H) to psFH), or a range of bytes within a paragraph (pqrH to pqFH) where, in each case, s is a digit greater than or equal to the digit r.

Table 1. Major Emulation Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GO</td>
<td>Begins real-time emulation and optionally specifies break conditions.</td>
</tr>
<tr>
<td>BR0, BR1, BR</td>
<td>Sets or displays either or both Breakpoint Registers used for stopping real-time emulation.</td>
</tr>
<tr>
<td>STEP</td>
<td>Begins single-step emulation and optionally specifies terminating conditions.</td>
</tr>
<tr>
<td>CR0, CR1, CR2, CR3, CR</td>
<td>Sets or displays comparison criteria in all or individual Comparison Registers used for stopping automatic single-step emulation.</td>
</tr>
<tr>
<td>TR</td>
<td>Specifies or displays trace-data collection conditions, and optionally sets Qualifier Register (QR).</td>
</tr>
</tbody>
</table>

Comparison Registers

Four comparison registers are provided that allow the user to halt single step emulation when the single condition specified in any one of these registers is satisfied. The comparison registers differ from the breakpoint registers in that, 1) the comparisons $<$, $\leq$, $>$, $\geq$, and $=$ are permitted in addition to the $=$ condition, 2) more 8022 and ICE variables may be compared, and 3) the comparators themselves may be variables.

Trace and Tracepoints

Tracing is used with both real-time and single-step emulation to record diagnostic information in the trace buffer as a program is executed. The information collected includes opcodes executed, program counter and Port 2 values, and 16 logic probe values for the last 500 instruction cycles. (There are one or two cycles per instruction, depending on the particular instruction.) This information can be displayed as assembler instruction mnemonics, if desired, for analysis during Interrogation or Single-Step Mode. The trace-collection facility may be set to run conditionally or unconditionally. One unique trace qualifier, specified in the same way as a breakpoint, governs conditional trace activity. It can be used to condition trace data collection to take place as follows:

• Under all conditions (constantly occurring)
• Only while the trace qualifier is satisfied
• For the 500 instruction cycles preceding the time when a trace qualifier is first satisfied (pre-triggered trace)
• For the next 500 instruction cycles after a trace qualifier is first satisfied (post triggered trace).

INTERROGATION AND UTILITY

Interrogation and utility commands give the user convenient access to detailed information about the user program and the state of the 8022 that is useful in debugging hardware and software. Changes can be made in both memory and the 8022 registers, flags, and digital port values. Commands are also provided for various utility operations such as loading and saving program files, defining symbols and logic probe groups, displaying trace data, controlling system synchronization and returning control to ISIS-II. A summary of the basic interrogation and utility commands is shown in Table 2. Two new emulator features are discussed below.

SINGLE-LINE ASSEMBLER — The single-line assembler (ASM command) is a new in-circuit emulation feature that permits the designer to examine and alter program memory using assembly language mnemonics, without leaving emulation mode or requiring time-consuming program reassembly. When assembling new mnemonic instructions into program memory, previously de-
fined symbolic references (from the original pro-
gram assembly, or subsequently defined during
the emulation session) may be used in the instruc-
tion operand field, and the emulator will supply
the absolute address or data values as stored in
the emulator symbol table. These features greatly
reduce the designer’s time spent translating to
and from machine code and searching for abso-
lute addresses, with a corresponding reduction in
transcription errors.

HELP — The HELP file is a new ICE feature that al-
 lows the designer to display ICE-22 command syn-
tax information at the Intellec console. By typing
“HELP”, a listing of all items for which help
messages are available is displayed; typing
“HELP <Item>” then displays relevant informa-
tion about the item requested, including typical
usage examples. The “HELP” listing and a “HELP
ASM” message for the ASM command are shown
in Table 3.

### Table 2. Major Interrogation and Utility Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD</td>
<td>Loads user object program (8022 code) into user-program memory, and user symbols into ICE-22 emulator symbol table.</td>
</tr>
<tr>
<td>DEFINE/REMOVE</td>
<td>Defines/removes symbols in ICE-22 emulator symbol table.</td>
</tr>
<tr>
<td>SAVE</td>
<td>Saves ICE-22 emulator symbol table and/or user object program in ISIS-II hexadecimal file.</td>
</tr>
<tr>
<td>LIST</td>
<td>Copies all emulator console input and output to ISIS-II file.</td>
</tr>
<tr>
<td>Change/Display Commands</td>
<td>Change or display value of symbolic reference in ICE-22 emulator symbol table, or contents of key-word references (including registers, I/O ports, and status flags), or memory references.</td>
</tr>
<tr>
<td>Group Commands</td>
<td>Define, change, remove, or display user-defined logic probe channel groups.</td>
</tr>
<tr>
<td>Trace Commands</td>
<td>Position trace buffer pointer; select and format trace output; enable or disable automatic display of trace data and register contents during single-step emulation.</td>
</tr>
<tr>
<td>PRINT</td>
<td>Displays trace data pointed to by trace buffer pointer.</td>
</tr>
<tr>
<td>Synchronization Line Commands</td>
<td>Set and display enabled/disabled status of SYNC0 and SYNC1 synchronization line outputs or latched inputs (used to allow real-time emulation or tracing to start and stop synchronously with external events).</td>
</tr>
<tr>
<td>ASM</td>
<td>Assembles mnemonic instructions into user-program memory, or disassembles and displays user-program memory contents.</td>
</tr>
<tr>
<td>INTERRUPT</td>
<td>Simulates external or timer interrupt sequence.</td>
</tr>
<tr>
<td>EVALUATE</td>
<td>Evaluates expression and displays resulting value.</td>
</tr>
<tr>
<td>SECONDS</td>
<td>Displays contents of emulation timer, in microseconds.</td>
</tr>
<tr>
<td>HELP</td>
<td>Displays help messages for ICE-22 emulator command-entry assistance.</td>
</tr>
<tr>
<td>EXIT</td>
<td>Terminates ICE-22 emulator operation.</td>
</tr>
</tbody>
</table>
Table 3. HELP Command

*HELP
Help is available for the following items. Type HELP followed by the item name. (For more information about HELP, type HELP HELP.)

<table>
<thead>
<tr>
<th>Real-Time Emulation:</th>
<th>Trace Collection:</th>
<th>Change/Display/Define/Remove:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GO GR SY0</td>
<td>TR QR SY1</td>
<td>ASM REGISTER DEFINE</td>
</tr>
<tr>
<td>BR BR0 BR1</td>
<td>&lt;MATCH&gt;</td>
<td>CBYTE STACK</td>
</tr>
<tr>
<td>&lt;BREAK&gt;</td>
<td>&lt;MATCH&gt;</td>
<td>DBYTE SECONDS</td>
</tr>
<tr>
<td>&lt;MATCH&gt;</td>
<td>Trace Display:</td>
<td>&lt;CHANGE&gt; CPUSREF SYMBOL</td>
</tr>
<tr>
<td>Step Emulation:</td>
<td></td>
<td>&lt;DISPLAY&gt; ICEREF</td>
</tr>
<tr>
<td></td>
<td>OLDEST</td>
<td></td>
</tr>
<tr>
<td>STEP SR</td>
<td>NEWEST</td>
<td>State/Mode:</td>
</tr>
<tr>
<td>CR CRO CR1 CR2 CR3</td>
<td>MOVE</td>
<td>BASE ENABLE REPRESENT</td>
</tr>
<tr>
<td>&lt;COMPARISON&gt;</td>
<td>PRINT</td>
<td>SUFFIX DISABLE</td>
</tr>
<tr>
<td>&lt;COMPARISON&gt;</td>
<td>DUMP</td>
<td>LIST RESET</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXIT</td>
<td>&lt;ADDRESS&gt;</td>
<td>&lt;INSTRUCTION&gt; PRIMARY</td>
</tr>
<tr>
<td>HELP</td>
<td>&lt;ADDRESS&gt;</td>
<td>&lt;INSTRUCTION&gt; PRIMARY#10</td>
</tr>
<tr>
<td>INTERRUPT</td>
<td>&lt;ADDRESS&gt;</td>
<td>&lt;INSTRUCTION&gt; STRING</td>
</tr>
<tr>
<td>LOAD</td>
<td>&lt;ADDRESS&gt;</td>
<td>&lt;INSTRUCTION&gt; SYMBOLIC#REF</td>
</tr>
<tr>
<td>SAVE</td>
<td>&lt;ADDRESS&gt;</td>
<td>&lt;INSTRUCTION&gt; SYSTEM#GROUP</td>
</tr>
<tr>
<td></td>
<td>&lt;ADDRESS&gt;</td>
<td>&lt;INSTRUCTION&gt; USER#GROUP</td>
</tr>
<tr>
<td></td>
<td>&lt;ADDRESS&gt;</td>
<td>&lt;INSTRUCTION&gt; PATHNAME</td>
</tr>
</tbody>
</table>

*HELP ASM
ASM – Command to display or change 8022 code memory using assembler instructions.

1. ASM <ADDRESS> [TO/LENGTH <ADDRESS>] (display 8022 code memory as assembler instructions)
2. ASM <ADDRESS> = <INSTRUCTION> END
   (change memory starting at <ADDRESS>)
   Ex:    ASM 100 =
          MOV A, 30
          JNZ 100
   END
3. ASM <ADDRESS> TO/LENGTH <ADDRESS> = <INSTRUCTION> END
   (change several locations and perform range checking or repetition.
   If the instructions require more memory than the size of the range,
   an error occurs. If the instructions require less memory, then
   the data is repeated until the range is filled.)

<INSTRUCTION> - Standard 8022 instructions typed one per line. The
operand "<EXPR>" can be used where "data" is required, and the operand
"<ADDRESS>" can be used where "addr" is required. A continuation
prompt "." is issued after each carriage return is typed.
SPECIFICATIONS

ICE-22 Operating Requirements
Intellec® Microcomputer Development System (32K RAM required)
System console
Intellec® Diskette Operating System (single or double density) ISIS-II v. 3.4 or later

Equipment Supplied
• Printed circuit boards (2)
• Emulation buffer box, Intellec interface cables, and user-interface cable with 8022 emulation processor
• 16 external trace probes
• Synchronization cables
• Crystal power accessory
• Operating instructions manual
• Diskette-based ICE-22 software (single and double density)

Emulation Clock
User’s system clock (0.6 to 3.6 MHz) or ICE-22 crystal power accessory (3.0 MHz)

Environmental Characteristics
Operating Temperature: 0° to 40°C
Operating Humidity: Up to 95% relative humidity without condensation.

Physical Characteristics
Printed Circuit Boards
Width: 12.00 in. (30.48 cm)
Height: 6.75 in. (17.15 cm)
Depth: 0.50 in. (1.27 cm)

Buffer Box
Width: 4.5 in. (11.43 cm)
Length: 10.0 in. (25.40 cm)
Depth: 1.25 in. (3.18 cm)
Packaged Weight: 8.0 lb (3.63 kg)

Electrical Characteristics
DC Power Requirements
\[ V_{CC} = +5V, \pm 5\%, -1\% \]
\[ I_{CC} = 13.2A \text{ max}; 11.0A \text{ typical} \]
\[ V_{DD} = +12V, \pm 5\% \]
\[ I_{DD} = 0.1A \text{ max}; 0.05A \text{ typical} \]
\[ V_{BB} = -10V, \pm 5\% \]
\[ I_{BB} = 0.05A \text{ max}; 0.01A \text{ typical} \]

ORDERING INFORMATION

Part Number Description
MCI-22-ICE 8022 Microcontroller In-Circuit Emulator, cable assembly and interactive diskette software
MCS™-48
DISKETTE-BASED SOFTWARE
SUPPORT PACKAGE

- Extends Intellec microcomputer development system to support MCS-48 development
- MCS-48 assembler provides conditional assembly and macro capability
- Takes advantage of powerful ISIS-II file handling and storage capabilities
- Provides assembler output in standard Intel hex format

The MCS-48 assembler translates symbolic 8048 assembly language instructions into the appropriate machine operation codes, and provides both conditional and macroassembler programming. Output may be loaded either to an ICE-49 module for debugging or into a Universal PROM Programmer for 8748 PROM programming. The MCS-48 assembler operates under the ISIS-II operating system on Intellec Microcomputer Development systems.
**FUNCTIONAL DESCRIPTION**

The MCS-48 assembler translates symbolic 8048 assembly language instructions into the appropriate machine operation codes. The ability to refer to program addresses with symbolic names eliminates the errors of hand translation and makes it easier to modify programs when adding or deleting instructions. Conditional assembly permits the programmer to specify which portions of the master source document should be included or deleted in variations on a basic system design, such as the code required to handle optional external devices. Macro capability allows the programmer use of a single label to define a routine. The MCS-48 assembler will assemble the code required by the reserved routine whenever the macro label is inserted in the text. Output from the assembler is in standard Intel hex format. It may be either loaded directly to an in-circuit emulator (ICE-49) module for integrated hardware/software debugging, or loaded into a Universal PROM Programmer for 8748 PROM programming. A sample assembly listing is shown in Table 1.

**SPECIFICATIONS**

**Operating Environment**

Required Hardware

Intellic Microcomputer Development System
32K RAM (non-macro use)
48K RAM (use of macro facility)
One or two Floppy disk drives
— Single or Double density
System Console
— CRT or interactive hardcopy device

Required Software

ISIS-II Diskette Operating System

Optional Hardware

ICE-49 In-Circuit Emulator
Line Printer
Universal PROM Programmer with 8748 personality card

**Shipping Media**

Diskette

**Reference Manuals**

9800255 — MCS-48 and UPI-41 Assembly Language Programming Manual (SUPPLIED)

9800236 — Universal PROM Mapper Operator’s Manual

9800306 — ISIS-II User’s Guide

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS-D48</td>
<td>Diskette-based assembler for MCS-48 family of microprocessors.</td>
</tr>
</tbody>
</table>
8051 SOFTWARE DEVELOPMENT PACKAGE

- Symbolic relocatable assembly language programming for 8051 microcontrollers
- Macro Assembler features conditional assembly and macro capabilities
- Extends Intellec® Microcomputer Development System to support 8051 program development
- CONV51 Converter for translation of 8048 assembly language source code to 8051 assembly language source code
- Produces Relocatable Object Code which is linkable to other 8051 Object Modules
- Provides upward compatibility from the MCS-48™ family of single-chip microcontrollers
- Encourage modular program design for maintainability and reliability

The 8051 software development package provides development system support for the powerful 8051 family of single chip microcomputers. The package contains a symbolic macro assembler and MCS-48 source code converter.

The assembler produces relocatable object modules from 8051 macro assembly language instructions. The object code modules can be linked and located to absolute memory locations. This absolute object code may be used to program the 8751 EPROM version of the chip. The assembler output may also be debugged using the ICE-51™ in-circuit emulator.

The converter translates 8048 assembly language instructions into 8051 source instructions to provide software compatibility between the two families of microcontrollers.

This diskette-based software package runs under ISIS-II on an Intellec Microcomputer Development System with 64K bytes of memory.

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8051 SOFTWARE DEVELOPMENT PACKAGE

8051 MACRO ASSEMBLER

- Supports 8051 family program development on Intellec® Microcomputer Development Systems
- Gives symbolic access to powerful 8051 hardware features
- Produces object file, listing file and error diagnostics

Object files are linkable and locatable
- Provides software support for many addressing and data allocation capabilities
- Symbolic Assembler supports symbol table, cross-reference, macro capabilities, and conditional assembly

The 8051 Macro Assembler (ASM51) translates symbolic 8051 macro assembly language modules into linkable and locatable object code modules. Assembly language mnemonics are easier to program and are more readable than binary or hexadecimal machine instructions. By allowing the programmer to give symbolic names to memory locations rather than absolute addresses, software design and debug are performed more quickly and reliably. Furthermore, since modules are linkable and relocatable, the programmer can do his software in modular fashion. This makes programs easy to understand, maintainable and reliable.

The assembler supports macro definitions and calls. This is a convenient way to program a frequently used code sequence only once. The assembler also provides conditional assembly capabilities.

Cross referencing is provided in the symbol table listing, showing the user the lines in which each symbol was defined and referenced.

ASM51 provides symbolic access to the many useful addressing features of the 8051 architecture. These features include referencing for bit and byte locations, and for providing 4-bit operations for BCD arithmetic. The assembler also provides symbolic access to hardware registers, I/O ports, control bits, and RAM addresses.

Math routines are enhanced by the MUltiply and DIVide instructions.

If an 8051 program contains errors, the assembler provides a comprehensive set of error diagnostics, which are included in the assembly listing or on another file. Program testing may be performed by using the Universal PROM Programmer and 8751 personality card to program the 8751 EPROM version of the chip, or by using the ICE-51 in-circuit emulator.

RL51 LINKER AND RELOCATOR PROGRAM

- Links modules generated by the assembler
- Locates the linked object to absolute memory locations

Enables modular programming of software for efficient program development
- Modular programs are easy to understand, maintainable and reliable

The 8051 linker and relocator (RL51) is a utility which enables 8051 programmers to develop software in a modular fashion. The linker resolves all references between modules and the relocator assigns absolute memory locations to all the relocatable segments, combining relocatable partial segments with the same name.

With this utility, software can be developed more quickly because small functional modules are easier to understand, design and test than large programs.

The number of symbols in the software is very large because the assembler symbol limit applies only per module not the entire program. Therefore programs can be more readable and better documented.

Modules can be saved and used on different programs. Therefore the software investment of the customer is maintained.

RL51 produces two files. The absolute object module file can be directly executed by the 8051 family. The listing file shows the results of the link/locate process.
CONV51
8048 TO 8051 ASSEMBLY LANGUAGE CONVERTER UTILITY PROGRAM

- Enables software written for the MCS-48™ family to be upgraded to run on the 8051
- Maps each 8048 instruction to a corresponding 8051 instruction
- Preserves comments; translates 8048 macro definitions and calls
- Provides diagnostic information and warning messages embedded in the output listing

The 8048 to 8051 Assembly Language Converter is a utility to help users of the MCS-48 family of microcomputers upgrade their designs with the high performance 8051 architecture. By converting 8048 source code to 8051 source code, the software investment developed for the 8048 is maintained when the system is upgraded.

The goal of the converter (CONV51) is to attain functional equivalence with the 8048 code by mapping each 8048 instruction to a corresponding 8051 instruction. In some cases a different instruction is produced because of the enhanced instruction set (e.g., bit CLR instead of ANL).

Although CONV51 tries to attain functional equivalence with each instruction, certain 8048 code sequences cannot be automatically converted. For example, a delay routine which depends on 8048 execution speed would require manual adjustment. A few instructions, in fact, have no 8051 equivalent (such as those involving P4-P7). Finally, there are a few areas of possible intervention such as PSW manipulation and interrupt processing, which at least require the user to confirm proper translation. The converter always warns the user when it cannot guarantee complete conversion.

CONV51 produces two files. The output file contains the ASM51 source program produced from the 8048 instructions. The listing file produces correlated listings of the input and output files, with warning messages in the output file to point out areas that may require users' intervention in the conversion.

SPECIFICATIONS

OPERATING ENVIRONMENT

Required Hardware:
- Intellec Microcomputer Development System with 64K Bytes of RAM
- Flexible Disk Drive(s)
- System Console
  - CRT or hard copy device
Optional Hardware:
- Universal PROM Programmer
- Line Printer
- ICE-51 In-Circuit Emulator

Required Software:
- ISIS-II Diskette Operating System (V3.4 or later)

Documentation Package:
- MCS-51 Macro Assembler User's Guide
- MCS-51 Utilities User's Guide for 8080/8085 Based Development System
- MCS-51 Macro Assembly Language Pocket Reference
- MCS-51 Assembler and Utilities Pocket Reference
- MCS-51 8048-to-8051 Assembly Language Converter Operating Instructions for ISIS-II Users

ORDERING INFORMATION

Part Number Description
MCI-51-ASM 8051 Software Development Package
The EM-51 emulation board is a small, ready-to-use microcomputer assembly that replaces an Intel 8051 family single-chip microcomputer in a prototype system. EM-51 includes sockets for 2716 or 2732 EPROMs, which substitute for the 8051/8751 on-chip program memory during prototype development. An Intel 2732A 4K x 8 EPROM is included with the board. With the memory in place, an EM-51 board becomes a full functional and electrical equivalent of the 8051 or 8751 microcomputer.
FUNCTIONAL DESCRIPTION

The EM-51 emulator board uses an Intel 8051 family single-chip microcomputer. The microcomputer is configured with additional input and output lines to let its on-chip ROM/EPROM program memory be replaced by EM-51 memory. The 8051's internal address, data, and control lines are connected through buffers to two sockets which accommodate the memory device(s).

Jumpers on the EM-51 board are used to select among memory, clock, and power options.

Memory Options

The EM-51 board uses an Intel 2732A EPROM, which provides 4K bytes of memory to replace the on-chip program memory. The board has two EPROM sockets, permitting you to use 2716 2K × 8 EPROM as an option. Table 1 lists the memory device options by speed and power.

Clock Options

EM-51 operates with either a prototype system crystal or an on-board crystal supplied by the user. For example, the on-board option is helpful if you need to reduce the crystal-to-chip spacing. Intel Application Note AP-35 describes crystal selection criteria.

Power Options

An EM-51 can be powered from the prototype 8051 socket, an external 5-volt power supply, or a combination of the two. The combination option lets your prototype power supply support the 8051 while an external supply powers the additional EM-51 circuitry.

Figure 1. Dimensions
Table 1.

<table>
<thead>
<tr>
<th>Memory Device</th>
<th>2732A-2</th>
<th>2732A</th>
<th>2732</th>
<th>2716-1</th>
<th>2716-2</th>
<th>2716</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size per device</td>
<td>4K × 8</td>
<td></td>
<td>2K × 8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access time (ns)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(from address)</td>
<td>200</td>
<td>250</td>
<td>450</td>
<td>350</td>
<td>390</td>
<td>450</td>
</tr>
<tr>
<td>(from output enable)</td>
<td>70</td>
<td>100</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Maximum Operating Frequency (MHz)</td>
<td>12.0</td>
<td>12.0</td>
<td>8.0</td>
<td>9.5</td>
<td>9.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Maximum Power Consumption (mA)

| (8051)* | 225 | 225 | 225 | 225 | 225 | 225 |
| (other circuitry) | 500 | 500 | 500 | 550 | 550 | 550 |

* The 8051 configuration used on EM-51 may require more power than standard 8051, 8751, or 8031 devices.

SPECIFICATIONS

Equipment Supplied
EM-51 board assembly
EM-51 Operator’s Manual
2732A EPROM

Equipment Required
EPROM programmer
Power supply

Optional Equipment
Crystal for on-board clock

Physical Characteristics
Length: 5.25 in. (13.34 cm)
Width: 2.75 in. (6.99 cm)
Depth: 0.75 in. (1.91 cm)
Weight: 4 oz. (113 gm)

Electrical Characteristics
DC Power: $V_{CC} = 5V \pm 5\%$
$\text{I}_{CC} = 775 \text{ mA (maximum)}$

Timing: Same as Intel 8051 microcomputer

Environmental Characteristics
Operating Temperature: 0°C to 55°C
Operating Humidity: 95% (Maximum) relative humidity, non-condensing

ORDERING INFORMATION
Part Number: MCI-51-EM
Description: 8051 Emulation Board
ICE-51™
8051 IN-CIRCUIT EMULATOR

- Precise, full-speed, real-time emulation
  - Load, drive, timing characteristics
  - Full-speed program RAM
  - Serial and parallel ports
- User-specified breakpoints
- Execution trace
  - User-specified qualifier registers
  - Conditional trigger
  - Symbolic groupings and display
  - Instruction and frame modes
- Emulation timer
- Full symbolic debugging
- Single-line assembly and disassembly for program instruction changes
- Macro commands and conditional block constructs for automated debugging sessions
- HELP facility: ICE-51 command reference at the console
- User confidence test of ICE-51 hardware

The ICE-51 module resides in the Intellec® Microcomputer Development System and interfaces to any user-designed 8051 system through a cable terminating in an 8051 emulator microprocessor and a pin-compatible plug. The emulator processor, together with 8K bytes of user program RAM located in the ICE-51 buffer box, replaces the 8051 device in the user system while maintaining the 8051 electrical and timing characteristics. Powerful Intellec debugging functions are thus extended into the user system. Using the ICE-51 module, the designer can emulate the system's 8051 in real-time or single-step mode. Breakpoints allow the user to stop emulation on user-specified conditions, and a trace qualifier feature allows the conditional collection of 1000 frames of trace data. Using the single-line 8051 assembler the user may alter program memory using ASM51 mnemonics and symbolic references, without leaving the emulator environment. Frequently used command sequences can be combined into compound commands and identified as macros with user-defined names.
FUNCTIONAL DESCRIPTION

Integrated Hardware and Software Development
The ICE-51 emulator allows hardware and software development to proceed interactively. This approach is more effective than the traditional method of independent hardware and software development followed by system integration. With the ICE-51 module, prototype hardware can be added to the system as it is designed. Software and hardware integration occurs while the product is being developed.

The ICE-51 emulator assists four stages of development:

SOFTWARE DEBUGGING
It can be operated without being connected to the user’s system before any of the user’s hardware is available. In this stage ICE-51 debugging capabilities can be used in conjunction with the Intellec text editor and 8051 macroassembler to facilitate program development.

HARDWARE DEVELOPMENT
The ICE-51 module’s precise emulation characteristics and full-speed program RAM make it a valuable tool for debugging hardware, including time-critical serial port, parallel port, and timer interfaces.

SYSTEM INTEGRATION
Integration of software and hardware can begin when any functional element of the user system hardware is connected to the 8051 socket. As each section of the user’s hardware is completed, it is added to the prototype. Thus, each section of the hardware and software is “system” tested in real-time operation as it becomes available.

SYSTEM TEST
When the user’s prototype is complete, it is tested with the final version of the user system software. The ICE-51 module is then used for real-time emulation of the 8051 to debug the system as a completed unit.

The final product verification test may be performed using the 8751 EPROM version of the 8051 microcomputer. Thus, the ICE-51 module provides the user with the ability to debug a prototype or production system at any stage in its development without introducing extraneous hardware or software test tools.

Symbolic Debugging
The ICE-51 emulator permits the user to define and use symbolic, rather than absolute, references to program and data memory addresses; additional symbols are predefined by the ICE-51 software for referencing registers, flags, and input/output ports. Thus, the user need not recall or look up the addresses of key locations in his program as they change with each assembly, or become involved with machine code.

When a symbol is used for memory reference in an ICE-51 emulator command, the emulator supplies the corresponding location as stored in the ICE-51 emulator symbol table. This table can be loaded with the symbol table produced by the assembler during application program assembly. The user can obtain the symbol table during software preparation simply by using the “DEBUG” switch in the ASM51 macroassembler. Furthermore, the user can interactively modify the emulator symbol table by adding new symbols or changing or deleting old ones. This feature provides great flexibility in debugging and minimizes the need to work with absolute memory values.

Through symbolic references in combination with other features of the emulator, the user can easily:
- Interpret the results of emulation activity collected during trace.
- Disassemble program memory to mnemonics, or assemble mnemonic instructions to executable code.
- Examine or modify 8051 internal registers, data memory, or port contents.
- Reference labels or addresses defined in a user program.

Automated Debugging and Testing

MACRO COMMAND
A macro is a set of commands which is given a name. A group of commands which is executed frequently can be defined as a macro. The user can execute the group of commands by typing a colon followed by the macro name. Up to ten parameters may be passed to the macro.

Macro commands can be defined at the beginning of a debug session and then used throughout the whole session. The user can save one or more macro definitions on diskette for later use. The Intellec text editor may be used to edit the macro file. The macro definitions are easy to include in any later emulation session.
The power of the development system can be applied to manufacturing testing as well as development by writing test sequences as macros. The macros are stored on diskettes for use during system test.

**COMPOUND COMMAND**

Compound commands provide conditional execution of commands (IF command) and execution of commands repeatedly until certain conditions are met (COUNT, REPEAT commands). Compound commands may be nested any number of times, and may be used in macro commands.

Example:

```
*DEFINE .1=0
*COUNT 100H
*IF .1 AND 1 THEN
  *CBYTE .1 = .1
.*END
.*.1 = .1 + 1
.*END
```

(The characters *, ., and .. shown in this example are system prompts which include an indication of the nesting level of compound commands.)

**Operating Modes**

The ICE-51 software is an Intellec RAM-based program that provides the user with easy-to-use commands for initiating emulation, defining breakpoints, controlling trace data collection, and displaying and controlling system parameters. ICE-51 commands are configured with a broad range of modifiers which provide the user with maximum flexibility in describing the operation to be performed.

**EMULATION**

The ICE-51 module can emulate the operation of a prototype 8051 system, at real-time speed (1.2 to 12 MHz) or in single steps. Emulation commands to the ICE-51 module control the process of setting up, running, and halting an emulation of the user’s 8051-based system. Breakpoints and tracepoints enable the ICE-51 emulator to halt emulation and provide a detailed trace of execution in any part of the user’s program. A summary of the emulation commands is shown in Table 1.

**Breakpoints**

The ICE-51 hardware includes two breakpoint registers that allow the user to halt emulation when specified conditions are met. The emulator continuously compares the values stored in the breakpoint registers with the status of specified address, opcode, operand, or port values, and halts emulation when this comparison is satisfied. When an instruction initiates a break, that instruction is executed completely before the break takes place. The ICE-51 emulator then regains control of the console and enters the Interrogation Mode. With the breakpoint feature, the user can request an emulation break when his program:

- Executes an instruction at a specific address or within a range of addresses.
- Executes a particular opcode.
- Receives a specific signal on a port pin.
- Fetches a particular operand from the user program memory.
- Fetches an operand from a specific address in program memory.

**Table 1. Major Emulation Commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GO</td>
<td>Begins real-time emulation and optionally specifies break conditions. Sets or displays either or both Breakpoint Registers used for stopping real-time emulation.</td>
</tr>
<tr>
<td>BR0, BR1, BR</td>
<td>Performs single-step emulation. Sets or displays match conditions for qualified trace.</td>
</tr>
<tr>
<td>STEP</td>
<td>Specifies or displays trace-data collection conditions and optionally sets Qualifier Register (QR0, QR1).</td>
</tr>
<tr>
<td>QR0, QR1, QR</td>
<td>Set and display status of synchronization line outputs or latched inputs. Used to allow real-time emulation or trace to start and stop synchronously with external events.</td>
</tr>
<tr>
<td>SY, SY1, SY0</td>
<td></td>
</tr>
</tbody>
</table>

**Trace and Tracepoints**

Tracing is used with both real-time and single-step emulation to record diagnostic information in the trace buffer as a program is executed. The information collected includes opcodes executed, port values, and memory addresses. The ICE-51 emulator collects up to 1000 frames of trace data.

This information can be displayed as assembler instruction mnemonics, if desired, for analysis during interrogation or single-step mode. The trace-collection facility may be set to run conditionally or unconditionally. Two unique trace qualifier registers, specified in the same way as break-
point registers, govern conditional trace activity. The qualifiers can be used to condition trace data collection to take place as follows:

- Under all conditions (forever).
- Only while the trace qualifier is satisfied.
- For the frames or instructions preceding the time when a trace qualifier is first satisfied (pre-trigger trace).
- For the frames or instructions after a trace qualifier is first satisfied (post-triggered trace).

Table 2 shows an example of a trace display.

**Table 2. Trace Display (Instruction Mode)**

| *BEH1* | *90* | *FF* | *E0* | *E7* | *E8* | *E9* | *EF* | *CE* | *C0* | *C1* | *C2* | *C3* | *C4* | *C5* | *C6* | *C7* | *C8* | *C9* | *CA* | *CB* | *CC* | *CD* | *CE* | *CF* | *DE* | *DF* |
|---------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| *BEH1* | *90* | *FF* | *E0* | *E7* | *E8* | *E9* | *EF* | *CE* | *C0* | *C1* | *C2* | *C3* | *C4* | *C5* | *C6* | *C7* | *C8* | *C9* | *CA* | *CB* | *CC* | *CD* | *CE* | *CF* | *DE* | *DF* |

**INTERROGATION AND UTILITY**

Interrogation and utility commands give the user convenient access to detailed information about the user program and the state of the 8051 that is useful in debugging hardware and software.

Changes can be made in memory and in the 8051 registers, flags, and port values. Commands are also provided for various utility operations such as loading and saving program files, defining symbols, displaying trace data, controlling system synchronization and returning control to ISIS-II. A summary of the basic interrogation and utility commands is shown in Table 3. Two time-saving emulator features are discussed below.

**SINGLE-LINE ASSEMBLER/DISASSEMBLER** — The single-line assembler/disassembler (ASM and DASM commands) permits the designer to examine and alter program memory using assembly language mnemonics, without leaving the emulator environment or requiring time-consuming program reassembly. When assembling new mnemonic instructions into program memory, previously defined symbolic references (from the original program assembly, or subsequently defined during the emulation session) may be used in the instruction operand field. The emulator will supply the absolute address or data values as stored in the emulator symbol table. These features eliminate user time spent translating to and from machine code and searching for absolute addresses, with a corresponding reduction in transcription errors.

**Table 3. Major Interrogation and Utility Commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HELP</td>
<td>Displays help messages for ICE-51 emulator command-entry assistance.</td>
</tr>
<tr>
<td>LOAD</td>
<td>Loads user object program (8051 code) into user program memory, and user symbols into ICE-51 emulator symbol table.</td>
</tr>
<tr>
<td>SAVE</td>
<td>Saves ICE-51 emulator symbol table and/or user object program in ISIS-II hexadecimal file.</td>
</tr>
<tr>
<td>LIST</td>
<td>Copies all emulator console input and output to ISIS-II file.</td>
</tr>
<tr>
<td>EXIT</td>
<td>Terminates ICE-51 emulator operation.</td>
</tr>
<tr>
<td>DEFINE</td>
<td>Defines ICE-51 emulator symbol or macro.</td>
</tr>
<tr>
<td>REMOVE</td>
<td>Removes ICE-51 emulator symbol or macro.</td>
</tr>
<tr>
<td>ASM</td>
<td>Assembles mnemonic instructions into user program memory.</td>
</tr>
<tr>
<td>DASM</td>
<td>Disassembles and displays user program memory contents.</td>
</tr>
<tr>
<td>Change/Display Commands</td>
<td>Change or display value of symbolic reference in ICE-51 emulator symbol table, contents of key-word references (including registers, I/O ports, and status flags), or memory references.</td>
</tr>
<tr>
<td>EVALUATE</td>
<td>Evaluates expression and displays resulting value.</td>
</tr>
<tr>
<td>MACRO</td>
<td>Displays ICE-51 macro or macros.</td>
</tr>
<tr>
<td>INTERRUPT</td>
<td>Displays serial, external, or timer interrupt register settings.</td>
</tr>
<tr>
<td>SECONDS</td>
<td>Displays contents of emulation timer, in microseconds.</td>
</tr>
<tr>
<td>Trace Commands</td>
<td>Position trace buffer pointer and select format for trace display.</td>
</tr>
<tr>
<td>PRINT</td>
<td>Displays trace data pointed to by trace buffer pointer.</td>
</tr>
</tbody>
</table>
HELP — The HELP file allows the user to display ICE-51 command syntax information at the Intel­lec console. By typing "HELP", a listing of all items for which help messages are available is displayed; typing "HELP <item>" then displays relevant information about the item requested, including typical usage examples. Table 4 shows some sample HELP messages.

![Image](image-url)

**Figure 1. A Typical 8051 Development Configuration.** The host system is an Intel­lec Model 225, plus 1 megabyte double-density flexible disk storage. The ICE-51 module is connected to an SDK-51 system design kit.

**Emulation Accuracy**

The speed and interface demands of a high-per­formance single-chip microcomputer require extremely accurate emulation, including full-speed, real-time operation with the full function of the microcomputer. The ICE-51 emulator achieves accurate emulation with an 8051 bond-out chip, a special configuration of the 8051 microcomputer family, as its emulation processor.

Each of the 40 pins on the user plug is connected directly to the corresponding 8051 pin on the bond-out chip. Thus the user system sees the emulator as an 8051 microcomputer at the 8051 socket. The resulting characteristics provide extremely accurate emulation of the 8051, including speed, timing characteristics, load and drive values, and crystal operation. The emulator may draw more power from the user system than a standard 8051 family device.

Additional bond-out pins provide signals such as internal address, data, clock, and control lines to the emulator buffer box. These signals let static RAM in the buffer box substitute for on-chip program ROM or EPROM or external program memory. The 8K bytes of full-speed RAM in the buffer box can be mapped in 4K blocks to anywhere within the 64K program memory space of the 8051. The bond-out chip also gives the emulator "backdoor" access to internal chip operation, so that the emulator can break and trace execution without interfering with the values on the user-system pins.

**Table 4. HELP Command**

```plaintext
HELP
HELP <item>

HELP IF
IF - The conditional command allows conditional execution of one or more commands based on the values of certain conditions.

IF (expr) <command> <command>
(IF <condition> <command> <command>)
(IF <condition> <command>)
(IF <condition>)

END

The conditions are evaluated as signed 16-bit integers. If one is reached whose value has low-order bit 0 (TRUE), all commands in the truefiles following that expr are then executed and all commands in the other truefiles and in the falsefiles are ignored. If all expressions have value with low-order bit 0 (FALSE), then no commands in the truefiles are skipped and, if FLIP is present, all commands in the falsefiles are executed.

(IF) IF <cond> THEN
(IF <cond> THEN)
(IF <cond>)

END

```

19-11

AFN-02026
ICE-51™

SPECIFICATIONS

ICE-51 Operating Requirements
Intellec® Microcomputer Development System (64K RAM required)
System console
Intellec® Diskette Operating System (single or double density) ISIS-II v. 3.4 or later

Equipment Supplied
• Printed circuit boards (2)
• Emulation buffer box, Intellec interface cables, and user-interface cable with 8051 emulation processor
• Crystal power accessory
• Operating instructions manual
• Diskette-based ICE-51 software (single and double density)

Emulation Clock
User's system clock (1.2 to 12 MHz) or ICE-51 crystal power accessory (12 MHz)

Environmental Characteristics
Operating Temperature: 0° to 40°C
Operating Humidity: Up to 95% relative humidity without condensation.

Physical Characteristics
Printed Circuit Boards
Width: 12.00 in. (30.48 cm)
Height: 6.75 in. (17.15 cm)
Depth: 0.50 in. (1.27 cm)

Buffer Box
Width: 8.00 in. (20.32 cm)
Length: 12.00 in. (30.48 cm)
Depth: 1.75 in. (4.44 cm)
Weight: 4.0 lb (1.81 kg)

Electrical Characteristics
DC Power Requirements (from Intellec system)
\[ \begin{align*}
V_{CC} &= +5V, \pm 5\% \pm 1\% \\
I_{CC} &= 13.2A \text{ max; } 11.0A \text{ typical} \\
V_{DD} &= +12V, \pm 5\% \\
I_{DD} &= 0.1A \text{ max; } 0.05A \text{ typical} \\
V_{BB} &= -10V, \pm 5\% \\
I_{BB} &= 0.05A \text{ max; } 0.01A \text{ typical}
\end{align*} \]

User plug characteristics at 8051 socket
Same as 8031, 8051, or 8751, except that the user system will see an added load of 25 pF capacitance and 50 μA leakage from the ICE-51 emulator user plug at ports 0, 1, and 2.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>MCI-51-ICE</td>
<td>8051 Microcontroller In-Circuit Emulator, cable assembly and interactive diskette software</td>
</tr>
</tbody>
</table>
ICE-41A™
UPI-41A IN-CIRCUIT EMULATOR

Extends Intellec microcomputer development system debug power to user configured system via external cable and 40-pin plug, replacing user UPI-41A™ devices

Emulates user system UPI-41A™ devices in real time

Allows user configured system to use static RAM memory for program debug

Provides hardware comparators for user designated break conditions

Eliminates need for extraneous debugging tools residing in user system

Collects address, data, and UPI-41A™ status information on machine cycles emulated

Provides capability to examine and alter UPI-41A™ registers, memory, and flag values, and to examine pin and port values

Integrates hardware and software efforts early in engineering cycle to save development time

The ICE-41A UPI-41A In-Circuit Emulator module is an Intellec system resident module that interfaces to any user configured UPI-41A system. The ICE-41A module interfaces with a UPI-41A pin-compatible plug which replaces the UPI-41A device in the system. With the ICE-41A plug in place, the designer has the capability to execute the system in real time while collecting up to 255 instruction cycles of real time trace data. In addition, he can single step the system program during execution. Static RAM memory is available through the ICE-41A module to store UPI-41A programs. The designer may display and alter the contents of program memory, internal UPI-41A registers and flags, and I/O ports. Powerful debug capability is extended into the UPI-41A system while ICE-41A debug hardware and software remain inside the Intellec system. Symbolic reference capability allows the designer to use symbols rather than absolute values when examining and modifying memory, registers, flags, and I/O ports in the system.
FUNCTIONAL DESCRIPTION

Debug Capability Inside User System
Intellec memory is used for the execution of the ICE-41A software. The Intellec CRT console and the file handling capabilities provide the designer with the ability to communicate with the ICE-41A module and display information on the operation of the prototype system. The ICE-41A module block diagram is shown in Figure 1.

Symbolic Debugging
Symbol Table — ICE-41A software allows the user to make symbolic references to I/O ports, memory addresses, and data in his program. The user symbol table which is generated along with the object file during a program assembly can be loaded to Intellec memory for access during emulation. The user may add to this symbol table any additional symbolic values for memory addresses, constants, or variables that he may find useful during system debugging. By referring to symbol memory addresses, the user can examine, change or break at the intended location. In addition, ICE-41A provides symbolic definition of all UPI-41A registers and flags.

Symbolic Reference — Symbolic reference is a great advantage to the system designer. He is no longer burdened with the need to recall or look up addresses of key locations in his program which can change with each assembly. Meaningful symbols from his source program can be used instead. For example, the command:

```
GO FROM .START TILL CODE. RSLT
```

begins execution of the program at the address referenced by the label START in the designer's assembly program. A breakpoint is set to occur the first time the microprocessor executes the program memory location referenced by RSLT. The designer does not have to be concerned with the physical locations of START and RSLT. The ICE-41A software driver supplies them automatically from information stored in the symbol table.

Memory Replacement
The 8741/8741A and 8041/8041A contain internal program and data memory. When the UPI-41A microcomputer is replaced by the ICE-41A socket in a system, the ICE-41A module supplies static RAM memory as a replacement for the internal microcomputer memory. The ICE-41A module has enough RAM memory available to emulate up to the total 1K control memory capability of the system.

Real-Time Trace
The ICE-41A module captures trace information while the designer is executing programs in real time. The instructions executed, program counter, port values for port 1 and port 2, and the values of selected UPI-41A status lines are stored for the last 255 instruction cycles executed. When retrieved for display, code is disassembled for user convenience. This provides data for determining how the user system was reacting prior to emulating break.

Figure 1. ICE-41A Module Block Diagram
Integrated Hardware/Software Development

The user prototype systems need no more than a UPI-41A socket and timing logic to begin integration of software and hardware development efforts. Through the ICE-41A module, Intellec system resources can be accessed to replace the prototype system. UPI-41A software development can proceed without the prototype hardware. Hardware designs can be tested using previously tested system software.

Hardware

The ICE-41A module is a microcomputer system utilizing Intel's UPI-41A microprocessor as its nucleus. This system communicates with the Intellec system 8080A processor via direct memory access. Host processor commands and ICE-41A status are interchanged through a DMA channel. ICE-41A hardware consists of two printed circuit boards, the controller board and the emulator board, which reside in the Intellec system chassis. A cable assembly interfaces the ICE-41A module to the user's UPI-41A system. The cable terminates in a UPI-41A pin-compatible plug which replaces any UPI-41A device in the user system.

Controller Board

The ICE-41A module interfaces to the Intellec systems as a peripheral device. The controller board receives commands from the Intellec system and responds through a DMA port. Three 10-bit hardware breakpoint registers are available which can be loaded by the user. While in emulation mode, a hardware comparator is constantly monitoring address lines for a match which will terminate an emulation. The controller board returns real-time trace data, UPI-41A registers, flag and port values, and status information to a control block in the Intellec system when emulation is terminated. This information is available to the user through the ICE-41A interrogation commands. Error conditions, when detected, are automatically displayed on the Intellec system console.

Emulator Board

The emulator board contains the 8741A and peripheral logic required to emulate the UPI-41A device in the user system. A 6 MHz clock drives the emulated UPI-41A device. This clock can be replaced with a user supplied TTL clock in the user system or can be strapped internally for 3 MHz operation.

Cable Card

The cable card is included for cable driving. It transmits address and data bus information to the user system through a 40-pin connector which plugs into the user system in the socket designed for the UPI-41A device.

Software

The ICE-41A software driver is a RAM-based program which provides the user with command language (see Table 1, Table 2, and Table 3) for defining breakpoints, initiating real-time emulation or single step operation, and interrogation and altering user system status recorded during emulation. The ICE-41A command language contains a broad range of modifiers which provide the user with maximum flexibility in defining the operation to be performed. The ICE-41A software driver is available on diskette and operates in 32K of Intellec RAM memory.

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable</td>
<td>Activates breakpoint and display registers for use with go and step commands.</td>
</tr>
<tr>
<td>Go</td>
<td>Initiates real-time emulation and allows user to specify breakpoints and data retrieval.</td>
</tr>
<tr>
<td>Step</td>
<td>Initiates emulation in single instruction increments. Each step is followed by register dump. User may optionally tailor other diagnostic activity to his needs.</td>
</tr>
<tr>
<td>Interrupt</td>
<td>Emulates user system interrupt</td>
</tr>
</tbody>
</table>

Table 1. ICE-41A Emulation Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>Prints contents of memory, UPI-41A device registers, I/O ports, flags, pins, real-time trace data, symbol table, or other diagnostic data on list device.</td>
</tr>
<tr>
<td>Change</td>
<td>Alters contents of memory, register, output port, or flag. Sets or alters breakpoints and display registers.</td>
</tr>
<tr>
<td>Base</td>
<td>Establishes mode of display for output data.</td>
</tr>
<tr>
<td>Suffix</td>
<td>Establishes mode of display for input data.</td>
</tr>
</tbody>
</table>

Table 2. ICE-41A Interrogation Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load</td>
<td>Fetches user symbol table and object code from input device.</td>
</tr>
<tr>
<td>Save</td>
<td>Sends user symbol table and object code to output device.</td>
</tr>
<tr>
<td>Define</td>
<td>Enters symbol name and value to user symbol table.</td>
</tr>
<tr>
<td>Move</td>
<td>Moves block of memory data to another area of memory.</td>
</tr>
<tr>
<td>Print</td>
<td>Prints user specified portion of trace memory to selected list device.</td>
</tr>
<tr>
<td>List</td>
<td>Defines list device.</td>
</tr>
<tr>
<td>Exit</td>
<td>Returns program control to ISIS-II.</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Converts expression to equivalent values in binary, octal, decimal, and hex.</td>
</tr>
<tr>
<td>Remove</td>
<td>Deletes symbols from symbol table.</td>
</tr>
<tr>
<td>Reset</td>
<td>Reinitializes ICE-41A hardware.</td>
</tr>
</tbody>
</table>

Table 3. ICE-41A Utility Commands
ICE-41A™

SPECIFICATIONS

ICE-41A Operating Environment

Required Hardware
Intellec microcomputer development system
System console
Intellec diskette operating system
ICE-41A module

Required Software
System monitor
ISIS-II
ICE-41A diskette-based software

System Clock
Crystal controlled 6.0 MHz or 3.0 MHz internal or user supplied TTL external

Physical Characteristics

Printed Circuit Boards
Width: 12.00 in. (30.48 cm)
Height: 6.75 in. (17.15 cm)
Depth: 0.50 in. (1.27 cm)
Weight: 8.00 lb (3.64 kg)

Cable Buffer Box
Width: 8.00 in. (20.32 cm)
Height: 4.00 in. (10.16 cm)
Depth: 1.25 in. (3.17 cm)
Flat Cable: 4.00 ft (121.92 cm)
User Cable: 15.00 in. (38.10 cm)

Electrical Characteristics

DC Power Requirements

Vcc = +5V, ±5%
Icc = 10A max; 8A typ

Input Impedance

@ ICE-41A user socket pins:
Vil = 0.8V min; Iil = 1.6 mA
Vih = 2.0V min; Ih = 40 μA

@ Bus:
Vil = 0.8V max; Iil = 250 μA
Vih = 2.0V min; Ih = 20 μA

Output Impedance

@ P1, P2:
VOL = 0.5V max; IOL = 16 mA
VOH = Vcc (10K pullup)

@ Bus:
VOL = 0.5V max; IOL = 25 mA
VOH = 3.65V min; IOH = 1 mA

Others

VOL = 0.5V max; IOL = 16 mA
VOH = 2.4V max; IOH = 400 μA

Equipment Supplied

Controller board
Emulator board
Interface cables and buffer module
Operator's manual
ICE-41A diskette based software

Reference Manuals

9800465 — ICE-41A Operator's Manual (SUPPLIED)

Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative, distributor office or from Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

ORDERING INFORMATION

Part Number Description
MDS-41A-ICE UPI-41A (8741, 8041, 8741A, 8041A) CPU
In-circuit emulator, cable assembly and interactive diskette software included

VDD = +12V, ±5%
IDD = 100 mA max; 60 mA typ
VBB = −10V
IBB = 30 mA
2920 SIGNAL PROCESSING APPLICATIONS COMPILER

- Compiler generates 2920 Assembly Language Code
- Extensive command set for designing electrical filters
- Graphics capability enhances analysis of filter response
- Powerful MACRO capability for executing frequently used routines
- Interactive software support tool for 2920 Signal Processor
- Extends Intellec® Microcomputer Development System support of the 2920
- Contains MACRO library for several standard filters and signal processing functions

The 2920 Signal Processing Applications Compiler (SPAS20) is an interactive tool for designing software to execute on the 2920 Signal Processor.

The SPAS20 package can be visualized as being comprised of three inter-related sections: A compiler section, a filter design section, and a MACRO section.

Among the capabilities of SPAS20 are: ability to generate 2920 assembly language code directly from specifications of signal processing building blocks such as filters and waveform generators; ability to generate 2920 assembly language code for several classes of algebraic equations such as \( Y = C \cdot X \), \( Y = C \cdot Y \), and \( Y = C \cdot X + Y \) where \( X, Y \) are variables and \( C \) is a constant; ability to examine time and frequency responses of filter sections specified by continuous or sampled poles and zeroes; ability for users to implement more complex commands by grouping sets of commonly used commands into a MACRO.

The SPAS20 package runs under ISIS-II on any Intellec Microcomputer Development System with 64K RAM. The output of SPAS20 can be assembled with the 2920 assembler, tested with the 2920 Simulator, and programmed into the 2920 chip with the Universal PROM Programmer for prototyping.
FUNCTIONAL DESCRIPTION

The 2920 Signal Processing Applications Compiler gives the analog designer a "high level language" for his 2920 applications—it decreases the need to code 2920 assembly language. Furthermore, the compiler is interactive. This feature enables the designer to define a filter, graph its response, and change its parameters many times, without having to program and test the filter in an actual 2920 implementation. The command language is very similar to that of Intel's In-Circuit Emulators.

Once a filter is realized by moving poles and zeros in the continuous and sampled planes, the filter may be coded and written onto an ISIS file. Several other file commands are available to store and retrieve command sequences for SPAS20 sessions.

SPAS20 Command Language

DEFINE
This command defines a pole or zero by associating it with a number (i.e., POLE 3), and with real and imaginary coordinates in the continuous or sampled plane.

This command also defines a symbol by associating a name with a numeric value, or a MACRO by providing a pointer to a specified command sequence.

GRAPH/OGRAPH
This command graphically displays the values of object(s) specified. For example, GRAPH GAIN and GRAPH PHASE are used to display filter response. The OGRAPH command will "overgraph" the new response over the old response, after any changes have been made. (You may also graph Group Delay, Step, and Impulse.)

MOVE
Allows the definition of a pole or zero to be changed—its coordinates, its plane, or both.

REMOVE
Deletes the definition of a pole, zero, symbol, or macro.

HELP
Types an explanatory message on the console, pertaining to a command or its attributes.

HOLD
Command to correct attenuation due to sample-and-hold distortion: if ON, it corrects absolute gain by \(\sin(x)/x\) and phase by adding \(x\), where \(x=TS*FREQ*\pi\). It corrects group delay by subtracting \(\pi*TS\).

EVALUATE
Gives the decimal numeric value of any expression.

CODE
Creates 2920 assembly language code for given poles, zeros, and equations.

The SPAS20 compiler also recognizes the following commands for file handling:

PUT/APPEND
Writes out objects (commands) to a specified file, either creating a new one or appending an existing one. This enables the user to store all or part of a SPAC20 session on a diskette to be brought back later with the INCLUDE command.

DISPLAY
Copies the contents of a file to the console.

INCLUDE
Executes a sequence of instructions from a diskette file as if they were typed in from the console.

LIST
Creates a file containing all console interactions.

In addition to naming macros for specific command sequences, compound and conditional commands may be formed using all of the above statements. These compound commands are:

IF
Establishes conditional flow of control within a block of commands.

REPEAT
Used for repetition of a block of commands; executes indefinitely or until a condition is met (using WHILE, UNTIL, and END statements).

COUNT
Establishes the number of times a command sequence is to be executed, in a looping fashion.
SPAS20 MACRO Facility

A macro is a sequence of commands that is stored on a temporary diskette file. The command sequence is executed when the macro name is entered as a command. This saves repetitive entry of the sequence, and permits algorithms to be saved on diskette for future use. This SPAS20 facility allows you to do the following:

- Display the text of any macro.
- Define a macro, specifying its name and any parameters that are to be used by the block. This definition is followed by the contents of the macro (commands) and the EM statement to end its definition.
- Invoke a macro by entering its name and appropriate values for any parameters.
- List the names of all defined macros.
- Remove any or all macros.

SAMPLE SPAS20 SESSION

```plaintext
-FI:SPAC20.SFT

ISIS-II 2920 SIGNAL PROCESSING APPLICATIONS COMPILER. VI.0

* DEFINE POLE 1 = -707.707 ; CREATE A POLE IN CONTINUOUS S-PLANE
* PZ ; LIST ALL POLES AND ZEROS
POLE 1 = -707.00000.707.00000.CONTINUOUS
* FSSCALE = 100,100000 ; ESTABLISHES FREQUENCY RANGE OF INTEREST
* YSCALE = -45.1 ; ESTABLISHES MAGNITUDE RESPONSE RANGE OF INTEREST
* GRAPH GAIN ; PLOT MAGNITUDE RESPONSE OF POLE PAIR

GAIN

-10 0 -12 1 -14 3 -16 5 -18 7 -20 9 -23 1 -25 3 -27 5 -29 - -31 9 -34 0 -36 2 -39 4 -40 6 -42 8 -45 0

DB/INZ

100 150 200 300 400 500 700 1000 1400 2000 3000 5000 10000

**

* : THE UNITS USED IN GRAPHING GAIN ARE SHOWN IN THE LOWER LEFT CORNER.
* : GAIN IN DECIBELS IS GRAPHED VERSUS FREQUENCY IN HERTZ.
* : PREPARE TO MOVE TO THE DIGITAL DOMAIN.
* : SAMPLE RATE MUST BE SPECIFIED.
* TS = 1/13020 ; RATE FOR 192 INSTRUCTION PROGRAM AND 10MHZ CLOCK
TS = 7.6805004/10**5
* 
```
SAMPLE SPAS20 SESSION (Cont'd.)

* MOVE POLE TO Z  ; CONVERT FILTER TO DIGITAL VIA MATCHED-Z TRANSFORMATION
  * POLES/ZEROES MOVED
*  
  *P  ; LIST TRANSFORMED POLE
POLE 1  =  0.71092036,0.34118369  ;
  
  *: COMPARE RESPONSES OF THE ANALOG AND DIGITAL FILTERS BY GRAPHING THE
  *: NEW RESPONSE OVER THE OLD
  *
  *:  

GAIN:  .................................................................

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G*

*: PLUS SIGNS INDICATE OLD CURVE.
*: NOTE THAT THE DIGITAL FILTER RESPONSE BEGINS TO INCREASE AGAIN
*: AT HALF THE SAMPLE RATE (6510 HZ).
*: THE PHASE CHARACTERISTICS OF THIS FILTER CAN BE EXAMINED.
*: *
*: YSCALE = -PI, PI  ; ESTABLISHES RANGE OF INTEREST
*: NUMBER OF
*: GRAPH PHASE

PHASE:  .................................................................

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P*

*:  
*: PUT :F1:POLE PZ  ; SAVE THE POLE LOCATION IN A DISK FILE BACKUP
*: CODE PILE : INST(11)  ; GENERATE 2920 ASSEMBLY CODE FOR THIS FILTER
B: = 0.33989990  827 = 0.50541914
SAMPLE SPAS20 SESSION (Cont'd.)

OPTIMIZED 2920 CODE IS NOW GENERATED. TO SAVE SPACE, SOME
OF THE SCREEN OUTPUT HAS BEEN DELETED. NORMALLY ALL ATTEMPTS
BY THE COMPILER TO GENERATE CODE ARE ECHOED ON THE SCREEN.

INSTR=10
POLE 1 = 0.71089458, 0.34147725.
BEST: PERROR = 3.3795874/10**5, 1.5884656/10**5.

NOTE: MAKE SURE SIGNAL IS <0.7463571.

LDW OUT2_P1,OUT1_P1,R00
OUT2_P1=1,000000000*OUT1_P1
LDW OUT1_P1,OUT0_P1,R00
OUT1_P1=1,000000000*OUT0_P1
SUB OUT0_P1,OUT1_P1,R05
OUT0_P1=1,000000000*OUT0_P1-0.312500000*OUT1_P1
ADD OUT0_P1,OUT0_P1,R03
OUT0_P1=1,125000000*OUT0_P1-0.335156250*OUT1_P1
ADD OUT0_P1,OUT1_P1,R02
OUT0_P1=1,125000000*OUT0_P1+0.21484375*OUT1_P1
SUB OUT0_P1,OUT2_P1,R01
OUT0_P1=1,125000000*OUT0_P1+0.21484375*OUT1_P1-0.500000000*OUT2_P1
SUB OUT2_P1,OUT1_P1,R08
OUT2_P1=1,125000000*OUT0_P1+0.21484375*OUT1_P1-0.503906250*OUT2_P1
ADD OUT0_P1,OUT2_P1,R11
OUT0_P1=1,125000000*OUT0_P1+0.21484375*OUT1_P1-0.503906250*OUT2_P1
ADD OUT0_P1,OUT0_P1,R09
OUT0_P1=1,125000000*OUT0_P1+0.21484375*OUT1_P1-0.503906250*OUT2_P1+1.000000000*IN0_P1.

* THE CODE COMMAND SPECIFIED THAT THE POLE PAIR BE CODED IN LESS THAN 11
* INSTRUCTIONS. SO 10 INSTRUCTIONS WERE GENERATED, WITH COMMENTS.
* THE FINAL ERROR IN RADIUS AND ANGLE FOR THE POLE PAIR WAS OF THE
* ORDER OF 1/10**5 AS INDICATED ABOVE IN PERROR.
" THIS OPTIMIZED 2920 ASSEMBLY CODE CAN NOW BE APPENDED TO A FILE
* WHICH MAY CONTAIN OTHER CODED FUNCTIONAL BLOCKS OF A 2920 PROGRAM.
* &EXIT

SPECIFICATIONS

Operating Environment

REQUIRED HARDWARE:
Intellec® Microcomputer Development System
—Model 800
—Series II (Model 220, 230, or 240)
64K bytes of memory
One or two floppy diskette drives
—Single or Double Density
System Console
—CRT or TTY

REQUIRED SOFTWARE:
ISIS-II diskette operating system, V3.4 or later

OPTIONAL HARDWARE:
isBC-310 High Speed Mathematics unit
(Speeds calculations by factor of 4X or more).
Universal PROM Programmer

OPTIONAL SOFTWARE:
MCI-20-SPS (Contains 2920 Signal Processor Applications Compiler and the 2920 Assembler Simulator.)

Documentation Package


Shipping Media

Single and Double Density Flexible Diskettes

ORDERING INFORMATION

Product Code Description
MCI-20-SPAS 2920 Signal Processing Applications Compiler
2920 SOFTWARE SUPPORT PACKAGE

- Complete software design and development support for the 2920
- Extends Intellec® Microcomputer Development System to support 2920 software development

The 2920 Software Support Package furnishes a 2920 Signal Processing Applications Software/Compiler, 2920 Assembler, and 2920 Software Simulator. These three software design and development tools run on the Intellec® Microcomputer Development System.

The 2920 Signal Processing Application Software/Compiler is an interactive tool for designing software to be executed on the 2920 Signal Processor. The compiler accepts English-like statements from the user and generates 2920 assembly language code.

The assembler translates symbolic 2920 assembly language programs into the machine operation code. The user can load the code into the simulator for 2920 simulation or to the Universal PROM Programmer for 2920 EPROM programming.

The simulator, operating entirely in software, allows the user to test and symbolically debug 2920 programs. The user can specify input signals, simulate program execution, set up breakpoints, display input and output, and display and alter the contents of the 2920 registers and memory locations. The simulator can also stop or trace the program and constructively give the user access to the key elements inside a 2920 for analyzing his program.

The compiler, assembler, and simulator enable the designer to develop and test an entire program without a complete prototype design. The 2920 designer works on the Intellec® Microcomputer Development System rather than on a breadboard. The development system can program, store and recall programs or routines and aid in 2920 program design.
2920 SIGNAL PROCESSING APPLICATIONS
SOFTWARE/COMPILER

- Compiler generates 2920 Assembly Language Code
- Extensive command set for designing electrical filters
- Graphics capability enhances analysis of filter response or piecewise linear function approximations
- Powerful MACRO capability for executing frequently used routines

- Interactive software support tool for 2920 Signal Processor
- Extends Intellec® Microcomputer Development System support of the 2920
- Contains MACRO library for several standard filters and signal processing functions

The 2920 Signal Processing Applications Software/Compiler (SPAS20) is an interactive tool for designing software to execute on the 2920 Signal Processor.

The SPAS20 package can be visualized as being comprised of four inter-related sections: A compiler section, a filter design section, a curve fitting section, and a MACRO section.

Among the abilities of SPAS20 are: ability to generate 2920 assembly language code directly from specifications of signal processing building blocks such as filters and waveform generators; ability to generate 2920 assembly language code for several classes of algebraic equations such as \( Y = C \cdot X \), \( Y = C \cdot Y \), and \( Y = C \cdot X + Y \) where \( X, Y \) are variables and \( C \) is a constant; ability to generate 2920 assembly language code for one variable function \( Y(X) = F(X) \); ability to examine time and frequency responses of filter sections specified by continuous or sampled poles and zeroes; ability to examine piecewise linear approximation of specific function; ability for users to implement more complex commands by grouping sets of commonly used commands into a MACRO.

The SPAS20 package runs under ISIS-II on any Intellec® Microcomputer Development System with 64K RAM. The output of SPAS20 can be assembled with the 2920 assembler, tested with the 2920 Simulator, and programmed into the 2920 chip with the Universal PROM Programmer for prototyping.
FUNCTIONAL DESCRIPTION

The 2920 Signal Processing Applications Software/ Compiler gives the analog designer a "high level language" for his 2920 applications—it decreases the need to code 2920 assembly language. Furthermore, the compiler is interactive. This feature enables the designer to define a filter, or transfer function, graph their response, and change their parameters many times, without having to program and test in an actual 2920 implementation.

Once a filter is realized by moving poles and zeros in the continuous and sampled planes, the filter may be coded and written onto an ISIS file. Similarly, after a function \( Y = F(X) \) has been defined, the code for a piecewise linear approximation can be stored onto an ISIS file. Several other file commands are available to store and retrieve command sequences for SPAS20 sessions.

SPAS20 Command Language

**DEFINE**

This command defines a pole or zero by associating it with a number (i.e., POLE 3), and with real and imaginary coordinates in the continuous or sampled plane.

This command also defines a symbol by associating a name with a numeric value, or a MACRO by providing a pointer to a specified command sequence.

**GRAPH/OGRAPH**

This command graphically displays the values of object(s) specified. For example, GRAPH GAIN and GRAPH PHASE are used to display filter response. The OGRAPH command will "overgraph" the new response over the old response, after any changes have been made. (You may also graph Group Delay, Step, and Impulse.)

**MOVE**

Allows the definition of a pole or zero to be changed—its coordinates, its plane, or both.

**REMOVE**

Deletes the definition of a pole, zero, symbol, or macro.

**HELP**

Types an explanatory message on the console, pertaining to a command or its attributes.

**FIT**

This command performs curve fitting, i.e. it approximates an arbitrary user supplied function with a piecewise linear function.

**DATA**

This command allows for specification of a set of vertices (i.e. \( X-Y \) coordinate pairs) which determine a piecewise linear approximation of some defined function, filter response characteristics, etc.

**HOLD**

Command to correct attenuation due to sample-and-hold distortion: if ON, it corrects absolute gain by \( \sin(x)/x \) and phase by adding \( x \), where \( x=TS*\text{FREQ}^\pi \). It corrects group delay by subtracting \( \pi TS \).

**EVALUATE**

Gives the decimal numeric value of any expression.

**CODE**

Creates 2920 assembly language code for given poles, and zeros, equations, and user defined functions.

The SPAS20 compiler also recognizes the following commands for file handling:

**PUT/APPEND**

Writes out objects (commands) to a specified file, either creating a new one or appending an existing one. This enables the user to store all or part of a SPAS20 session on a diskette to be brought back later with the INCLUDE command.

**DISPLAY**

Copies the contents of a file to the console.

**INCLUDE**

Executes a sequence of instructions from a diskette file as if they were typed in from the console.

**LIST**

Creates a file containing all console interactions.

In addition to naming macros for specific command sequences, compound and conditional commands may be formed using all of the above statements. These compound commands are:

**IF**

Establishes conditional flow of control within a block of commands.

**REPEAT**

Used for repetition of a block of commands; executes indefinitely or until a condition is met (using WHILE, UNTIL, and END statements).

**COUNT**

Establishes the number of times a command sequence is to be executed, in a looping fashion.
Intel also supplies several MACRO library files containing the following commonly needed MACROS:

- **Filter design MACROS**
  - Butterworth filter
  - Chebyshev filter
  - Bilinear transform
  - Evaluate gain or phase of digital filter in parallel form
  - Time response simulation

- **Function design MACROS**
  - Code and error optimization
  - Calculate inertertial error

- **MACROs for generation of 2920 code**
  - Code for all-POLE filter
  - Input and A/D conversion
  - Multiplication
  - Division
  - Logarithm functions
  - Square-root functions
  - Sinewave oscillator

---

**SPAS20 MACRO Facility**

A macro is a sequence of commands that is stored on a temporary diskette file. The command sequence is executed when the macro name is entered as a command. This saves repetitive entry of the sequence, and permits algorithms to be saved on diskette for future use. This SPAS20 facility allows you to do the following:

- Display the text of any macro.
- Define a macro, specifying its name and any parameters that are to be used by the block. This definition is followed by the contents of the macro (commands) and the EM statement to end its definition.
- Invoke a macro by entering its name and appropriate values for any parameters.
- List the names of all defined macros.
- Remove any or all macros.

---

**SAMPLE SPAS20 FILTER DESIGN SESSION**

```
azes` : SPAS20 . SFT
ISIS-II 2920 SIGNAL PROCESSING APPLICATIONS COMPILER. V2.0
* DEFINE POLE 1 = -707.707; CREATE A POLE IN CONTINUOUS S-PLANE
* PREQUEST ALL POLES AND ZEROS
POLE 1 = -707.00000.707.00000. CONTINUOUS
* FSCALE = 100.10000 ; ESTABLISHES FREQUENCY RANGE OF INTEREST
* YSCALE = -45.1 ; ESTABLISHES MAGNITUDE RESPONSE RANGE OF INTEREST
* GRAPH GAIN ; PLOT MAGNITUDE RESPONSE OF POLE PAIR

GAIN

1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6
5.8
6.0
6.2
6.4
6.6
6.8
7.0
7.2
7.4
7.6
7.8
8.0
8.2
8.4
8.6
8.8
9.0
9.2
9.4
9.6
9.8
10.0

100 150 200 300 400 500 700 1000 1400 2000 3000 5000 10000

**:
* : THE UNITS USED IN GRAPHING GAIN ARE SHOWN IN THE LOWER LEFT CORNER.
** : GAIN IN DECIBELS IS GRAPHED Verses FREQUENCY IN HERTZ.
*: PREPARE TO MOVE TO THE DIGITAL DOMAIN.
** : SAMPLE RATE MUST BE SPECIFIED.
*: TS = 1/13020 ; RATE FOR 192 INSTRUCTION PROGRAM AND 10MHZ CLOCK
TS = 7.6805004/10**5
```
SAMPLE SPAS20 FILTER DESIGN SESSION (Cont'd.)

*MOVE POLE TO Z

; CONVERT FILTER TO DIGITAL VIA MATCHED-Z TRANSFORMATION
I POLES/ZEROS MOVED

*P

; LIST TRANSFORMED POLE
POLE 1 = 0.71092836 0.34118369 2

*E

; COMPARE RESPONSES OF THE ANALOG AND DIGITAL FILTERS BY GRAPHING THE
I NEW RESPONSE OVER THE OLD

*GRAPH

*GRAPH GAIN

G =

* PLUS SIGNS INDICATE OLD CURVE
* NOTE THAT THE DIGITAL FILTER RESPONSE BEGINS TO INCREASE AGAIN
* AT HALF THE SAMPLE RATE (6510 HZ).

*GRAPH PHASE

PHASE

P =

*PUT /PI:POLE PZ

; SAVE THE POLE LOCATION IN A DISK FILE BACKUP

*SAVE POLE 1 INST 11

; GENERATE 2920 ASSEMBLY CODE FOR THIS FILTER
B: #1 33989990 B2=-0.50541914
SAMPLE SPAS20 FILTER DESIGN SESSION (Cont'd.)

OPTIMIZED 2920 CODE IS NOW GENERATED TO SAVE SPACE. SOME OF THE SCREEN OUTPUT HAS BEEN DELETED NORMALLY ALL ATTEMPTS BY THE COMPILER TO GENERATE CODE ARE ECHOED ON THE SCREEN.

```
INST=10
POLE 1 = 0.71089458, 0.34116779

NOTE: MAKE SURE SIGNAL IS < 0.74635571

THE CODE COULD SPECIFIED THAT THE POLE PAIR BE CODED IN LESS THAN 11 INSTRUCTIONS, BUT 10 INSTRUCTIONS WERE GENERATED. WITH COMMENTS.

THE FINAL ERROR IN RADIUS AND ANGLE FOR THE POLE PAIR WAS OF THE ORDER OF 1/106 AS INDICATED ABOVE IN PERROR.

THIS OPTIMIZED 2920 ASSEMBLY CODE CAN NOW BE APPENDED TO A FILE WHICH MAY CONTAIN OTHER CODED FUNCTIONAL BLOCKS OF A 2920 PROGRAM.

EXIT
```

SAMPLE SPAS20 CURVE FITTING SESSION

```
-: DEMONSTRATION OF THE SPAS20 CURVE-FITTING PACKAGE
-
-: SPAS20.SFT

ISIS-II 2920 SIGNAL PROCESSING APPLICATIONS SOFTWARE/COMPILER, V2.0

*: LIST XCHRN.R29
*
*: THE CURVE FITTING COMMANDS IN SPAS20 WILL GENERATE 2920 CODE TO CALCULATE
*: SOME FUNCTION SUCH AS X**1, X**2 COULD BE COMPUTED ON THE 2920 CHIP
*: WITH TWO MULTIPLIES USING ABOUT 10 INSTRUCTIONS AND THE BAR. HOWEVER IT
*: SHOULD NOT BE USED THE BAR TOO LONG. THE CODE GENERATED BY THE CURVE FITTING
*: COMMANDS DOES NOT USE THE BAR.
*
*: CODE FIT XCHRN(X) = X**3 ERROR<.05 ;ERROR BOUND OF .05
*
*: XCHRN
*: LDA TEMP,X,ROO
*: TEMP=1.00000000*X
*: XCHRN=0.51562500*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.50000000*TEMP
*: XCHRN=0.01125000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP= 0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=0.00000000*X+1.00000000*TEMP
*: XCHRN=0.00000000*X
*: ADD XCHRN,TEMP,ROO
*: TEMP=1.00000000*TEMP
*
*"INST = THE FUNCTION WAS CODED IN THIS MANY INSTRUCTIONS;
*"INST = 10,000000
*```
*ERROR ; THE CODE APPROXIMATES X**3 WITHIN THIS ERROR;
ERROR = 0.066675000
*
*DATA IS TYPE 1 ; SIMULATE THE RISING LINEAR FUNCTION WHICH:
DATA 0.0000000000 = 0.0000000000 AT 0.0000000000
DATA 0.0000000010 = 0.4000000000 AT 0.4000000000
DATA 0.0000000020 = 0.8000000000 AT 0.8000000000
DATA 0.0000000030 = 1.2000000000 AT 1.2000000000
*
*GRAPH; DATA(X) ; THE DATA ARRAY APPROXIMATES THE FUNCTION AND CAN BE GRAPED.
FUNCTION ! . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
0.00 0.00
0.01 0.01
0.02 0.02
0.03 0.03
0.04 0.04
0.05 0.05
0.06 0.06
0.07 0.07
0.08 0.08
0.09 0.09
0.10 0.10
0.11 0.11
0.12 0.12
0.13 0.13
0.14 0.14
0.15 0.15
0.16 0.16
0.17 0.17
0.18 0.18
0.19 0.19
0.20 0.20
0.21 0.21
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0.26 0.26
0.27 0.27
0.28 0.28
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0.33 0.33
0.34 0.34
0.35 0.35
0.36 0.36
0.37 0.37
0.38 0.38
0.39 0.39
0.40 0.40
0.41 0.41
0.42 0.42
0.43 0.43
0.44 0.44
0.45 0.45
0.46 0.46
0.47 0.47
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0.49 0.49
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0.89 0.89
0.90 0.90
0.91 0.91
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0.93 0.93
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0.97 0.97
0.98 0.98
0.99 0.99
1.00 1.00

*GRAPH ; X**3 ; THE DIFFERENCE BETWEEN THE CODED AND THE ACTUAL APPEARS AS "+".
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0.03 +
0.02 +
0.01 +
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*GRAFX ; X**3 ; THE DIFFERENCE BETWEEN THE CODED AND THE ACTUAL APPEARS AS "+".
FUNCTION ! . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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0.08 +
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0.02 +
0.01 +
0.00 +

*EXIT ; THAT'S ALL FOLKS
2920 SOFTWARE SUPPORT PACKAGE

2920 ASSEMBLER

2920 program development on Intellec® Microcomputer Development Systems Produces Assembly Listing, Object Code File, and Error Diagnostics

Translates symbolic assembly language instructions into 2920 machine code Output used for 2920 programming with the Intellec PROM Programmer or the 2920 Simulator for program debug

The 2920 Assembler translates symbolic 2920 Assembly Language instructions into the appropriate machine operation codes. Through this facility, the programmer is able to symbolically program 2920 hardware operations. Compared to machine code, these symbolic references provide faster programming, easier debugging, and greater reliability.

The Assembler produces an object code file (executable machine code), a complete assembly listing, and error diagnostics. The object code output from the Assembler may be loaded directly into the Intel Universal PROM Programmer for programming the 2920 EPROM. The object code may also be loaded to the 2920 Simulator for 2920 system design and debug.

The 2920 Assembler runs under the ISIS-II Operating System on the Intellec Microcomputer Development Systems.

Sample 2920 Assembly Listing

```
ISIS-II 2920 ASSEMBLER X102
ASSEMBLER INVOKED BY: AS2920 SAV ASM DEBUG
SAWTOOTH WAVE GENERATOR

LINE LOC OBJECT SOURCE STATEMENT

1   $TITLE('SAWTOOTH WAVE GENERATOR')
2   ;
3   ;
4   0 0000EF  INO ; SAMPLE INPUT CHANNEL 0
5   1 0000EF  INO
6   2 0000EF  INO
7   3 0084EF  SUB Y,KP1.INO ; SIMULTANEOUSLY CALCULATE SAWTOOTH
8   4 0084EF  SUB Y,KP1.R1.I1NO ; BY SUBTRACTING 3/16 FROM Y
9   5 0044EF  LDA Y,KP1.I1NO ; ALSO CHECK SIGN BIT OF Y
10  6 7880EF  ADD Y,KP7.CMDS ; IF Y NEGATIVE START NEXT TOOTH
11  7 6000EF  CVTS ; CONVERT SAMPLED INPUT TO DIGITAL (SIGN BIT)
12  8 7082EF  LDA Y,KP0.CMDS ; SUPPRESS SAWTOOTH IF INPUT WAS < 0
13  9 4044EF  LDA DAR.Y ; PREPARE TO OUTPUT SAWTOOTH
14 10 4000EF  NOP ; ANALOG LEVEL MUST SETTLE
15 11 4000EF  NOP
16 12 4000EF  NOP
17 13 8800EF  OUT0 ; OUTPUT SAWTOOTH
18 14 8800EF  OUT0
19 15 8800EF  OUT0
20 16 5000EF  EOP
21 17 8000EF  OUT0 ; PROGRAM WILL END IN THREE MORE INSTRUCTIONS
22 18 8000EF  OUT0
23 19 8800EF  OUT0
24 20 8800EF  OUT0
25  END

SYMBOL: VALUE:
Y = 0

ASSEMBLY COMPLETE
ERRORS = 0
WARNINGS = 0
RAMSIZE = 1
ROMSIZE = 20
```

21-13
2920 SOFTWARE SUPPORT PACKAGE

2920 SIMULATOR

Speeds test and debug of 2920 programs

Simulates 2920 internal operation

Operates on Intellec® Microcomputer Development Systems

Allows users to specify 2920 input signals, and display or alter ROM, RAM, and system variables

Output and internal data can be saved on disk for further analysis.

Provides ability to set breakpoints and to collect trace information

Easy-to-learn commands

The 2920 Simulator is a software facility that provides testing and symbolic debugging of 2920 programs in an Intellec Microcomputer Development Systems environment. The 2920 designers have the capability to specify the 2920 input signals, to set breakpoints, to collect and display 2920 input, output, system variables, and ROM and RAM data values during simulation. The 2920 Simulator accepts the hex format object files produced by the 2920 assembler. Output values and internal trace data may be saved on ISIS-II disk files for further analysis.

Functional Description

2920 Input Signal Specification

The four analog signal inputs to the 2920 processor can be specified as algebraic combinations of basic functions of time. The basic functions are SIN, COS, EXP, LOG, SQR, SAW, SQW, ABS.

2920 Simulation

The simulation of 2920 machine instructions is performed in software. All 2920 internal registers, memory, input values, output values, and other system variables can be examined and modified. The internal processing of the 2920 is simulated. Time constants for the sample and hold capacitors are assumed to be zero. Calculation of input signals is performed in single precision floating point. The speed of simulation varies with the complexity of the input signal, breakpoint setting, and trace condition. Exclusive of I/O time requirements, 2920 instructions will be simulated at a rate of approximately several hundred instructions per second.

Breakpoint Capabilities

After each instruction is simulated, the breakpoint is evaluated to determine whether to stop or continue simulation. Conditional breakpoints are also provided for debugging purposes. Simulation can be manually stopped at any time by pressing the ESC key on the Intellec console.

Trace Capabilities

Based on the qualifier's condition, trace data records can be collected during simulation. The trace data records are stored in Intellec resident memory and are optionally written to the console for display or to a disk file for record.

Symbolic Debugging Capabilities

The 2920 Simulator allows the user to refer to program addresses symbolically. The user can load or save the symbols generated from the hex format object files or created during the debugging session. 2920 program memory in ROM can be disassembled, or filled with assembled instructions.

The 2920 Simulator is designed to provide users with powerful, easy-to-use commands. The user interfaces to the Simulator by entering commands to the Intellec console. The commands consist of one command line, terminated by one of the two line terminators — carriage return or line feed.

The 2920 Simulator offers two types of commands:

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulate</td>
<td>Starts simulation of the input signals and the 2920 program in simulated ROM memory. Initial setting is &quot;FOREVER.&quot;</td>
</tr>
<tr>
<td>Trace</td>
<td>Controls the trace selection. Initial setting is &quot;TIME.&quot;</td>
</tr>
<tr>
<td>Qualifier</td>
<td>Sets qualifier condition during trace. Initial setting is &quot;ALWAYS.&quot;</td>
</tr>
<tr>
<td>Breakpoint</td>
<td>Sets breakpoint condition during simulation. Initial setting is &quot;NEVER.&quot;</td>
</tr>
</tbody>
</table>
Interrogation and Utility Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>Displays the values of symbols, RAM, ROM, input, output, registers and system variables.</td>
</tr>
<tr>
<td>Change</td>
<td>Alters the values of symbols, RAM, ROM, input, register and system variables.</td>
</tr>
<tr>
<td>Base</td>
<td>Establishes the mode of display for output data.</td>
</tr>
<tr>
<td>Suffix</td>
<td>Establishes the mode of display for input data.</td>
</tr>
<tr>
<td>Load</td>
<td>Fetches user symbol table and object code from input device.</td>
</tr>
<tr>
<td>Save</td>
<td>Sends user symbol table and object code to output device.</td>
</tr>
<tr>
<td>Define</td>
<td>Enters symbol name and value to user symbol table.</td>
</tr>
<tr>
<td>Console</td>
<td>Controls the console on/off display.</td>
</tr>
<tr>
<td>List</td>
<td>Defines list device.</td>
</tr>
<tr>
<td>Exit</td>
<td>Returns program control to ISIS-II.</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Converts expression to equivalent values in binary, decimal, and hex.</td>
</tr>
<tr>
<td>Remove</td>
<td>Deletes symbols from symbol table.</td>
</tr>
<tr>
<td>Help</td>
<td>Provides a brief summary of the syntax for the command languages.</td>
</tr>
<tr>
<td>Graphics</td>
<td>Switches output mode between list and graphics.</td>
</tr>
<tr>
<td>On/Off</td>
<td>Enters horizontal display size.</td>
</tr>
</tbody>
</table>

Software Simulator Keyword References

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIME</td>
<td>Elapsed simulated time in seconds (read only)</td>
</tr>
<tr>
<td>TQUAL</td>
<td>Time when the qualifier last matched in seconds (read only)</td>
</tr>
<tr>
<td>COUNT</td>
<td>Number of instructions simulated since last SIMULATE command (integer, read only)</td>
</tr>
<tr>
<td>BUFFERSIZE</td>
<td>Number of trace data records (integer, read only)</td>
</tr>
<tr>
<td>TINST</td>
<td>Time between successive instructions in seconds (read only)</td>
</tr>
<tr>
<td>SIZE</td>
<td>Number of instructions in program disregarding actual EOP placement</td>
</tr>
<tr>
<td>TPROG</td>
<td>Time between successive program passes in seconds</td>
</tr>
<tr>
<td>VREF</td>
<td>Reference analog level voltage in volts</td>
</tr>
</tbody>
</table>

The above keyword references are designed to aid 2920 program debugging.

ISIS Compatibilities

The 2920 software simulator runs under the ISIS "submit" facility. The 2920 software simulator uses the ISIS-II line editing capabilities to correct errors in an input line on the Intelcic console.

Sample 2920 Simulation Session

```
- SIM2920.SFT
ISIS-II 2920 SIMULATOR, V1.1
* 1; THIS IS THE SIMULATION OF THE 'SAWTOOTH GENERATOR'
*LIST SRC,LOG   ; LISTS THE SIMULATION SESSION TO AN ISIS FILE
*LOAD SRC,HEX   ; LOAD THE OBJECT CODE INTO THE 2920 SIMULATOR
*ROM 0 TO 5     ; DISPLAY SRC PROGRAM
  ROM 000 = LDA .K,KP5,R00,NOP
  ROM 001 = ADD .K,KP1,R05,NOP
  ROM 002 = LDA .K,K,R02,NOP
  ROM 003 = SUB .OSC,K,R00,NOP
  ROM 004 = LDA DAR,.OSC,R00,NOP
  ROM 005 = ADD .OSC,KP4,01,CRDS
  *TPROG=1/10000  ; SET THE SAMPLE RATE
  *TRAP=PC, RAM .K  ; SET THE ITEMS TO BE TRACED
  *BASE=8   ; DISPLAY THE RESULTS IN BINARY
  *SIMULATE FROM 0 TO COUNT=3 ; SIMULATE THREE INSTRUCTIONS TO VERIFY CONSTANT

PC  RAM 0
SIMULATION BEGUN
  0.00000000000000000000000000000000  0.10000000000000000000000000000000
  2.00000000000000000000000000000000  0.10000000000000000000000000000000
  3.00000000000000000000000000000000  0.00100000000000000000000000000000
SIMULATION TERMINATOR
*QUALIFIER=PC=0 ; TRACE EVERY PROGRAM PASS
*TRACE=PC,DAR, RAM .OSC ; SET THE ITEMS TO BE TRACED
*RAM .OSC=ONE ; INITIALIZE THE RAM LOCATION
*BREAKPOINT=T0,00112  ; SIMULATE FOR TWO CYCLES
*RASE=0   ; SET THE BASE TO DECIMAL
*SIMULATE FROM 0  ; BEGIN SIMULATION
  T  DAR  RAM 1
```
SPECIFICATIONS

Operating Equipment

Required Hardware

Intellic® Microcomputer Development System
— Model 800 or 888
— Series II Model 220, 225, 230
64K Bytes of RAM Memory
One or two Floppy Disk Drives
— Single or Double Density
System Console
— CRT or interactive hard copy device

Optional Software

FORTRAN-80 (Product Code MDS-301)

Documentation Package

2920 Assembly User's Guide (9800987)
2920 Simulator User's Guide (9800988)
2920 Signal Processing Application Compiler
User's Guide (121529)

Optional Hardware

ISIS-II Diskette Operating System

Shipping Media

Flexible Diskettes
— Single and Double Density

ORDERING INFORMATION

Product Code Description

MCI-20-SPS 2920 Software Support Package
Includes 2920 Signal Processing Application Software/Compiler and 2920 Assembler/Simulator Software
SERIES 90
GENERAL PURPOSE MEMORY SYSTEM

- Memory Modules only or Fully Integrated and Tested Packaged Systems
- Standard BXP™ Memory Bus
- 10 MHz Word Transfer Rates (Maximum)
- Word Widths from 16 Bits to 88 Bits
- Multiple System Packages Available
- Variety of Storage Technologies and Performances
- Optional Enhancement Modules Available Including ECC
- User Configurable for Each Application

The Intel® Series 90 is a family of general purpose memory products which are available as standard systems and are user configurable to provide an optimum solution for individual applications. The system can incorporate new and future generations of technologies as they become available, without changing the user’s system design, providing an easy growth path for the future. All systems are fully tested to Intel’s quality standards in the user’s configuration.

For full information, refer to the Series 90 Data Catalog.

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FUNCTIONAL DESCRIPTION

The heart of the Series 90 is the standard BXP™ (Byte Exchange Path) memory bus, which provides a common data exchange and control path for a wide variety of memory storage media. Basic system architecture is shown in Figure 1. The user has the option of interfacing to the system either to the BXP bus (System 90 and System 92 only) or to the general purpose enhancement modules described below.

There are three basic systems presently in the Series 90 family. The System 90 is a high-performance dynamic memory system with performances of 275 and 350 nanosecond cycle times and capacities ranging from 256 kilobytes up to 16 megabytes within a single chassis. The System 91 is a lower-cost product with slower cycle times of 500 and 650 nanoseconds and capacities up to 32 megabytes in a single chassis. Greater capacities can be easily accommodated by daisy-chaining systems together. The System 91 becomes cost effective at capacities greater than a megabyte.

The System 92 is the highest-performance member of the Series 90 family and uses static technology with a cycle time of 100 nanoseconds. See capacities range from 64 Kb to 4 Mb in a single chassis.

INTERFACE TYPES

As stated above, the Series 90 may be used by interfacing either to the BXP bus or to a general purpose enhancement module. This section gives the user an overview of the product features and enables a preliminary selection of the optimum configuration.

BXP™ Systems

The BXP memory bus provides an extremely flexible, yet easy to use, set of protocols. The bus may be operated in either a synchronous or asynchronous mode of operation, for read, write, read-modify-write, or swap cycles. Interleaving is an important feature of these systems, improving throughput by overlapping memory module cycles. Interleaving enables word data rates up to 10 MHz bus limitation, independent of the cycle time of the memory modules and can be achieved with either synchronous (sequential addresses) cycles or asynchronous cycles.

For users who do not need the additional features of the general purpose enhancement modules, the BXP systems provide an efficient solution, and are available within either the System 90 or System 92 members of the family.

Figure 1. System Architecture
Enhancement Features

These enhancements provide additional degrees of functionality over and above that provided by the ECX (error correcting) and iQX (intelligent controller). See Table 2 for a feature comparison, including memory module speeds and capacities.

ECX

This feature essentially performs all the functions of the BXP systems, and provides additional functions, primarily Error Checking and Correction (ECC). This corrects all single bit errors and detects double bit errors. These systems are also available with an optional error logger and display to facilitate maintenance and diagnostics.

iQX

For asynchronous applications that do not require interleaving, this intelligent enhancement offers advanced features such as ECC; fault-tolerant (uninterruptible) operation; versatile maintenance tools; self-test and automatic memory diagnostics; remote error reporting and fault-isolation; offloading of memory management overhead; and simple message-driven interface protocol.

SYSTEM PACKAGES

The Series 90 is available as a completely tested and packaged system. There are two Series 90 packaged systems available for 19” rack mount.

The 5½” high HMS chassis has self-contained power supplies and cooling, and will house up to four memory modules.

The 12½” high VMS has self-contained power supplies and requires externally supplied vertical air flow. An optional 5¼” rack-mountable blower assembly is available. The VMS will house up to 16 memory modules.

The maximum system capacities as a function of the module capacities shown in Table 2 are shown in Table 3.

Table 2. Feature Comparison

<table>
<thead>
<tr>
<th>BXP™ Systems</th>
<th>Enhancement Features</th>
<th>iQX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ECX</td>
<td></td>
</tr>
<tr>
<td>System 90</td>
<td>275 ns cycle, 256 Kb; 275 ns cycle, 256 Kb; 500 ns cycle, 256 or 1024 Kb; asynchronous; ECC plus fault tolerance; advanced diagnostics</td>
<td></td>
</tr>
<tr>
<td>System 90</td>
<td>350 ns cycle, 256 or 1024 Kb; synchronous or asynchronous; interleaved</td>
<td></td>
</tr>
<tr>
<td>System 91</td>
<td>Not Available</td>
<td>500 or 650 ns cycle; 2048 Kb; asynchronous; ECC plus fault tolerance; advanced diagnostics</td>
</tr>
<tr>
<td>System 92</td>
<td>100 ns cycle, 64 Kb or 256 Kb; synchronous or asynchronous</td>
<td>800 ns cycle; 2048 Kb; asynchronous; ECC plus fault tolerance; advanced diagnostics</td>
</tr>
</tbody>
</table>

Table 3. System Capacity Versus Module Capacity. Kb (Kilobytes), Mb (Megabytes)

<table>
<thead>
<tr>
<th>Kb per Memory Module</th>
<th>HMS Maximum Capacity</th>
<th>VMS Maximum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>System 90</td>
<td>256 Kb</td>
<td>1 Mb</td>
</tr>
<tr>
<td></td>
<td>1024 Kb</td>
<td>4 Mb</td>
</tr>
<tr>
<td>System 91</td>
<td>2048 Kb</td>
<td>8 Mb</td>
</tr>
<tr>
<td>System 92</td>
<td>64 Kb</td>
<td>256 Kb</td>
</tr>
<tr>
<td></td>
<td>256 Kb</td>
<td>1024 Kb</td>
</tr>
</tbody>
</table>

ORDERING INFORMATION

Consult Series 90 Configuration Guide.
SERIES 90/iQX INTELLIGENT MEMORY SYSTEM

- Uninterrupted System Availability
- Simple Message-Driven Interface
- Memory Task Processing
- ECC Plus Soft-Error Scrubbing
- Built-In Diagnostics
- Remote Maintenance and Error Reporting
- Word Widths Up to 80 Bits Plus ECC
- Up to 32 Megabytes Capacity
- Cycle Time: 500 ns and 800 ns
- Asynchronous, Bidirectional Operation
- Power Supply Monitoring and Control
- Optional Hand-Held Maintenance Terminal

The Intel Series 90/iQX is an optional intelligent enhancement to the Series 90 family of random-access memory systems. It is available as System 90/iQX, a high-performance dynamic RAM system; and System 91/iQX, a high-density dynamic RAM system. The enhancement feature, which is based on an Intel 8086 microprocessor, provides uninterrupted system availability, memory tasking, ECC plus soft-error scrubbing, extensive built-in diagnostics, remote maintenance, and error-reporting capabilities. An integral power-supply monitor and control unit monitors, reports, and margins up to four power supplies.

Optionally available for the Series 90/iQX is a hand-held maintenance terminal (the Service Communicator) which allows the operator to communicate with the Series 90/iQX using a versatile set of simple instructions.

The Series 90/iQX can provide up to 32 megabytes of memory in a self-contained system. Two system configurations are available, a horizontal mount system and a vertical mount system.

For full information, refer to Series 90 Data Catalog.
FUNCTIONAL DESCRIPTION

The Series 90/iQX system (Figure 1) consists of a Series 90 vertical or horizontal mount memory system. The vertical system provides up to 16 memory modules and up to 32 megabytes of memory; the horizontal system provides up to 4 memory modules and up to 8 megabytes of memory. The iQX module is located between the user and the BXP™ bus; it provides the memory system's intelligence features, such as fault tolerance, diagnostics, and memory tasking. In addition, a power-supply monitor and control unit is included to monitor, report on, and margin up to four power supplies. It will automatically issue a warning if an out-of-tolerance voltage is detected.

The Service Communicator (option) is a hand-held unit by which the operator, through a 40-key alphanumeric keyboard and a 16-character LED display, can communicate with the Series 90/iQX. Its primary function is as a maintenance tool for running diagnostic programs. Approximately 40 commands are available to the operator.

The memory system is operated in an asynchronous, non-interleaved mode on bidirectional lines and performs the five basic operating cycles (read, write, byte write, read-modify-write, and swap). Refresh operations are user-programmed to be either burst, distributed, or distributed bursts. Word widths of up to 80 bits plus 8 ECC bits can be accommodated.
RELIABILITY

The Series 90/iQX provides uninterrupted system availability through a comprehensive fault-tolerant mechanism that includes ECC, soft-error scrubbing, and dynamic memory re-allocation.

The error correction circuitry corrects single-bit errors and detects double-bit errors. Soft errors are generally transient single-bit errors. However, cumulative soft errors may lead to uncorrectable double-bit errors. The soft-error scrubber monitors the error detection circuits for single-bit errors. If the errors are soft, they are corrected and restored; if hard, they are handled by the memory re-allocation mechanism, which automatically redirects memory selection away from failed locations to spare memory. The re-allocation activities are totally transparent to the host system. An alert message is sent to the host when the spare memory reserve is low.

With ECC, soft-error scrubbing, and memory re-allocation, data integrity and system reliability are greatly improved. The mean time between failures of the system is extended by effective checks against system degradation over repeated hard-error and soft-error occurrence. By proper spare-memory design, full system availability can be attained between longer service intervals.

MAINTAINABILITY

The Series 90/iQX is designed to reduce maintenance and repair costs over the life of the equipment through a complete package of versatile maintenance tools from error logging and on-board diagnostics to a friendly interactive procedure with the iQX controller. Highlights of the maintenance features are described below:

1. The Service Communicator can be connected to the memory system to read out error counts and locations logged during system operation. The error locations are interpreted by the 8086 and displayed to service personnel by rows and columns.

2. The service communicator can perform diagnostics on the memory system in either the “off-line” or “on-line” modes of the host. The on-board diagnostic capability allows system troubleshooting without using host time or requiring special test routines on the host. Voltage margin operation for preventive maintenance can also be controlled from the terminal.

3. The 8086-based module also serves as a communications controller that links the system, through a modem, to a remote diagnostic site. The aforementioned on-board diagnostics and fault reporting can all be requested and directed from the remote site, resulting in fewer site visits by service personnel and shortening the visits that are required. This remote capability helps OEM and network services implement centralized maintenance and system control.

MESSAGE-DRIVEN INTERFACE (MAILBOX) AND TASKING

Tasking allows the iQX intelligent memory controller to perform operations on itself or on the data contained in the memory system. To accomplish tasking, a “mailbox” protocol is used. The “mailbox” is a portion of the memory set aside for the iQX/host communication. The host places a command word and parameters in the mailbox and activates an alert signal. The iQX reads the mailbox, executes the command, stores any resulting data in the mailbox, and returns a “task complete” signal. This message-driven (or “mailbox”) protocol can support a more extensive exchange of control information with a simple interface. Furthermore, tasking can relieve the host of such chores as moving blocks of memory, filling parts of the memory with constants, setting/resetting memory protect, or executing diagnostic programs and reporting results. All tasking software resides in the intelligent controller module.

CAPACITY AND PERFORMANCE

The total capacity of the Series 90/iQX is determined by the memory module and system package (horizontal or vertical). The capacities available are listed under Specifications, Storage Capacity, in this data sheet. With the VMS the capacity is up to 32 megabytes of dynamic RAM. System capacity can be further increased, up to a total of four Series 90 chassis.

The Series 90/iQX memory system is available with system cycle times of 500 and 800 nanoseconds, depending on memory module type. Refer to the Specifications section of this document, the Series 90 Configuration Guide, or the Series 90 Data Catalog for further information.
CHASSIS

Two chassis configurations are available for the Series 90/iQX: a horizontal mount chassis and a vertical mount chassis. Each system is available with either 115 or 220 VAC input power.

The horizontal mount chassis (HMS) includes up to four memory modules, its own DC power supplies, and a blower assembly to provide cooling air. The chassis measures 5.21 in. (13.2 cm) high by 19 in. (48.2 cm) wide by 19.5 (49.5 cm) deep, and weighs approximately 30 lbs (13.5 Kg).

The vertical mount chassis (VMS) includes up to 16 memory modules and its own DC power supplies. The vertical mount system does not include an integrated blower. A separate blower assembly is available. The vertical chassis measures 12.25 in. (31.1 cm) high by 19.0 in. (48.2 cm) wide by 17.5 in. (44.4 cm) deep, and weighs approximately 100 lbs (45 Kg).

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Cycle and Access Times</th>
<th>Cycle Time</th>
<th>Access Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>System 90/iQX</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>System 91/iQX</td>
<td>800</td>
<td>800</td>
</tr>
</tbody>
</table>

Word Lengths

16, 32, 37, 64, and 80 bits plus ECC

Storage Capacity

<table>
<thead>
<tr>
<th>System 90/iQX</th>
<th>HMS: Up to 1 Mb in 256 Kb increments or up to 4 Mb in 1 Mb increments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VMS: Up to 4 Mb in 256 Kb increments or up to 16 Mb in 1 Mb increments</td>
</tr>
</tbody>
</table>

System 91/iQX

<table>
<thead>
<tr>
<th></th>
<th>HMS: Up to 8 Mb in 2 Mb increments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VMS: Up to 32 Mb in 2 Mb increments</td>
</tr>
</tbody>
</table>

Operating Cycles

- Read Cycle
- Write Cycle
- Byte Write Cycle
- Read-Modify-Write Cycle
- Swap Cycle

Environmental Requirements

- Ambient Operating Temperature—0°C to +50°C
- Ambient Storage Temperature—40°C to +125°C
- Relative Humidity—10% to 90% without condensation
- Operating Altitude—0 to 10,000 feet (0 to 3,048 meters)
- Non-Operating Altitude—0 to 50,000 feet (0 to 15,240 meters)

ORDERING INFORMATION

Consult Series 90 Configuration Guide
The Intel® CM-5044E memory card is designed for use in any DEC* UNIBUS, modified UNIBUS, or extended UNIBUS computer. It is an ECC version similar to and compatible with the DEC MS11M memory used on the PDP 11/44. Compatibility extends to hardware, operating system, and diagnostic software. The CM-5044E can also be used as an ECC replacement for the DEC MS11L parity memory used on the PDP 11/24, PDP 11/34 and other UNIBUS computers.

The CM-5044E is available in capacities of 256K, 512K or 1M byte. This gives the user space and power savings while performance is equal to or better than the MS11 models. The card occupies a single slot and addressing is switch selectable to 128K byte boundaries so that the CM-5044E can be used with any number of MS11 memory cards. Features supported include interleaving (switch selectable), battery back-up, and a Control Status Register which allows the processor to read and manipulate status on the memory card. The Intel CM-5044E also contains power, select and error indicators, socketted memory chips and spare memories, and an on-line/off-line switch. All Intel memory cards are fully tested and include a one year factory warranty. In addition, the CM5044E is fully supported by Intel’s field service plans which include installation and on-site contracts for maintenance.

*PDP, DEC, UNIBUS are Trademarks of Digital Equipment Corporation
SPECIFICATIONS

Word Size
32 bits + 7 ECC bits

Memory Capacity
256K, 512K, 1024K Bytes

Performance
500 ns cycle (maximum)
500 ns read access (maximum)
250 ns write access (maximum)

Power
Configuration Operating, Max Standby, Max
256 KB 7.3 AMPS 5.6 AMPS
512 KB 7.5 AMPS 5.8 AMPS
1 MB 7.9 AMPS 6.2 AMPS

Address Selection
DIP switches select the starting address or any
64K word (128K Byte) boundary.

Modes of Operation
Read Refresh (Transparent)
Write (full word) Memory Initialization
Byte Write (Transparent)
Interleaving

Compatibility
computers
Interface protocol is compatible with unibus, modified
unibus, and extended unibus protocols.
5044 can be used in any system as a replacement
for MS11L (parity) or MS11M (ECC) memory
modules.
Completely software compatible with all operating
systems and CZMSD Diagnostics.

Dimensions
15.7 in (39.88 cm) Width
8.5 in (21.69 cm) Height
0.375 in (0.953 cm) Depth
2.2 lbs (1.0 kg) Weight

Environment
0°C to 50°C Operating
−40°C to 125°C non-operating
0% to 90% relative humidity (no condensation)

Reference Manual
112586 CM-5044E Technical Manual (supplied)

ORDERING INFORMATION

Model Number Capacity Equivalent
CM-5044E-256 256 Bytes with ECC One MS11MB
CM-5044E-512 512K Bytes with ECC Two MS11MB
CM-5044E-1MB 1 Megabyte with ECC Four MS11MB
in-1671
*PDP-11/70 ADD-ON MEMORY SYSTEM

- Total hardware and software compatibility with *PDP-11/70
- in-1671 256K-byte basic system expandable to two megabytes in 256K-byte increments
- User access to full *PDP-11/70 main memory space at nearly four megabytes
- MOS RAMs provide high-density memory with low system cost
- Two-way memory system interleaving
- ECC and error coding for single-bit error correction and double-bit error detection.
- High-speed CPU data transfer rate
  - write cycle time 550 ns
  - byte write cycle time 1000 ns
  - read cycle time 770 ns
  - refresh cycle time 550 ns
  - access time 550 ns (no error)
  - access time 600 ns (with single-bit error)
- Installation and maintenance available from Intel
- UL recognition

The Intel® in-1671 *PDP-11/70 Add-On Memory System is a monolithic memory system offering up to two megabytes of add-on memory for *PDP-11/70 users, thus improving *PDP-11/70 system performance with increased capacity, increased data transfer speed, improved functional and component reliability, and reduced cost. The complete in-1671 utilizes five types of printed circuit cards: power control card, memory unit cards, control unit card, data card, and error logging card. All components are fully hardware- and software-compatible with the DEC* central processing unit (CPU) and are engineered to meet or exceed the specifications of similar DEC components. The Intel in-1671 is used in *PDP-11/70 computer systems as a direct replacement for the memory module (MJ11) supplied by DEC, and uses cables and interface signals identical to those used in DEC memory modules. The unit may be installed without change or modification to the DEC software, CPU, memory bus, or I/O structure. High-density memory is provided by dynamic MOS RAM devices, and is expandable in 256K-byte increments to 2048K bytes. High-speed 770-nanosecond read and 550-nanosecond write cycle times allow maximum utilization of Unibus* data throughput. The in-1671 system includes error check and correction (ECC), error monitoring, and error logging.
FUNCTIONAL DESCRIPTION

The in-1671 semiconductor memory system is specifically designed as an add-on memory for the DEC *PDP-11/70 processor. The basic memory device is a monolithic integrated circuit using N-channel MOS transistors. The complete system uses five types of printed circuit cards: 1) control card containing address and control circuitry; 2) data card to provide interfacing and parity checking for read and write data; 3) error logger card to monitor and log data error conditions; 4) memory cards (MU-167As) for storage; and 5) power control card to provide AC and DC low status to the processor. Each memory module contains its own power supply and cooling. All on-line operating sequences are controlled by processor-supplied controller signals and by internally-generated response signals sent to the processor from the memory, and all system components are engineered to meet or exceed the specifications of similar DEC components. A simplified block diagram of the in-1671 memory system is shown in Figure 1.

Compatibility

The in-1671 is specifically designed for use in *PDP-11/70 computer systems as a direct replacement for the DEC-supplied memory module (MJ-11), and uses cables and address, data, and interface control signals identical to those in DEC memory modules. The unit may be installed in the DEC central processing unit (CPU) memory cabinet without change or modification to the DEC software, CPU, memory bus, or I/O structure. All system voltages, currents, timing, and I/O signal requirements are compatible with the *PDP-11/70.

Capacity

Card Capacity—Each memory card in the in-1671 memory system has a capacity of 128K bytes. Two memory cards make up the basic 256K-byte storage area of the in-1671 memory system. A fully-expanded memory system contains two megabytes. Interleaving is possible between two memory systems with the same capacity.

![Figure 1. in-1671 Add-On Memory System Block Diagram](AFN-01904A)
System Capacity—The storage area of the in-1671 system consists of 16 Intel MU-167A memory system units. Each MU-167A contains 80 Intel 2117 16K dynamic MOS RAMs to provide a capacity of 64K words by 20 bits per card. The 16 MU-167As in the system are configured to provide 2 megabytes of storage with a double-word 40-bit interface. Thirty-two bits are assigned as interface data and eight bits to error check and correction (EGC). These systems are housed in a chassis with power supplies and fan assemblies. Two such chassis may be mounted in one equipment rack and interfaced in daisy-chain fashion with the processor.

Expandability—Each unit is easily field-upgradable to larger capacities with the addition of memory cards or a memory rack containing cards. A diagram showing CPU and memory cabinet dimensions is shown in Figure 2.

Card Controls—The following controls are located either on the control card or on the error logger card:

- Address select switches to set the starting address for the memory bank
- Memory on-line/off-line switch to disconnect the in-1671 from the PDP-11/70 memory bus
- Reset logic switch
- Error logger on-line/off-line switch
- Lamp test
- ECC on/off switch
- Error logger scan switch

Card Indicators—The following indicators are provided either on the control card or on the error logger card:

- Address parity error indicator
- Mismatch error indicator
- Write data parity error indicator
- Address display
- Syndrome bits display
- Single-bit mode or double-bit mode indicator
- ECC on-line/off-line mode indicator

(1) on control card
(2) on error logger card

The in-1671 memory system includes error check and correction (EGC) as a standard feature. During read and byte-write operations, multiple bit errors are detected and single-bit errors are corrected prior to the transfer of data. The standard 'PDP-11/70 parity bits (one per eight-bit byte) are also generated and are included in the data transfer. The in-1671 EGC improves memory system reliability 10 to 25 times over systems with parity checking only. During write operations, the four standard parity bits are used to check the 32-bit word for errors and then EGC logic removes the parity bits from the data word and generates eight EGC bits to be stored with the data word. During a read operation, the eight EGC bits are read from memory with the 32-bit data word. All 40 bits are processed to generate eight syndrome bits which indicate whether or not a single- or multiple-bit error has occurred. Single-bit errors are automatically corrected before the data is sent to the processor. Multiple-bit errors cause all four standard parity bits to be forced to the error state and to be sent to the processor. The error logger records the location of the row of memory chips in error and which MU-167A board failed.

Reliability
Each unit is fully tested in a temperature-cycling environment. Because of the 100% burn-in performed on each card, the user is assured of receiving Intel's proven quality and reliability. All Intel DSC-compatible products are covered by a one-year warranty.
SPECIFICATIONS

Storage Capacity
Up to 2048 bytes in 256K-byte increments

Word Length
16 bits per memory word, plus 4 parity bits per double word

Performance
Cycle Time — 1000 ns max
Access Time — 600 ns max

Operational Modes
Read
Write
Byte write (1 or 2 bytes)

Interface Characteristics
TTL-compatible
36 bidirectional data input/output lines
23 binary address input lines (single-ended)

Installation Requirements
All cables and connectors supplied by Intel
1 DEC memory cabinet (21"W x 30"D x 72"H)
1 in-1671 memory system

Notes
1. Installation can be done by the customer or purchased from Intel.
2. Maintenance contracts are available from Intel.

Physical Characteristics
Width — 17.12 in. (43.48 cm)
Height — 10.5 in. (26.67 cm)
Depth — 25.0 in. (63.50 cm)
Weight — Less than 70 lb (31.5 kg)

Electrical Characteristics

<table>
<thead>
<tr>
<th>Requirement</th>
<th>115V AC (max)</th>
<th>220V AC (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>98V AC to 132V AC</td>
<td>187V AC to 252V AC</td>
</tr>
<tr>
<td>Frequency</td>
<td>47 to 63 Hz single-phase</td>
<td>47 to 63 Hz single-phase</td>
</tr>
<tr>
<td>Input current</td>
<td>8A max</td>
<td>4A max</td>
</tr>
</tbody>
</table>

Environmental Characteristics
Temperature — 0°C to 50°C operating ambient, −40°C to +85°C non-operating
Humidity — 10% to 90% non-condensing
Altitude — 10,000 ft max, operating; 40,000 ft max, non-operating

Equipment Supplied
Ribbon cable supplied for installation

Reference Manuals
TM-1670-000 — in-1670/in-1671 Technical Manual (SUPPLIED)
Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative.
ORDERING INFORMATION

SY-1671-256D/I* — 256K bytes (128K words)
Add-On Memory System for PDP-11/70

SY-1671-512D/I — 512K bytes (256K words)
Same as above except for capacity

SY-1671-768D/I — 768K bytes (384K words)
Same as above except for capacity

SY-1671-1024D/I — 1.024M bytes (512K words)
Same as above except for capacity

SY-1671-1280D/I — 1.280M bytes (640K words)
Same as above except for capacity

SY-1671-1536D/I — 1.536M bytes (768K words)
Same as above except for capacity

SY-1671-1792D/I — 1.792M bytes (896K words)
Same as above except for capacity

SY-1671-2048D/I — 2.048M bytes (1.024M words)
Same as above except for capacity

*Specify SY-1671-256D for domestic (115VAC)
SY-1671-256I for international (220VAC)

XF-1671-256 256K bytes expansion for in-1671
PDP-11/70

EX-1671 Card Extender
XX-1671-001 Memory Card
XX-1671-002 Data Interface Card
XX-1671-003 Control Interface Card
XX-1671-004 Error Logger Card
XX-1671-005 Terminator Card
XX-1671-006 Power Control Card
XX-1671-007 I/O Cable Assembly (Short)
XX-1671-008 Power Supply
XX-1671-009 Diagnostic Memory Tape
XX-1671-010 Branch Spare Kit
(contains EX-1671 and XXX-1671-001
- thru -009)

XX-1671-011 I/O Cable Assembly (Long)
The Intel® in-5034 is a 64K x 18 bit plug in memory card designed for use in any PDP-11/04, 11/34 computer memory slot. It is totally hardware and software compatible with the PDP-11 system. No modifications or jumpers to the computer or memory module are required for installation.

The in-5034 memory, with all address and control circuitry, is contained on a single Hex-Height PC card. This memory card requires only one modified Unibus slot.

The in-5034 is designed for low power dissipation. When operating at full speed in a PDP-11/34, or PDP-11/04, the in-5034 dissipates 25.5 watts. In standby, the power dissipation is 12.7 watts. The power dissipation is calculated for worst case maximum. The in-5034, upon detection of power-fail, switches to refresh cycles only. The contents of the memory will be retained provided that there are battery backups on +5VBB, +15VBB and -15VBB voltages.

The in-5034 provides on-board parity checking and generation. Control Status Register (CSR) is also included on-board at no extra cost. Parity check and CSR perform the equivalence of DEC's parity controller modules function for the in-5034 memory.
Two pre-tested memory devices plugged into sockets are provided on board for spare. These spare memory devices can be used to replace any failing memory devices in the field. The failing memory devices can be pinpointed with the aid of the address decode chart and DEC memory diagnostic messages.

The in-5034 features maximum read and write cycle times of 600 nanoseconds allowing maximum utilization of modified Unibus throughput.

With DEC's memory management, up to 128K words of in-5034 memory can be added to the PDP-11 system. The address range for each card is set by on-board DIP switches.

Each memory card is fully tested in a temperature cycling environment. Because of the 100% burn-in performance on each card, the customer is assured of receiving Intel's proven quality and reliability. In addition, all Intel PDP-11 compatible products are covered by a one year Intel warranty.

**PRODUCT SPECIFICATIONS**

Storage Capacity: 64K words per board  
Word Length: 16-bits plus 2 parity bits  
Cycle Time: 600ns  
Read Access Time: 410ns  
Write Access Time: 320ns  
Modes of Operation: Read, Write, Read byte, Write byte

Address Input: 18 Lines, binary, (Single-ended)  
Data Input/Output: 18 Lines, bi-directional, (Single-ended)  
Input Control: 3 lines, (Single Ended)  
Output Control: 1 line, (Single Ended)  
Interface: Modified UNIBUS compatible, 1 bus load

**DC POWER REQUIREMENTS**

<table>
<thead>
<tr>
<th>POWER</th>
<th>OPERATING</th>
<th>STANDBY</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+5V ± 5%</td>
<td>2 Amps</td>
<td>2 Amps</td>
</tr>
<tr>
<td>+15V ± 5%*</td>
<td>0.7 Amps</td>
<td>0.1 Amps</td>
</tr>
<tr>
<td>+20V ± 5%**</td>
<td>0.7 Amps</td>
<td>0.1 Amps</td>
</tr>
<tr>
<td>−15V ± 5%</td>
<td>30mA</td>
<td>20mA</td>
</tr>
<tr>
<td>Battery Backup Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+5V ± 5%</td>
<td></td>
<td>500mA</td>
</tr>
<tr>
<td>+15V ± 5%*</td>
<td></td>
<td>100mA</td>
</tr>
<tr>
<td>+20V ± 5%**</td>
<td></td>
<td>100mA</td>
</tr>
<tr>
<td>−15V ± 5%</td>
<td>200mA</td>
<td></td>
</tr>
</tbody>
</table>

*Used if semiconductor backplane.  
**Used if core memory backplane.

Temperature: 0°C to +50°C operating ambient, −40°C to +125°C non-operating  
Relative Humidity: Up to 90% with no condensation  
Altitude: 0 to 10,000 feet operating. Up to 50,000 feet non-operating  
Dimensions: 15.4" W x 8.5" D x 0.375" H  
Weight: Less than 3 lbs.

**OTHER INTEL PDP-11 PRODUCTS**

- The in-1671 provides up to 2 megabytes of add-on memory with Error Correction Codes for PDP-11/70 users.

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Model</th>
<th>Capacity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM-5034-864</td>
<td>64K x 18</td>
<td>PDP-11/04 and PDP-11/34 Add-In memory</td>
</tr>
</tbody>
</table>
Software compatibility with NOVA 3 family

On-board parity control

Optional error correction with on-board error logger and error display

Optional on-board memory management and protection unit

64K, or 128K word capacity and compatible with resident core memory

High circuit density, reducing system cost

Low power dissipation

Battery backup operation supported

Full commercial operating temperature/humidity range

One year warranty

The Intel in-5160 is a 64K, or 128K word plug compatible memory card designed for use in the Data General NOVA 3 computer. It is totally hardware and software compatible with the NOVA 3, and configures easily with resident Data General memory boards. All in-5160 control memory, address, parity, bus driving, and voltage regulator circuitry, as well as all options, are contained on one 15-inch x 15-inch printed circuit card, which occupies only one card slot. This high circuit density allows a NOVA 3/4 to be configured with the maximum addressable memory, a memory management unit, the memory protect option, and the parity generate/check option, with two slots left for a disk controller and a serial controller or any other two cards. The in-5160 is designed for low power dissipation and uses a maximum of 50 watts (40 watts typical). In case of power failure the contents of the memory will be retained if a battery backup is provided. With this low power dissipation, no additional cooling fans are required. The parity feature and the optional memory management and protection unit (MMPU) are functionally identical to the corresponding units available from Data General and both features are fully compatible with the NOVA 3 software. The parity feature generates and checks parity on a 16-bit data word and will work not only for the in-5160, but for any other 17-bit memory in the same system. The optional MMPU allows memory addressing and allocation up to 128K words and provides several system protect functions under software control. The optional ECC error check and correction provides error correction facilities on the board along with an error logger. All single bit errors will be corrected; all double bit errors and a significant portion of multiple bit errors are detected. 

*NOVA is a registered trademark of Data General Corporation.
FUNCTIONAL DESCRIPTION

The in-5160 NOVA 3 Add-In Memory is a semiconductor memory system specifically designed as a single card add-in containing the maximum amount of memory addressable by existing software. Also on the board are all memory associated system functions previously available only on a separate card, or not available at all: parity generation and checking, memory management, memory protection, error detection/correction, and error logging with error location display. All normal memory functions are also contained on the card: address buffers and decoding logic, data transceivers, control logic, timing, mode enable logic, and refresh control logic. Online operating sequences are controlled by processor supplied control signals, signals received from data channel devices and by internal control signals. Response signals sent to the central processing unit (CPU) are generated by the parity logic, MMPU, and other control logic circuitry. All system components are engineered to meet or exceed the specifications of similar Data General components.

Compatibility

The in-5160 can be inserted into any NOVA 3 series computer and will work with any 17-bit memory already in the system. The 96kW version must be positioned in lower memory. Other capacities may start on any 32kW boundary. If the previous memory capacity is not a multiple of 32K words, the in-5160 is set to occupy the address range from zero up to the in-5160 card capacity.

The previously installed memory is then set to follow the ending address of the in-5160. For example, a 64K word in-5160 could be used as shown in Table 1.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Address Range for In-5160</th>
<th>Address Range for Resident NOVA Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>No previous memory</td>
<td>0-64KW</td>
<td>64KW-80KW</td>
</tr>
<tr>
<td>16K resident memory</td>
<td>0-64KW</td>
<td>—</td>
</tr>
<tr>
<td>32K resident memory</td>
<td>32KW-96KW</td>
<td>0-32KW</td>
</tr>
<tr>
<td>64K resident memory</td>
<td>64KW-128KW</td>
<td>0-64KW</td>
</tr>
</tbody>
</table>

Table 1. in-5160 Memory Address Range

Capacity

The in-5160 is manufactured with two types of memory devices: a 16K x 1-bit dynamic RAM and an 8K x 1-bit dynamic RAM. Both chips are manufactured with NMOS technology and are tested to the same specifications.

Addressability

Card select for the in-5160 is determined by the decode of the three extended address inputs and the settings of the address select switches on the card. These switches enable the card’s starting and ending addresses to be set on any 32K word boundaries within the 128K word address field available with memory management. For cards with memory capacity greater than 32K words, the address range must be selected so that the memory occupies contiguous 32K address blocks.
Operating Modes
The in-5160 emulates all of the operating modes supported by Data General on the NOVA 3 series computers. In normal operation, the in-5160 performs read, read-hold, write, and read-modify-write processor controlled cycles. Refresh cycles are timed out internally and use chip row addresses generated by a counter on the board. The in-5160 offers the largest storage capacity that can be handled by existing software and has a higher effective speed than the NOVA 3 semiconductor memories. Read or write operations required 500 nanoseconds and the read-modify-write operation is completed in 1100 nanoseconds, whether initiated when the memory is idle or immediately following a preceding cycle. On consecutive memory cycles, the Data General NOVA 3 memory requires 500 nanoseconds for read cycles, 1200 nanoseconds for write cycles and 2200 nanoseconds for read-modify-write. Since consecutive memory cycles occur frequently, the Intel memory can provide significantly faster throughput. The data valid time is extended during the read-hold cycle by the processor pulling the hold input low. The longer data valid time is required during defer cycles, console initiated read cycles (the examine switch), or during data channel read cycles. For data channel memory cycles, the memory operates in either write or read-hold modes. All read, write, or read-modify-write cycles can be performed with or without single bit error correction, map, memory protection, or parity error reset or interrupt.

Memory Management and Protection Unit (MMPU)
Memory expansion — The MMPU provides the capability to use a memory of up to 128K words and supplies the hardware necessary to make use of the NOVA 3 software protection features. The expansion of memory capacity is accomplished by replacing the five highest order address bits (the logical address) with seven bits from a location in the translation memory (the physical address). Each logical address is ‘mapped’ (or translated) to one, and only one, physical address, which may be anywhere within the 128K physical address field. The contents of the translation memory (the map) may be set up using ordinary I/O instructions.

Memory protection — The memory protection function of the MMPU provides detection capability for five types of software violations:
- Write protect — prevents writing into a write protected 1K page
- Validity — prevents accessing, in any manner, a page declared invalid
- Defer — protects against runaway defer cycles
- I/O — enables I/O violation detection in the CPU
- Auto Index — Prevents auto-indexing operations.

When a violation is detected, the MMPU initiates a map interrupt routine in the processor.

Parity
The parity feature is standard on all in-5160 memory boards. During write operations, the parity logic generates a parity bit for the 16-bit data word. Data and parity bit are then stored in the memory. During read operations, 16 bits of data and one parity bit are read out from the memory and checked for a parity error. If a parity error is detected, the address and parity bit are latched in the parity error address register, and either a reset or interrupt signal (jumper selectable) is returned to the processor. The CPU reads the contents of the parity error address register by using standard I/O instructions. The parity feature services not only the in-5160, but all 17-bit memories in the same system. On boards with the ECC option, the parity logic still functions for other 17-bit memories in the system and reports multiple bit errors detected by the ECC logic to the CPU as parity errors.

Error Correction and Error Logger
The in-5160 error correction circuitry (ECC) provides onboard capability to correct any single bit error and detect any double bit error in the read data. Many errors of more than 2 bits will also be detected. ECC greatly increases memory reliability and minimizes non-recoverable system failures. The multiple bit errors are flagged to the processor as parity errors. All errors are logged as they occur and are simultaneously displayed on the in-5160’s control panel. The error correction function can be disabled by a switch on the control panel; however, the error logger will continue to monitor and store error information. The chip location of single bit errors and row location of double bit and multiple bit errors are stored in the error logger memory and displayed on LEDs on the control panel as they occur. The error logger controls and indicators are shown in Figure 2.

![Figure 2. Error Logger Control Panel and Indicators](image-url)
INSTALLATION
The installation of the in-5160 on a NOVA 3 system is covered in detail by the technical manual which accompanies the product. The main points of consideration during installation are address selection and parity error action (RESET or interrupt). The location of these switches and jumpers are illustrated in the manual for easy location.

RELIABILITY
The in-5160 is designed for low power dissipation. When operating with all options, and at full speed in a NOVA 3, the 128K in-5160 dissipates 170 Btu/hr; in battery backup (standby) mode, it dissipates 55 Btu/hr. This results in a cooler running system, an increased margin for power supply operation, and improved system reliability. Every card is fully tested in a temperature cycling environment for eight hours and in a NOVA 3 computer to test all options with the NOVA software. Because of the 100% burn-in performed on each card, the user is assured of receiving Intel's proven quality and reliability. In addition, all Data General compatible products manufactured by Intel are covered by a one year warranty.

SPECIFICATIONS

Storage Capacity
64K, or 128K words

Word Length
Standard — 16 data bits and one parity bit
With ECC — 16 data bits and six ECC check bits

Cycle Time
Read or Write Cycle — 500 ns
RMW — 1100 ns

Access Time
300 ns (access and cycle times are extended 100 ns if error correction takes place)

Operating Modes for Memory
Processor — Read, read-hold, write, read-modify-write
Data Channel — Read-hold, write
MMPU — Translation enabled/disabled
Parity — Disabled/generate even parity, generate odd parity

Interface Characteristics
Interface — NOVA-3 backplane compatible, one card slot required.

Note: If the in-5160 is equipped with MMPU option, backplane slot 2 is required.

Address Input — MADR 1-15: 15 Lines; ALU 0-6: 7 lines; DS 0-5: 6 lines
Address Input/Output — MADR 1-15
(Generated in MMPU) X MADR 0-2

Memory Data Input/Output — 16 bidirectional lines
I/O Data Input/Output — 16 bidirectional lines
Control Inputs — 36 lines
Control Outputs — 14 lines

Physical Characteristics
Width — 15 in. (38.1 cm)
Length — 15 in. (38.1 cm)
Height — 0.4 in. (1.02 cm)
Weight — Less than 3 lb (1.36 kg)

Electrical Characteristics
DC Power Requirements (128K, all options)

<table>
<thead>
<tr>
<th>Voltage (±5%)</th>
<th>Active</th>
<th>Current Battery Backup</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5V</td>
<td>6.8A</td>
<td>2.2A</td>
</tr>
<tr>
<td>+15V</td>
<td>890mA</td>
<td>350mA</td>
</tr>
<tr>
<td>-5V</td>
<td>5mA</td>
<td></td>
</tr>
</tbody>
</table>

Environmental Characteristics
Temperature — 0°C to 50°C operating ambient; -40°C to 120°C non-operating ambient
Relative Humidity — Up to 90% with no condensation
Altitude — 10,000 ft max operating; 50,000 ft max non-operating

Reference Manuals
TM-5160-000 — in-5160 Technical Manual, Number 111768 (SUPPLIED)
Reference manuals are shipped with each product only if designated SUPPLIED (see above). Manuals may be ordered from any Intel sales representative.
## ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Model</th>
<th>Capacity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM-5160A-064</td>
<td>64K x 17-bit</td>
<td>64K memory with parity</td>
</tr>
<tr>
<td>CM-5160A-128</td>
<td>128K x 17-bit</td>
<td>128K memory with parity</td>
</tr>
<tr>
<td>CM-5160B-064</td>
<td>64K x 22-bit</td>
<td>64K memory with ECC</td>
</tr>
<tr>
<td>CM-5160B-128</td>
<td>128K x 22-bit</td>
<td>128K memory with parity and ECC</td>
</tr>
<tr>
<td>CM-5160C-064</td>
<td>64K x 22-bit</td>
<td>64K memory with parity and MMPU</td>
</tr>
<tr>
<td>CM-5160C-128</td>
<td>128K x 22-bit</td>
<td>128K memory with parity and MMPU</td>
</tr>
<tr>
<td>CM-5160D-0364</td>
<td>64K x 22-bit</td>
<td>64K memory with parity, ECC and MMPU</td>
</tr>
<tr>
<td>CM-5160D-128</td>
<td>128K x 22-bit</td>
<td>128K memory with parity, ECC and MMPU</td>
</tr>
</tbody>
</table>
The Intel in-5770 Video-Refresh Memory System is a special-purpose, single-card, random-access memory system designed to store and retrieve digital video image data for sophisticated computer-driven CRT displays. The storage capacity of each card is 256K (K = 1024) 4-bit words arranged in four image planes to provide the 16 grey shades necessary to ensure the high picture quality required for medical and scientific laboratory computer modeling displays; a typical image enhancement application is the detailed analysis and interpretation of black-and-white x-ray images. Multiple in-5770 cards may be used in parallel for systems applications requiring more than four bits per picture element for special graphic displays such as color enhancement, overlays, or enlargements of portions of the display. The in-5770 refresh memory is specifically designed for image enhancement applications; refresh may be accomplished either by normal read and write cycles or by user-generated refresh cycles within the specified retention time. Each memory card contains all the logic and timing circuitry required to generate memory addresses and clock pulses, and utilizes 16K x 1 MOS dynamic RAM technology for maximum bit density at low system cost. An optional chassis is available for multiple card housing.
FUNCTIONAL DESCRIPTION

The in-5770 is a video-refresh, random-access memory card system designed specifically for storing and retrieving digital video image data with high resolution, but also used for conventional storage applications. The complete system consists of one 16 x 11.25-inch edge connector-type printed circuit card containing the semiconductor storage area and all the required address and data latches and control logic needed to operate the memory. The two standard configurations are 512 x 512 using Intel's 16K x 1 dynamic MOS RAM and 512 x 256 using the 8K x 1 dynamic MOS RAM. The memory is arranged in four planes either 16K x 16 or 8K x 16. A block diagram of the in-5770 memory system is shown in Figure 1.

Capacity

Each CM-5770 memory card has the capacity to store a 512 x 512 display with four bits per picture element. The two standard configurations are 512 x 512 x 4 (CM-5770-512) and 512 x 256 x 4 (CM-5770-256). The memory storage area in the 512 x 512 version consists of 64 Intel 16K x 1 dynamic N-channel MOS RAM silicon-gate memory chips. The 16,384 storage cells on each chip are arranged in a 128 x 128 array requiring seven row and seven column addresses to select one cell. Each cell holds one bit of information. The memory chips are arranged in four rows of 16 chips each, with each 4 x 4 block of chips representing one 16K x 16 plane of data. The memory storage area in the 512 x 256 version uses 64 Intel 8K
x 1 dynamic N-channel MOS RAM memory chips with 8192 storage cells arranged as a 64 x 128 array. The 8K RAMs are partial 16K devices with only one half of the array operational. The in-5770 memory capacity may be expanded using up to a maximum of 24 CM-5770 cards per system.

Figure 2. in-5770 Card Dimensions

Operation

The in-5770 provides both parallel- and single-bit mode control to perform four basic memory operations plus the refresh operation. The card is read in a sequential manner for CRT refreshing, with random-access read, write, or read-modify-write operations performed in between the CRT refresh reads. During a CRT refresh read, 16 bits of data from each plane are read on the memory card and are internally converted to serial bit lines, clocked at 70-nanosecond or longer intervals.

READ OPERATION

In all read modes, a full 16-bit data word is read out from the addressed location in each memory plane. During parallel read operations, a 16-bit data word is read from each plane of the memory array and placed on the output lines, 64 lines in all, resulting in 64 bits being simultaneously available at the interface. During serial read operations, 16 bits from each memory plane are loaded into shift registers and transferred out serially on four output lines. During single-bit read operations, a 16-bit word is read from each of the four memory planes, but only one bit from each plane is transferred to the single-bit output lines.

WRITE OPERATION

In write modes, 64 bits of data are stored in the location specified by the address inputs. During parallel write operations, 64 bits are received at the interface, and stored as four 16-bit words, one in each memory plane. The parallel write mode writes a 16-bit data word selectively in any or all of the planes, under control of a plane select mask. During single-bit write operations, four bits (one pixel) are received at the interface and stored with one bit in each memory plane.

READ-MODIFY-WRITE OPERATION

In a read-modify-write operation, internal memory timing is arranged so that read data is output from the card during the first portion of the cycle, followed by a 90 ns modify period during which a new data word is generated by the user and stored in the memory. During a parallel read-modify-write operation, a full 16-bit word is read and rewritten in each memory plane. During a single bit read-modify-write operation, a single bit is read and rewritten into each memory plane.

CLEAR OPERATION

A clear mode provides a convenient way for clearing the screen and for generating test patterns. During a clear mode operation, the data applied on the single-bit input lines is written into all 16 bits of the selected address in all four memory planes.

VIDEO REFRESH OPERATION

In image enhancement applications, photographic or video images are converted to a matrix of picture elements with binary elements designating the intensity assigned to each. This information is sent from the computer to the refresh memory and stored for later CRT display. Since data sent directly to a screen from the computer quickly fades, the in-5770 continuously recreates stored graphic images as required by projecting a 512 x 512 matrix of shaded picture elements onto the CRT screen.

MEMORY REFRESH OPTIONS

All rows of memory devices within the in-5770 must be refreshed once every 2 milliseconds to prevent loss of data. The refresh operation takes place automatically during serial read for video refresh. However, if normal read operations do not use all 128 chip rows within the memory, refresh cycles must be externally initiated. Data refreshing in N-Channel MOS RAMs is normally achieved by sequentially scanning the memory at the rate of 128 times each 2 milliseconds.

Interface

INPUT/OUTPUT

All in-5770 input/output signals are compatible with TTL integrated circuits. The input and output signal operations for the in-5770 are summarized in Tables 2 and 3, respectively.
Table 2. in-5770 Input Signal Operations

<table>
<thead>
<tr>
<th>Signal</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addresses (0-17)</td>
<td>Controls address selection of both single bit data and parallel data on 18 bidirectional lines.</td>
</tr>
<tr>
<td>Card select</td>
<td>Enables memory activity on card when low.</td>
</tr>
<tr>
<td>Memory cycle start</td>
<td>Initiates memory cycle upon going from high to low.</td>
</tr>
<tr>
<td>Bit mode</td>
<td>Indicates to memory, when low, that single bit write cycle or read-modify-write cycle is to be performed. Enables parallel operation when high.</td>
</tr>
<tr>
<td>Write</td>
<td>Initiates write operation when held low at beginning of memory cycle.</td>
</tr>
<tr>
<td>Read-modify-write</td>
<td>Initiates read operation when held low at beginning of memory cycle.</td>
</tr>
<tr>
<td>Plane select write mask</td>
<td>Inhibits writing operation, when driven low during write or read-modify-write operation on data within given planes, on all data within that plane.</td>
</tr>
</tbody>
</table>

Reliability

Intel manufactures all the integrated circuit devices from which all Intel memory systems are produced. Because of this vertical integration, Intel controls the quality of its equipment from the beginning process of making the device through the final test and delivery of the system, thus assuring the users of products with proven quality and reliability. In addition all Intel memory systems products are covered by a one year Intel warranty.

Table 3. in-5770 Output Signal Operations

<table>
<thead>
<tr>
<th>Signal</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data available</td>
<td>Indicates to processor, upon going high at access time, that valid read data is available on data bus.</td>
</tr>
<tr>
<td>Single bit data (0-3)</td>
<td>Transfer single bit read data out of memory on four unidirectional lines.</td>
</tr>
<tr>
<td>Serial video data (0-3)</td>
<td>Transfers serial video data out of memory on four unidirectional lines.</td>
</tr>
</tbody>
</table>

SPECIFICATIONS

Storage Capacity

256K x 4 bits, addressable as 64-bit words (16 bits per image plane), or as 4-bit words (1 bit per image plane)

Word Length

16 bits on the parallel bus per image plane
1 bit on the single bit bus per image plane
1 bit on the serial data bus per image plane

Performance

CYCLE TIME
Read, Write, or Refresh: 450 ns max
Read-Modify-Write: 780 ns max

ACCESS TIME
Parallel Data: 380 ns max
Single Bit Data: 390 ns max

RETENTION TIME
2 ms max
**SERIAL DATA RATE**
14.3 MHz max

**Operational Modes**
Parallel write (16 bits)
Parallel read-modify-write (16 bits)
Single bit write
Single bit read-modify-write
Parallel read (16 bits)
Single bit read
Serial read
Clear mode write
Memory refresh

**Interface Characteristics**

**CONNECTOR**
Two 80-pin double-sided PC edge, 0.125 in. centers, type SAE 8100 (Stanford Applied Engineering) or equivalent

**INPUT/OUTPUT**
TTL compatible (single ended)

**ADDRESS INPUT**
18 binary lines

**DATA INPUT**
Parallel Data: 64 bidirectional lines
Single Bit Data: 4 unidirectional lines

**DATA OUTPUT**
Parallel Data: 64 bidirectional lines
Single Bit Data: 4 unidirectional lines
Serial Mode Data: 4 unidirectional lines

**CONTROL INPUT**
17 lines: memory cycle start, write, single bit mode, read-modify-write, card select, refresh, plane select write masks 0 through 3, clear mode, parallel read enable 0 through 3, serial data clock, serial data load enable, video data load sync

**CONTROL OUTPUT**
Data available

**Interface Signals**

**INPUT**
Low ................. −1.0V to +0.8V @ 2 mA
High ................ +2.2V to +5.5V @ 100 μA

**OUTPUT**
Low ................. −0.5V to +0.5V @ 15 mA
High ................ +2.4V to +5.2V @ 200 μA

**Physical Characteristics**

**CARD**
Width .............. 11.25 in. (28.58 cm)
Length ............. 16 in. (40.64 cm)
Weight ............. 2 lb (1 kg)
Mounting Centers .... 0.625 in. (1.59 cm)

**Electrical Characteristics**

**DC POWER REQUIREMENTS**

<table>
<thead>
<tr>
<th>Voltage (±5%)</th>
<th>Current (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+12V</td>
<td>2.5A</td>
</tr>
<tr>
<td>+5V</td>
<td>2.75A</td>
</tr>
<tr>
<td>−5V</td>
<td>100 mA</td>
</tr>
</tbody>
</table>

**Environmental Requirements**

**TEMPERATURE**
0°C to 55°C operating ambient
−40°C to 125°C non-operating

**RELATIVE HUMIDITY**
Up to 90% non-condensing

**ALTITUDE**
10,000 ft max, operating
40,000 ft max, non-operating

**COOLING**
200 linear ft per minute

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Model</th>
<th>Capacity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM-5770-512</td>
<td>256K × 4</td>
<td>512 × 512 × 4 video refresh memory system card</td>
</tr>
</tbody>
</table>
MU-5750
VAX* 11/750, PDP* 11/70 ADD-IN MEMORY

- Replaces DEC* MS750AA or MS750AB
- 256K or 512K byte capacity
- On-line/off-line switch
- Hardware/software compatible
- Supports battery backup

The Intel® MU-5750 is an add-in memory board for use in the DEC* VAX* 11-750 or PDP* 11/70 computers and is functionally equivalent to DEC's own memory board. The VAX or PDP 11/70 memory subsystem provides all of the necessary control and timing for this memory board. No modification to the computer is necessary to use the MU-5750. An on-line/off-line switch is provided on-board to allow memory boards to be isolated for diagnostic purposes without being removed.

The 256KB MU-5750 is a direct replacement for one DEC M8728 memory board (MS750AA) and the 512KB MU-5750 replaces two M8728 boards (MS750AB). Up to eight 256KB boards or up to four 512KB boards can be used to expand the VAX 11/750 memory capacity up to a full 2M bytes. Similarly, the MU-5750 can be used to expand the PDP 11/70 to its full capacity of 4M bytes.

*DEC, PDP, and VAX are trademarks of Digital Equipment Corporation, Maynard, Massachusetts.
Storage Capacity
256K or 512K Eight-Bit Bytes

Word Length
32 Data Bits Plus 7 Error Check and Correction (ECC) Bits

Speed
Access Time .................... 285 Nanoseconds
Cycle Time .................... 350 Nanoseconds

Operational Cycles
Read, Write, Byte Write, Initialize, Refresh

Interface Characteristics
—TTL Compatible
—7 Chip Row and Column Address Lines
—13 Control Lines

Electrical

<table>
<thead>
<tr>
<th>Model (KB)</th>
<th>Voltage (Volts)</th>
<th>Standby Current (mA)</th>
<th>Operating Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>256</td>
<td>+12</td>
<td>234.00</td>
<td>1540.50</td>
</tr>
<tr>
<td></td>
<td>+5</td>
<td>2.60</td>
<td>1.59</td>
</tr>
<tr>
<td></td>
<td>-5</td>
<td>7.80</td>
<td>13.70</td>
</tr>
<tr>
<td>512</td>
<td>+12</td>
<td>468.00</td>
<td>1774.50</td>
</tr>
<tr>
<td></td>
<td>+12</td>
<td>3.10</td>
<td>3.12</td>
</tr>
<tr>
<td></td>
<td>-5</td>
<td>15.60</td>
<td>25.35</td>
</tr>
</tbody>
</table>

Dimensions
Length .................... 8.0 in. (20.3 cm)
Height .................... 15.69 in. (39.0 cm)
Width .................... (256KB) One Card Slot
                      (512KB) Two Card Slots

Environment
TEMPERATURE
0°C to 50°C ............ Operating
-40°C to 125°C .......... Non-Operating

HUMIDITY
Up to 90% Without Condensation

ALTITUDE
Up to 10,000 ft. (3,030m) .... Operating
Up to 50,000 ft. (15,150m) .... Non-Operating

RELIABILITY
Intel tests each MU-5750 at elevated voltages and temperatures for a period proven to bring out most latent defects in semiconductor devices. This process, together with temperature cycling, is designed to remove all potential failures before the memory card reaches the customer. Because of the 100% burn-in performed on each card, the user is assured of Intel's proven quality and reliability. This product is covered by a one-year warranty.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Model</th>
<th>Capacity</th>
<th>Equivalent VAX 11/750</th>
<th>Equivalent PDP 11/70</th>
</tr>
</thead>
<tbody>
<tr>
<td>MU-5750-256</td>
<td>256K eight-bit bytes</td>
<td>MS750-AA (one M8728)</td>
<td>— (one M8728)</td>
</tr>
<tr>
<td>MU-5750-512</td>
<td>512K eight-bit bytes</td>
<td>MS750-AB (two M8728)</td>
<td>MK11-CE (two M8728)</td>
</tr>
</tbody>
</table>
MU-5780
VAX*-11/780 ADD-IN MEMORY CARD

- Replaces DEC* MS780-DA, DB or DC
- Equivalent to 1, 2 or 4 DEC M8210 Memory Modules
- 256KB, 512KB or 1024KB Capacity
- Complete Hardware and Software Compatibility
- On-Line/Off-Line Switch
- Supports Battery Back Up

The Intel® MU-5780 Add-In Memory Card is a 256KB, 512KB or 1024KB plug-compatible memory card designed for use in any DEC VAX-11/780 computer, to expand the MS780-C or MS780-CC basic VAX-11/780 memories up to 4096K bytes (four megabytes). The MU-5780 operates at speeds controlled by the VAX-11/780 memory controller. Typical read cycle and access times are 530 and 250 nanoseconds respectively. All card components are hardware- and software-compatible with the VAX-11/780 computer. The MU-5780 can be installed without change or modification to either the computer or the memory module by plugging it into the proper memory backplane slot. The MU-5780 measures 39.8 cm (15.7 inches) by 31.4 cm (12.4 inches) and requires the same +5VDC, −5VDC, +12VDC, and +5VDC battery backup as the memory card it replaces.

*VAX and DEC are registered trademarks of Digital Equipment Corporation.
FUNCTIONAL DESCRIPTION

The MU-5780 Add-In Memory Card consists of a single printed-circuit card designed to fit into the memory backplane of a DEC VAX-11/780. It contains all circuitry required for memory operation, including address-decoding circuits, memory-control circuits, and a memory storage area. All system components are engineered to meet or exceed the specifications of similar DEC components. A block diagram of the MU-5780 memory system is shown in Figure 1.

Compatibility

The MU-5780 can be operated with or in place of the DEC Model M8210 Semiconductor Array. It must be used in conjunction with the DEC M8213 Memory Controller, the M8212 Memory Data Path, and the M8214 Memory SBI Interface Boards.

Figure 1. MU-5780 Block Diagram
Capacity

The MU-5780 is available in three configurations, 256K bytes (MU-5780-256), 512 bytes (MU-5780-512) or 1024K bytes (MU-5780-1MB). The configurations are organized as 32K x 72 bits, 64K x 72 bits or 128K x 72 bits. Each word contains 64 data bits and 8 check bits. The memory storage area consists of either 72, 144, or 288, Intel 2121, 32K x 1 dynamic memory IC's.

Addressability

The MU-5780 memory address circuitry consists of 19 address inputs plus four slot-code bits supplied to the memory by the VAX computer. The four slot-code bits are subtracted from the last four address bits (ARY ADR 16, 17, 18, and 19). Each subtraction selects a 256KB memory segment of the MU-5780 installed in the addressed slot.

An on-board multiplexer, under control of the MUX CNTRL command, applies seven address bits as row addresses, which select one of 128 rows on the memory modules, and seven column addresses, which select one of 128 columns on the memory modules. One address bit, 13, selects the memory bank. Figure 2 shows the address configuration.

INSTALLATION

The Intel® MU-5780 memory cards are installed in Slots 3 through 17 of the DEC MS-780 Memory System Backplane. Since some MU-5780s have a higher capacity than the DEC boards they replace, all memory slots may not be used in the MU-5780 application. With the MU-5780 512 version, the first card is installed in the first vacant memory slot (17 or lower), and in every alternate slot. With the MU-5780 1MB version, the first card is installed in the first vacant slot (17 or lower) and then in every fourth slot. Intel-supplied continuity boards must be installed in the empty slots between these MU-5780s. Continuity boards simulate the memory cards which would normally be installed in the slots and also direct air flow over the memory cards.

Reliability

Each MU-5780 is fully tested in a temperature-cycling environment. Because of the 100% burn-in performed on each card, the user is assured of receiving Intel’s proven quality and reliability. In addition, the MU-5780 is covered by a one-year Intel warranty.

Figure 2. MU-5780 Address Configuration
SPECIFICATIONS

Storage Capacity
256KB ........................ MU-5780-256
512KB ........................ MU-5780-512
1024KB ........................ MU-5780-1MB

Word Length
64 data bits plus 8 check bits

Performance (Cycle Times—Maximum)
Read .......................... 600 nanoseconds
Write .......................... 600 nanoseconds
Initialize ...................... 600 nanoseconds
Refresh ........................ 600 nanoseconds
(Times shown are for the VAX memory controller. MU-5780 performance is 530 nanoseconds cycle time and 250 nanoseconds access time.)

Operational Modes
Read Initialize
Write Refresh

Refresh Rate
14 microseconds

Interface Characteristics
Address Lines: 23 lines, including four slot code lines
Data Inputs/Outputs: 72 bidirectional lines (64 data lines, 8 check bit lines)
Control Inputs: Seven lines low-power Schottky
Power Requirement: +5VDC, -5VDC, +12VDC, +5VDC battery backup

Physical Characteristics
Width .................... 39.8 cm (15.7 inches)
Height .................... 31.4 cm (12.4 inches)
Thickness ........... One card slot
Weight ................. 2.05 kilos (4.5 lbs.)

Environmental Characteristics
Temperature: 0°C to 50°, operating ambient
–40°C to +125°C, non-operating
Relative Humidity: Up to 90% without condensation
Altitude: 3,030 meters (10,000 ft) maximum, operating
15,151 meters (50,000 ft) maximum, non-operating

Reference Manuals
MU-5780 Add-In Memory Card (supplied), 112388
Reference manuals are shipped with each product only if designated (see above). Manuals may be ordered from any Intel sales representative.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Capacity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MU-5780-256</td>
<td>256K Bytes</td>
<td>256KB, 32K x 72</td>
</tr>
<tr>
<td>MU-5780-512</td>
<td>512K Bytes</td>
<td>512KB, 64K x 72</td>
</tr>
<tr>
<td>MU-5780-1MB</td>
<td>1024K Bytes</td>
<td>1024KB, 128K x 72</td>
</tr>
</tbody>
</table>
iSBC 254™
BUCKET MEMORY BOARD

- 128K Byte to 512K Byte Capacity on Single iSBC™ Board
- 48MS Average Access Time
- Low Power Consumption 35 Watts for 512 KB Version
- Non-Volatile Storage
- Multiple I/O Modes, Including DMA
- Driver Software for Operation with RMX 80/86

The iSBC 254™ is a non-volatile memory utilizing the Intel 7110 one-megabit bubble memory element. The board is offered in three capacities: 128K, 256K, or 512K bytes.

The iSBC 254 can be operated in three I/O modes: polled status, interrupt-driven, or DMA. The 128K byte version can operate at a maximum transfer rate of 12.5K bytes per second. The multiple bubble elements of the 256K byte and 512K byte versions can be accessed in parallel to achieve maximum transfer rates of 25K and 50K bytes per second, respectively.

The physical outline of the iSBC 254 is the standard 12 inch by 6.75 inch iSBC card format. The depth of the board, however, is 0.62 inches, requiring two normally spaced card slots for adequate mechanical clearance. Power requirements for the iSBC 254 are 4 Amps at +5 volts and 1.2 Amps at +12 volts, maximum.
OPERATIONAL DESCRIPTION

Three distinct modes of operation relate to the transfer of data. Each is briefly described below.

Data Transfer

In DMA (Direct Memory Access) Mode, the iSBC 254 board utilizes the Intel 8257 DMA Controller, in conjunction with the 7220 Bubble Memory Controller, to perform three distinct types of DMA operation: DMA Read, DMA Write, and DMA Verify. In a DMA Read operation, data is transferred from memory to the FIFO (first-in/first-out RAM) of the 7220 BMC (Bubble Memory Controller). In a DMA Write operation, data is transferred from the 7220 BMC FIFO to memory. In a DMA Verify operation, the iSBC 254 board gains control of the bus, but no actual transfer of data takes place. DMA Read and DMA Write operations are used for high-speed data transfers involving bus-accessible memory; DMA Verify operations are typically used to maintain control of the system bus while verification tasks, such as checking newly acquired data, are being performed.

In Poll Mode, the CPU periodically checks the Status Register of the 7220 BMC. The Status Register can indicate a variety of conditions, one of which is that the BMC FIFO is ready to receive data or that the FIFO contains data to be read.

In DRQ (Data Request) Mode, when the FIFO of the 7220 BMC is half empty (during a write operation) or half full (during a read operation), the DRQ pin becomes active and an interrupt is issued, signalling that data may be written (bus to iSBC 254 board) or read (iSBC 254 board to bus).

Two distinct modes of operation relate to monitoring the bubble memory board status (via the 7220 Bubble Memory Controller). Each is briefly described below.

Status Monitoring Modes

In Interrupt Mode, a change in the 7220 BMC Status Register will cause an interrupt to occur, and the host processor will then look at that register to see what change has occurred. Any of the following may be indicated: the BMC sequencer is busy; an operation has been completed; an operation has failed; a timing error has occurred; and/or a correctable, uncorrectable, or parity error has occurred.

In Poll Mode, as described above under Data Transfer, the CPU periodically checks the Status Register of the 7220 BMC. The Status Register can indicate a variety of conditions: that the BMC Sequencer is busy; that an operation is complete; that an operation has failed; that a timing error has occurred; that a correctable, uncorrectable, or parity error has occurred; or, in terms of data transfer, that the BMC FIFO is ready to receive data or that the FIFO contains data to be read.

SOFTWARE DESCRIPTION

The iSBC 254 board can run under either the iRMX/80 or the iRMX/86 operating system.

Under the iRMX/80 operating system, the Bubble Manager (BMGR), a software task that runs with the iRMX/80 operating system, keeps track of free or available space on the Magnetic Bubble Memory. Another task, Bubble I/O (BUBIO), controls all iSBC 254 board operations. Bubble I/O can run with or without the Bubble Manager.

Under the iRMX/86 operating system, the iSBC 254 board is supported as an integral part of the I/O system software, which is part of the iRMX/86 operating system. (The iRMX/86 operating system device driver for the iSBC 254 board is linked with the I/O system software, which is in turn linked with the iRMX/86 operating system.) Because the iRMX/86 operating system provides convenient codes for performing operations, because all devices "look" the same when running under this operating system, and because of a variety of built-in features, the the iRMX/86 operating system provides great flexibility.

Software programs on both single- and double-density diskettes are provided with the iSBC 254 board. EX-254 is a set of programs that demonstrates how to use the various iSBC 254 board software commands.
SPECIFICATIONS

Memory Size
128K, 256K, or 512K bytes

Interface
All address, data, and control signals are TTL-compatible and Intel MULTIBUS system compatible.

Electrical Characteristics
D.C. Power
+5 volts D.C. ±5%, 3.0A (max.)
+12 volts D.C. ±5%, 1.4A (max.)

Performance
Rotating Field Rate: 50KHz
Maximum Data Rate: 50K bytes/second
Average Access Time: 48ms

Connector
86-pin double-sided PC edge connector with 0.40 cm (0.156 in.) contact centers.
Mating Connector: Control Data VFB01E43D0A1 or Viking 2VH43/1ANE5.

Physical Characteristics
Length: 30.48 cm (12 in.)
Height: 17.15 cm (6.75 in.)
Depth: 1.57 cm (0.62 in.)
Note: Because of its depth, the iSBC 254 board requires two card slots.

Environment
Board Operating Temperature: 0–55°C

Equipment Supplied
iSBC 254 Bubble Memory Board
iSBC 254 Operation Manual
iSBC 254 Software (single- and double-density diskettes)
## iPAB
**PLUG-A-BUBBLE™ MEMORY SYSTEM**

- Removable bubble memory cassette
- 128K bytes storage capacity per cassette
- Ruggedized cassettes
- Optional interface to iSBX™ multimodule bus
- Automatic error correction
- Non-volatile storage
- Powerfail data protection
- Write protection

- Average access time of 48 ms
- Burst data rate of 12.5K bytes per second
- Designed to support DMA
- Operates from standard +5V and +12V power supplies
- Low power consumption
- Accommodates up to sixteen holders and cassettes

The Plug-A-Bubble™ system (iPAB) is a bubble memory system designed for easy removal and replacement of media (bubble memory cassettes), similar to the removal and replacement of media (magnetic discs) in disc systems.

The “media” of the iPAB system is a sturdy protective casing that contains a one-megabit bubble memory, support components, three LEDs, and discrete capacitors and resistors. The protective casing is designed to protect these devices from dust, shock, and other elements of an adverse environment.

For users of single-board computers with the iSBX bus, an iSBX Multimodule interface card (MMI/O card) is available for generating the required signals for the cassette holder.

iPAB is a bubble memory system and is therefore non-volatile memory. Like disc systems, the iPAB system has write protection (a switch on the cartridge holder provides this); it also has powerfail protection.

Below is a photo of the components that can make up an iPAB system. The photo shows: top left, standard cable (iPAB 0362); top center, chassis (iPAB 525); top right (slightly lower), holder and cassette (iPAB 381); bottom left, Multimodule interface (MMI/O) card (iPAB 258); bottom right, cassette (iPAB 128). (For various configurations of an iPAB system, see Figure 1.)
GENERAL DESCRIPTION

A Plug-A-Bubble™ iPAB system may be configured in various ways, depending on a user's needs, but common to every iPAB system is at least one iPAB cassette and one iPAB holder (iPAB 381).

An iPAB cassette consists of a PC board with a one-megabit bubble memory device, support components including a controller, three LEDs, a number of discrete resistors and capacitors, and a protective casing that encloses the PC board and protects it from dust, shock, and other elements of an adverse environment.

An iPAB cassette holder "holds" a cassette (a holder and a cassette are mated via a plug on the holder and a jack on the cassette); it also contains a jack for the required external signals to/from the holder. The holder provides logic for selection of the cassette, bidirectional circuitry for gating of data, and write protection logic.

Variable components of an iPAB system are the standard data cable, (iPAB 0362), an MMI/O card (iPAB 258), a chassis (iPAB 525). (See Figure 1 for various user and iPAB system configurations.)

The standard cable is shielded and 36 inches long. It comes with four connectors: Two are for connecting holders; one is for connecting the cable to an MMI/O card, if an MMI/O card is used, or to a user-supplied device that generates the required holder signals, if an MMI/O card is not used; and one is for connecting the end of the cable to a terminator card in the last holder.

The MMI/O card is an iSBX Multimodule interface card available for users with single-board computers with the ISBX bus. The function of this card is to generate, under control of the user's system, the required signals for the iPAB cassette holder(s). Without external power, a single MMI/O card can support two holders and cassettes; with external power, up to eight holders and cassettes can be supported. The MMI/O card contains: latches for the address lines that are used for iPAB cassette selection; data gating circuitry; parity generating circuitry; MMI/O status logic; circuitry for generating a wait signal for a DMA controller (not contained in the iPAB system) or the CPU; circuitry for generating the iPAB clock; and jumpers for selecting a variety of options. The MMI/O card comes with the standard cable described above.

If the MMI/O card is not used, the user must generate the required signals for the iPAB cassette holder(s). Note that a holder has manual switch setting and address lines that allow the user to select any one of sixteen different holders, so that with sufficient power a single iPAB system without an MMI/O card may support up to sixteen holders and cassettes.

The iPAB chassis houses two iPAB holders. Its dimensions are 5.75 × 3.25 × 8.0 inches, so that it occupies the same space as a 5.25-inch floppy disc drive.

COMMUNICATION

Communication with individual iPAB cassettes is accomplished via reading/writing two I/O ports in the 7220-1 Bubble Memory Controller (BMC). (The 7220-1 BMC is one of the bubble memory support components contained in the iPAB cassette.) These two ports allow access to a variety of registers in the 7220-1 BMC, so that commands may be issued, status may be read, and a variety of parameters relating to bubble memory operation may be set.

MODES OF OPERATION

There are three possible modes of operating: Interrupt Mode, Polled Mode, and DMA (Direct Memory Access) Mode. Interrupt Mode and Polled Mode are used both for data transfers and for monitoring status; DMA Mode, which requires some additional circuitry to implement, is used for data transfers only.

In terms of data transfers, Interrupt Mode is implemented by connecting the Data Request line to a host interrupt line, the Data Request line indicating, when active, that the FIFO of the 7220-1 Bubble Memory Controller is half empty (during a write operation) or half full (during a read operation), and hence that service is required by the host processor. (The 7220-1 BMC FIFO is a First-In/First-Out register used as a data buffer between host and bubble memory.) In Polled Mode, the host processor periodically checks the status register of the 7220-1 BMC to determine whether service is required. With some additional circuitry, a third mode, DMA Mode, is possible. (The 7220-1 BMC has DMA handshaking capability for DMA transfers, but to implement this mode a user-supplied DMA controller is necessary.)

In terms of monitoring cassette status, Interrupt Mode is implemented by connecting the 7220-1 BMC Interrupt (INT) line to a host interrupt line and setting
USER CONFIGURATIONS

I. 

II. 

IPAB SYSTEM

Figure 1. User iPAB Configurations/Options
Figure 2. IPAB System Overall Block Diagram (with optional MMI/O card)

*Currently N 2. With future design changes, the value of N may be increased (up to N 8).
For ease of presentation, only one IPAB basic system is shown.
various bits in the enable register (Enable ICD, Enable RCD, and/or Interrupt Enable (Error) for error interrupts; Interrupt Enable (Normal) for an interrupt to occur at the completion of a task). Then either (or both) the completion of a task or the occurrence of an error will result in an interrupt. In Polled Mode, the host processor periodically reads the 7220-1 BMC status register to determine if an operation has been completed or if an error has occurred.

SOFTWARE

Actual control of bubble memory operation is accomplished via reading or writing various registers in the 7220-1 Bubble Memory Controller as described above. But for most users it is convenient to talk to bubble memory in a higher-level language—or via a software “driver” that translates the higher-level language into the language of the bubble memory.

For users with the iRMX/86 or iRMX/88 operating systems, who wish to perform data transfers in DMA Mode, iPAB software drivers are available as part of those operating systems.

For users who want to write their own drivers, detailed instructions are provided in the iPAB technical manual (Part Number 112583) on how to program the registers for desired bubble memory operation, and technical support is available from the Intel Application group.

For users with Intel Microcomputer Development Systems, a Bubble Demo package is available on floppy disc, allowing users to read data from, and write data to, the bubble system; test its operation; read the bubble's bootloop; and test the iPAB's write protection switch.

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Capacity per Cassette</th>
<th>128K bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page Length</td>
<td>68 bytes—ECC disabled; 64 bytes—ECC enabled</td>
</tr>
<tr>
<td>Number of Pages</td>
<td>2,048</td>
</tr>
<tr>
<td>Rotating Field Rate</td>
<td>50 kHz</td>
</tr>
<tr>
<td>Date Rate</td>
<td>12.5K bytes/sec. (burst rate)</td>
</tr>
<tr>
<td>Average Access Time</td>
<td>48 ms</td>
</tr>
</tbody>
</table>

Power Requirements

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Holder</td>
</tr>
<tr>
<td>VCC +5V ± 5%</td>
<td>280 ma</td>
</tr>
<tr>
<td>VDD +12V ± 5%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Environmental Specifications

<table>
<thead>
<tr>
<th>Environmental Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature</td>
<td>0 to 55°C</td>
</tr>
<tr>
<td>Non-Operating Temperature (with Data Retention)</td>
<td>-40 to +100°C</td>
</tr>
<tr>
<td>Humidity (Without Condensation)</td>
<td>0 to 95% FRH</td>
</tr>
<tr>
<td>Shock</td>
<td>30g over 11 ms with ½ sinewave shape</td>
</tr>
<tr>
<td>Vibration</td>
<td>5 Hz to 15 Hz @ .50 inches double-amplitude displacement (65g to 6g); 15 Hz to 2000 Hz @ 5g (.42 to .000025 inches double-amplitude displacement)</td>
</tr>
<tr>
<td>Insertion Cycles</td>
<td>2000</td>
</tr>
</tbody>
</table>
ORDER INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPAB 381</td>
<td>Cassette holder (7.75&quot; × 3.8&quot; × 1&quot;) and one 128K byte cassette (6.1&quot; × 3.6&quot; × .81&quot;). (Note: When fully inserted in the holder, the cassette extends 2.5&quot; from the end of the holder into which it is inserted.)</td>
</tr>
<tr>
<td>iPAB 128</td>
<td>128K-byte bubble memory cassette.</td>
</tr>
<tr>
<td>iPAB 258</td>
<td>iSBX Multimodule interface card (MMI/O card). This comes with shielded 36&quot; cable with connectors for two cassette holders.</td>
</tr>
<tr>
<td>iPAB 525</td>
<td>This is a 5.75&quot; × 3.25&quot; × 8.0&quot; chassis housing two iPAB cassette holders. It occupies the same space as does a 5.25&quot; floppy disc drive.</td>
</tr>
<tr>
<td>iPAB 0362</td>
<td>Shielded 36&quot; cable with connectors for two cassette holders.</td>
</tr>
</tbody>
</table>

Software

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>iRMX™/86 iPAB Driver</td>
<td>Comes with iRMX/86 software.</td>
</tr>
<tr>
<td>iRMX/88 iPAB Driver</td>
<td>Comes with iRMX/88 software.</td>
</tr>
<tr>
<td>Bubble Demo</td>
<td>This is also available from MSO Intel upon request (Order No. 113073-001).</td>
</tr>
</tbody>
</table>
iSBX 251™
MAGNETIC BUBBLE
MULTIMODULE™ BOARD

- iSBX™ bus compatible
- Capacity: 128K bytes
- Performance:
  - average access time: 48ms
  - burst data rate: 12.5K bytes/sec
- DMA compatibility
- Non-volatile storage
- Automatic error correction
- Operates from standard +5V and +12V power supplies
- Software compatibility with iRMX™ Operating System
- Power fail data protection
- Low power consumption

The Intel iSBX 251 magnetic bubble MULTIMODULE board is a completely assembled and tested non-volatile memory based on the Intel 7110 one-megabit bubble memory. This board plugs into any Intel iSBC Single Board Computer equipped with an iSBX connector, providing immediate, high density storage. This arrangement frees the MULTIBUS for other traffic while the host iSBC board accesses the bubble memory.

Support circuitry provides the user with a simple interface to the bubble memory. For instance, sixteen commands are available to transfer data and to view the operational status of the iSBX 251 board. Additionally, memory reliability is increased if the automatic Error Check and Correction (ECO) feature of the support circuitry is selected.

The iSBX 251 board can be wired to transfer data in one of three modes: polled access, interrupt driven, and Direct Memory Access (DMA). The user may also select polled or interrupt driven access to the 7220-1 Status Register. Thus, the user can tailor the type of access to the individual application.
### SPECIFICATIONS

#### Storage Capacity
- 128K Eight-Bit Bytes
- 2048 Pages
- Page Length:
  - 64 bytes with ECC
  - 68 bytes without ECC

#### Operational Modes
Polled, Interrupt Driven, or DMA (with Host DMA Controller)

#### Electrical Requirements
D.C. power, supplied through iSBX connector:
- +5V ±5%, 365 mA (max.)
- +12V ±5%, 400 mA (max.)

#### Performance
- Rotating Field Rate: 50 KHZ
- Maximum Data Rate: 12.5K byte/sec
- Average Access Time: 48 ms

### Interface Requirements
- TTL compatible
- iSBX 251 male connector plugs into 36-pin or 44-pin host female connector
- Connector located per Intel iSBX Bus Specification (order number 142686) double wide form factor

### Physical Characteristics
- Width: 7.24 cm (2.85 in.)
- Length: 19.05 cm (7.50 in.)
- Height: 2.53 cm (0.996 in.)
- Weight: 362.9 gm (12.8 oz.)

### Environment
- Temperature:
  - Operating: 0°C to 60°C (32°F to 140°F)
  - Non-Operating: -40°C to 100°C (-40°F to 212°F)
- Relative Humidity: 0% to 95% without condensation

### RELIABILITY
Intel tests each iSBX 251 board at elevated voltages and temperatures for a period proven to bring out most latent defects. This process, together with temperature cycling, is designed to remove all potential failures before the memory board reaches the customer. Because of the 100% burn-in performed on each board, the user is assured of Intel's proven quality and reliability.

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![Block Diagram](Figure_1_Block_Diagram.png)

**Figure 1. Block Diagram**
Insite, Intel’s Software Index and Technology Exchange Library, is a collection of programs, subroutines, procedures, and macros written by users of Intel’s microcomputers, single-board computers, and Intellec development systems. Thanks to customer contributions to Insite, Intel is able to make these programs available to all users of Intel microcomputers who are Library members. By taking advantage of the availability of these general-purpose routines, the microcomputer design engineer and programmer can save many hours of programming and debugging time. The library of programs also serves as a good learning tool for those unfamiliar with Intel assembly language or the high-level languages for Intel’s family of microcomputers.

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**Program Library Service.** PAPER TAPES, DISKETTES OR SOURCE LISTINGS are available for every program in Insite. Diskettes are available on single or double density. Membership is required to purchase programs.

**Insite™ Program Library Catalog.** Each member will be sent the Program Library Catalog consisting of an abstract for each program indicating the function of the routine, required hardware and software, and memory requirements.

Insite members will be updated with abstracts of new programs submitted to the Library during the subscription period. For catalog and yearly subscription fee please refer to the Intel OEM Price List or contact the nearest Intel Sales Office.

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COMPANY: ______________________________________ TELEPHONE: __________________________

SHIP TO: ________________________________________

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North America: Intel Corporation, Insite Program Library MS 6-5000, Microcomputer Systems, 3065 Bowers, Santa Clara, California 95051, Ph. 408-987-8080

Europe: Intel International Corp. S.A., Insite Program Library, Rue du Moulin a Papier 51, Boite 1, B-1160 Brussels, Belgium, Ph. 02-660-3010

Oriental: Intel Japan K.K., Insite Program Library, Flowerhill-Shinmachi, East Bldg., 1-23-9 Shinmachi, Setagaya-ku, Tokyo 154, Japan, Ph. 813-426-9261 (PME & FSE), 813-426-9267 (CS & Fin.)
INSITE PROGRAM
SUBMITTAL REQUIREMENTS

Submittal Requirements

Programs submitted for Insite review must follow the guidelines below:

A. Programs must support Intel products
B. Program submittals must be packaged to include:
   — Complete submittal form
   — Source listing (the output of a compilation/assembly)
   — Well-documented source code and executable code furnished on ISIS-formatted diskette or ASCII-coded paper tape
   — Detailed instructions (step-by-step from source code compilation/assembly through program execution)
   — Test program demonstrating accurate operation and output
C. Programs must be written in a language capable of compilation/assembly by the currently supported version of an Intel standard compiler/assembler. Acceptable languages are documented in the following manuals (available through Intel's Literature Department):
   — MCS-48/UP1-41 Assembly Language Manual, Stock Number 305000
   — 8080/8085 Assembly Language Programming Manual, Stock Number 401100
   — 8086 Assembly Language Reference Manual, Stock Number 402105
   — BASIC-80 Reference Manual, Stock Number 400710
   — ICIS-COBOL Language Reference Manual, Stock Number 409115
   — Fortran-80 Programming Manual, Stock Number 400625
   — PL/M-80 Programming Manual, Stock Number 401700
   — PL/M-86 Programming Manual, Stock Number 402325
   — PASCAL-80 Language Reference Manual, Stock Number 400660

Submittal Acknowledgement

Program acceptance/rejection will be acknowledged through correspondence. Programs accepted by Insite become the property of the Insite Library. Programs rejected by Insite will be returned to the submittor with an explanation for the rejection.
DIGITAL RESEARCH INC.
CP/M* 2.2 OPERATING SYSTEM

- High-performance, single-console operating system
- Simple, reliable file system matched to microcomputer resources
- Table-driven architecture allows field reconfiguration to match a wide variety of disk capacities and needs
- Extensive documentation covers all facts of CP/M applications
- General-purpose subroutines and table-driven data-access algorithms provide a truly universal data management system
- Upward compatibility from all previous versions
- More than 500 commercially available compatible software products

CP/M 2.2 is a monitor control program for microcomputer system and application development using the Intel 8080/8085-based microcomputer with IBM-compatible flexible disks for backup storage (see the CP/M-86* Operating System data sheet for information on CP/M for Intel 8086/8088-based systems). CP/M provides a general environment for program construction, storage, and editing, along with the program assembly and check-out facilities.

The CP/M monitor provides rapid access to programs through a comprehensive file management package. The file subsystem supports a named file structure, allowing dynamic allocation of file space as well as sequential and random file access. Using this file system, a large number of distinct programs can be stored in both source- and machine-executable form.

CP/M also supports a powerful context editor, Intel-compatible assembler, and debugger subsystems. Optional software includes a powerful Intel-compatible macro assembler, and a symbolic debugger, along with various high-level languages.

FEATURES

CP/M is logically divided into four distinct modules:

**BIOS—Basic I/O System**

—Provides primitive operations for access to disk drives and interface to standard peripherals (teletype, CRT, paper tape reader/punch, and user-defined peripherals)

—Allows user modification for tailoring to a particular hardware environment

**BDOS—Basic Disk Operating System**

—Provides disk management for one to sixteen disk drives containing independent file directories

—Implements disk allocation strategies for fully dynamic file construction and minimization of head movement across the disk

—Uses less than 4K of memory

—Makes programs transportable from system to system

—Entry points include the following primitive operations which can be programmatically accessed:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEARCH</td>
<td>Look for a particular disk file by name</td>
</tr>
<tr>
<td>OPEN</td>
<td>Open a file for further operations</td>
</tr>
<tr>
<td>CLOSE</td>
<td>Close a file after processing</td>
</tr>
<tr>
<td>RENAME</td>
<td>Change the name of a particular file</td>
</tr>
<tr>
<td>READ</td>
<td>Read a record from a particular file</td>
</tr>
<tr>
<td>WRITE</td>
<td>Write a record to a particular file</td>
</tr>
<tr>
<td>SELECT</td>
<td>Select a particular disk drive for further operations</td>
</tr>
</tbody>
</table>
**CCP—Console Command Processor**

—Provides primary user interface by reading and interpreting commands entered through the console

—Loads and transfers control to transient programs, such as assemblers, editors, and debuggers

—Processes built-in standard commands including:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERA</td>
<td>Erase specified files</td>
</tr>
<tr>
<td>DIR</td>
<td>List file names in the directory</td>
</tr>
<tr>
<td>REN</td>
<td>Rename the specified file</td>
</tr>
<tr>
<td>SAVE</td>
<td>Save memory contents in a file</td>
</tr>
<tr>
<td>TYPE</td>
<td>Display the contents of a file on the console</td>
</tr>
</tbody>
</table>

**TPA—Transient Program Area**

—Holds programs which are loaded from the disk under command of the CCP

—Programs created under CP/M can be checked out by loading and executing these programs in the TPA

—User programs, loaded into the TPA, may use the CCP area for the program's data area

—Transient commands are specified in the same manner as built-in commands

—Additional commands can be easily defined by the user

—Defined transient commands include:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIP</td>
<td>Peripheral Interchange Program—implements the basic media transfer operations necessary to load, print, punch, copy, and combine disk files; PIP also performs various reformatting and concatenation functions. Formatting options include parity-bit removal, case conversion, Intel hex file validation, subfile extraction, tab expansion, line number generation, and pagination</td>
</tr>
<tr>
<td>ED</td>
<td>Text Editor—allows creation and modification of ASCII files using extensive context editing commands: string substitution, string search, insert, delete and block move; ED allows text to be located by context, line number, or relative position with a macro command for making extensive text changes with a single command line</td>
</tr>
</tbody>
</table>

**ASM** Fast 8080 Assembler—uses standard Intel mnemonics and pseudo operations with free-format input, and conditional assembly features

**DDT** Dynamic Debugging Tool—contains an integral assembler/disassembler module that lets the user patch and display memory in either assembler mnemonic or hexadecimal form and trace program execution with full register and status display; instructions can be executed between breakpoints in real-time, or run fully monitored, one instruction at a time

**SUBMIT** Allows a group of CP/M commands to be batched together and submitted to the operating system by a single command

**STAT** Lists the number of bytes of storage remaining on the currently logged disks, provides statistical information about particular files, and displays or alters device assignments

**LOAD** Converts Intel hex format to absolute binary, ready for direct load and execution in the CP/M environment

**SYSGEN** Creates new CP/M system disks for back-up purposes

**MOVCPM** Provides regeneration of CP/M systems for various memory configurations and works in conjunction with SYSGEN to provide additional copies of CP/M

**BENEFITS**

—Easy implementation on any computer configuration which uses an Intel 8080/8085 Central Processing Unit (see the CP/M-86 data sheet for CP/M applications on the iAPX86 CPU)

—Extensive selection of CP/M-compatible programs allows production and support of a comprehensive software package at low cost

—Easy migration path to timesharing systems with multiprogramming and multiterminal features (see the MP/M*, CP/NET*, and MP/NET* data sheets)

—Field programmability for special-purpose operating system requirements

—Upward compatibility from previous versions of CP/M release 1
—Provides field specification of one to sixteen logical drives, each containing up to eight megabytes.
—Files may contain up to 65,536 records of 128 bytes each but may not exceed the size of any single disk.
—Each disk is designed for 64 distinct files—more directory entries may be allocated if necessary.

SPECIFICATIONS

Hardware Required

Intellec Microcomputer Development System
—Series II or
—Model 800

Optional:
—RAM up to 64K
—additional floppy disk drives
—Winchester disk drive

Documentation Package

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<td>CP/M 2.2 documentation consisting of 7 manuals:</td>
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<td>121864</td>
<td>An Introduction to CP/M Features and Facilities</td>
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<td>CP/M Dynamic Debugging Tool (DDT) User’s Guide</td>
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<td>ED: A Context Editor for the CP/M Disk System User’s Manual</td>
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Shipping Media

(Specify by Alpha Character when ordering.)

A—single density (Intellec compatible, IBM 3740/1 format)

Order Code   Product Description
Availability: January 1982

An Intel Master Software License and Amendment required.
*CP/M is a registered trademark of Digital Research, Inc.
*CP/M-86, MP/M, CP/NET, and MP/NET are trademarks of Digital Research, Inc.
DIGITAL RESEARCH INC.
CP/M-86* OPERATING SYSTEM

- High-performance, single-user operating system for 16-bit computers based on Intel's iAPX-86 (8086) and compatible iAPX-88 (8088) microprocessors
- CP/M-86 files are completely compatible with versions of CP/M* used with Intel 8-bit 8080- and 8085-based microcomputer systems
- Supports up to 16 logical drives, each containing up to eight megabytes for a total of 128 megabytes of on-line storage
- CP/M-86 manages up to 1 Mbyte of on-line RAM storage for full support of programs as large and as powerful as those found on minicomputers
- The standard CP/M-86 package includes an assembler, an interactive debugger, and additional utilities for complete program development

CP/M-86 is a single-user operating system designed especially for 16-bit computers based on the Intel iAPX-86 (8086) and compatible iAPX-88 (8088) microprocessors. The system fully utilizes the one megabyte (1,048,576 bytes) of main memory available for application programs.

CP/M-86 occupies only 11K of memory with a floppy disk-based I/O System occupying about 1K, depending on the number of peripherals supported. The remainder of the 8086/8088 address space may be defined by the user. Flexibility is provided by the system's ability to reside anywhere in memory, and it can be relocated by the user without changing the operating system.

Because CP/M-86 files are completely compatible with CP/M for Intel 8-bit microprocessors, there is an easy upgrade of existing CP/M applications software to 16-bit iAPX-86 (8086)-based systems.

FEATURES

Major features of the CP/M-86 operating system include:

Modular Design

Based on a proven, modular design, the system includes the:

—CCP: Console Command Processor
The CCP is the human interface to the operating system and performs decoding and execution of user commands

—BDOS: Basic Disk Operating System
The BDOS is the logical, invariant portion of the operating system; it supports a named file system with a maximum of 16 logical drives, containing up to 8 megabytes each for a potential of 128 megabytes of on-line storage

—BIOS: Basic Input/Output System
The physical variant portion of the operating system, BIOS contains the system-dependent input/output device handlers

CP/M Compatibility

CP/M-86 files are completely compatible with CP/M for 8080- and 8085-based microcomputer systems. This simplifies the conversions of software developed under CP/M and allows full advantage of 16-bit 8086-based systems.

The user will notice no significant difference between CP/M and CP/M-86. Commands such as DIR, TYPE, REN, ERA, PIP, ED, and STAT respond the same way in both systems.
CP/M-86 uses the 8086 registers corresponding to 8080 registers for system call and return parameters to further simplify software transport. The execution environment in CP/M-86 allows code and data segments to overlap, making the mixture of code and data that often appears in 8-bit applications acceptable to the 8086.

**File Management**

CP/M-86 can support up to 16 logical drives, each containing up to eight megabytes, for a maximum of 128 megabytes of on-line storage. Any one file can reach the full drive size, with space dynamically allocated and released. Each device has a directory of file control blocks that map the physical location of each file on the disk. Disk definition tables in the BIOS translate this logical drive, directory, and file structure to the physical characteristics of the disk. This file system is identical to the file system of CP/M.

**Memory Management**

CP/M-86 can reside anywhere in memory and is easily located to minimize dependence on absolute addresses. Multiple programs may reside in memory simultaneously. Also, a transient program may load additional programs for execution under its own control. Up to a total of 8 programs may use non-contiguous memory areas which are managed through a user-defined memory configuration table.

**Basic I/O System (BIOS) Organization**

The distribution version of CP/M-86 is set up for operation with the Intel iSBC 86/12A and an Intel 204 diskette controller. All hardware dependencies are, however, concentrated in subroutines which are collectively referred to as the Basic I/O System, or BIOS. A CP/M-86 system implementor can modify these subroutines to tailor CP/M-86 to fit nearly any 8086 or 8088 operating environment.

To simplify the preparation of a custom BIOS, a source listing of a working BIOS, a skeleton for a custom module, and cross-development utilities are supplied. The cross-development programs allow development of custom BIOS and CP/M-86 applications software on an 8-bit CP/M system.

**PROM Loader**

For users who have the iSBC 86/12 hardware configuration, there is an optional PROM Loader. The firmware brings the CP/M-86 loader into the system and sets up the hardware to initialize CP/M-86.

**Utilities**

CP/M-86 is supplied with eight utilities:

**PIP**

The Peripheral Interchange Program provides file transfer between devices and disk files and performs various reformatting and concatenation functions. Formatting options include parity-bit removal, case conversion, Intel “hex” file validation, subfile extraction, tab expansion, line number generation, and pagination.

**ED**

The CP/M-86 Text Editor allows creation and modification of ASCII files using extensive commands: string substitution, string search, insert and delete. ED allows text to be located by context, line number, or relative position with a macro command for making extensive text changes with a single command line.

**ASM-86**

ASM-86, the CP/M-86 Assembler is an 8086 assembler using standard Intel mnemonics. It also allows users to define unique instructions with the code-macro facility. ASM-86 is supplied in two forms: an 8086 cross assembler designed to run under CP/M (an 8-bit system), and an 8086 assembler designed to run under CP/M-86.

**DDT-86**

The CP/M-86 Dynamic Debugging Tool allows the user to test and debug programs interactively in a CP/M-86 environment. The command set allows users to trace program execution with full register and status display. DDT-86 contains an integral assembler/disassembler module that lets users patch and display memory in assembler mnemonic form.

**SUBMIT**

Allows a group of CP/M-86 commands to be batched together and submitted to the operating system by a single command.

**STAT**

Lists the number of bytes of storage remaining on the currently logged disks, provides statistical information about particular files, and displays or alters device assignments.

**GENCMD and LMCMD**

GENCMD and LMCMD are used to produce CMD
memory image files suitable for execution under CP/M-86. The GENCMD utility processes Intel files, which may be produced either by Digital Research’s ASM-86 or by Intel’s OH86 utility. LMCMD processes Intel L-module files resulting from the standard Intel LOC86 Object Code Relocator Utility. These commands allow generation of new utilities.

**BENEFITS**

—Designed especially for full advantage of Intel iAPX-86/12A (8086)-based computer systems
—Complete compatibility with versions of CP/M for Intel 8080/8085-based microcomputer systems makes it easy to upgrade existing CP/M applications software to preserve software investment (see the CP/M Operating System data sheet for additional CP/M benefits)
—Cross-development tools, including the ASM-86 assembler and the GENCMD utility, can reside on a 8080/8085-based CP/M system; with these tools, the programmer can assemble a custom BIOS program and generate a loadable object file that runs on the target system
—Proven modular design occupies a small amount of memory to give maximum user-defined space for application programs in the available one-megabyte main memory.
—Allows up to 128 megabytes of on-line magnetic storage
—CP/M-86 manages up to 1 Mbyte of on-line RAM storage for full support of programs as large and as powerful as those found on minicomputers
—Allows multiple programs in memory for transient program execution; multiple programs may use non-contiguous memory areas for application programs
—ASM-86 and DDT-86 provide the basic tools for assembly language development and program debugging using the iAPX-86/12A (8086) microprocessor
—CP/M-86 is a complete system including the operating system and development tools; a comprehensive set of manuals describes system operation, customization, interfacing of applications programs, listings of sample programs, and operation of the assembler, debugger, and editor
—The CP/M-86 package includes full documentation for the product; documentation is also available separately; a CP/M-86 PROM loader is available for the Intel Single-Board Computer

**SPECIFICATIONS**

**Hardware Required**

—iSBC 86/12A
—iSBC 204
—CRT

Optional:

—up to 1 megabyte RAM
—up to 16 disk drives (8 megabytes each)

**Documentation Package**

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<td>121866</td>
<td>CP/M-86 system, program and user’s guides</td>
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**Shipping Media**

(Specify by Alpha Character when ordering.)
A—Single Density (Intellec compatible, IBM 3740/1 format)

**Order Code**

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*CP/M is a registered trademark of Digital Research, Inc.
*CP/M-86 is a trademark of Digital Research, Inc.
MICROSOFT* MACRO-80 UTILITY SOFTWARE PACKAGE

- Includes the MACRO-80 macro assembler, LINK-80 linking loader, and CREF-80 cross-reference facility
- Supports a complete, Intel-standard MACRO facility, including IRP, IRPC, REPEAT, local variables, and EXITM
- Supports conditional assembly, including testing of assembly pass, symbol definition, and parameters to MACROs
- Code is assembled in relocatable modules for easy manipulation by the LINK-80 linking loader
- Assembly rate of over 1000 lines per minute
- Provides "big computer" assembler features without sacrificing speed or memory space
- Provides a complete set of listing controls
- LINK-80 loads relocatable modules at user-specified locations
- CREF-80 cross-reference facility alphabetizes program variables and shows where each is defined and referenced

The Microsoft Utility Software Package is a complete system for developing assembly language programs, routines, and subroutines. The Utility Software Package includes the MACRO-80 macro assembler, the LINK-80 linking loader, and the CREF-80 cross-reference facility. The CP/M* version also includes the LIB-80 Library Manager.

The Utility Software Package is supplied with all Microsoft compilers to provide assembly language subroutine support to main programs in the high-level programming languages. The LINK-80 linking loader is used by all Microsoft compilers for linking and loading compiled relocatable modules. Thus, LINK-80 allows the programmer to link together relocatable modules from different Microsoft languages.

FEATURES

MACRO-80 Macro Assembler

MACRO-80 incorporates almost all "big computer" assembler features without sacrificing speed or memory space. The assembler supports a complete, Intel-standard macro facility, including IRP, IRPC, REPEAT, local variables, and EXITM. Macro names take precedence over instruction mnemonics and pseudo operations. Nesting of macros is limited only by memory. Code is assembled in relocatable modules that are easily manipulated with the flexible linking loader. Conditional assembly capability is greatly enhanced by an expanded set of conditional pseudo operations that include testing of assembly pass, symbol definition, and parameters to macros. Conditionals may be nested up to 255 levels.

More MACRO-80 features:
- Comment blocks
- Variable input radix from base 2 to base 16
- Octal or hex listings
- INCLUDE statement assembles an alternate source file into the current program
- PRINTX statement for printing assembly or diagnostic messages
- PHASE/DEPHASE statements allow code to reside in one area of memory but execute in another
- Complete set of listing controls
LINK-80 Linking Loader

With LINK-80, any number of programs may be loaded with one command, relocatable modules may be loaded in user-specified locations, and external references between modules are resolved automatically by the loader. The loader also performs library searches for system subroutines and generates a memory load map showing the locations of the main program and subroutines.

CREF-80 Cross-Reference Facility

The Cross-Reference Facility that is included with the Utility Software Package supplies a convenient alphabetic list of all program variable names, along with line numbers where they are referenced and defined.

SPECIFICATIONS

Operating Environment

MACRO-80 resides in approximately 19K bytes of memory. LINK-80 resides in approximately 14K bytes of memory. CREF-80 requires about 6K bytes. The MACRO-80 Utility Software Package is compatible with the CP/M* operating system.

Required Hardware

Intellec® Microcomputer Development System
—Model 800 or
—Series II
—minimum of 1 diskette drive

Required Software

CP/M Operating System or MP/M-II* Operating System.

Documentation Package

One copy of each manual is supplied with the software package. Additional copies are available.

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Shipping Media

(Specify by Alpha Character when ordering.)
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B—Double Density (Intellec® compatible, M²FM format)

ORDERING INFORMATION

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*Microsoft is a trademark of Microsoft, Inc.
*CP/M is a registered trademark of Digital Research, Inc.
*MP/M-II is a trademark of Digital Research, Inc.
MICROSOFT* BASIC-80 INTERPRETER
SOFTWARE PACKAGE

- Compatible with other Microsoft BASIC compilers and interpreters
- Sophisticated string handling and structured programming features for applications development
- Direct transfer of BASIC programs to the 8085, 8086 and 8088
- Random and sequential file manipulation where random file record length is user-definable
- Read or write memory location capabilities
- Meets the requirements for the ANSI subset standard for BASIC, and supports many enhancements
- Extensive text editing features built-in
- Automatic line number generation and renumbering
- Supports assembly language subroutine calls
- Trace facilities for easier debugging

BASIC Release 5.0 from Microsoft is an extensive implementation of BASIC. Microsoft BASIC gives users what they want from a BASIC—ease of use plus the features that are comparable to a minicomputer or large mainframe.

BASIC-80 meets the requirements for the ANSI subset standard for BASIC, as set forth in document BSRX3.60-1978. It supports many unique features rarely found in other BASICs.

FEATURES

- Four variable types: Integer (−32768, +32767), String (up to 255 characters), Single-Precision Floating Point (7 digits), Double-Precision Floating Point (16 digits).
- Trace facilities (TRON/TROFF) for easier debugging.
- Error trapping using the ON ERROR GOTO statement.
- PEEK and POKE statements to read or write any memory location.
- Automatic line number generation and renumbering, including reference line numbers.
- Matrices with up to 255 dimensions.
- Boolean operators OR, AND, NOT, XOR, EQV, IMP.
- Formatted output using the PRINT USING facility, including asterisk fill, floating dollar sign, scientific notation, trailing sign, and comma insertion.
- Direct access to I/O ports with the INP and OUT functions.
- Extensive program editing facilities via EDIT command and EDIT mode subcommands.
- Assembly language subroutine calls (up to 10 per program) are supported.
- IF/THEN/ELSE and nested IF/THEN/ELSE constructs.
- Supports variable-length random and sequential disk files with a complete set of file manipulation statements: OPEN, CLOSE, GET, PUT, KILL, NAME, MERGE.
### BASIC-80 Commands, Statements, Functions

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### Arithmetic Functions

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### Operators

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<td>EQV</td>
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### Input/Output Statements and Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Symbol</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
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<tr>
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### Special Functions

<table>
<thead>
<tr>
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<tr>
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<tr>
<td>ERR</td>
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<tr>
<td>PEEK</td>
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</table>

### SPECIFICATIONS

#### Operating Environment

The standard disk version of Microsoft BASIC-80 occupies 24K bytes of memory. Microsoft BASIC-80 Interpreter is compatible with the CP/M* operating system.

#### Required Hardware

Intellic Microcomputer Development System
- Model 800 or
- Series II
- Minimum of 1 diskette drive

#### Required Software

CP/M Operating System or MP/M-II* Operating System.

#### Documentation Package

One copy of each manual is supplied with the software package. Additional copies are available.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>121806</td>
<td>BASIC-80 Reference Manual</td>
</tr>
<tr>
<td>121857</td>
<td>BASIC Reference Book</td>
</tr>
</tbody>
</table>
MICROSOFT* COBOL-80
SOFTWARE PACKAGE

- GSA validation at low-intermediate level implementation of ANSI 74 requirements
- Combines the most useful Level 1 and Level 2 ANSI 74 features, making it the most extensive implementation of COBOL for microcomputers
- Interactive accept/display features allow direct interaction between data, program and operator
- Highly efficient pseudo-code compiler produces compact, fast code
- Complete utility software package, including macro assembler, linking loader, and MICROSOFT M/SORT
- Tailorable screen-formatting facilities allow configuration to any intelligent terminal for menu and forms generation
- COBOL offers four kinds of files for simplicity and speed in data retrieval

COBOL has been the language of choice for commercial data processing for over two decades, and because of its established superiority, more useful business software has been written in COBOL than in any other language. That means quality, full-function packages, many written by the field's foremost experts, are available now. Existing systems for payroll, accounts receivable, general ledger, inventory, order entry, and forecasting can run under Microsoft COBOL-80.

COBOL offers the flexibility that makes products adaptable, versatile, and available to thousands of microcomputer users. COBOL-80 not only retains the high-level features of standard COBOL, but also introduces superior interactive capabilities and user-oriented features which represent a major advance in the commercial use of COBOL. With COBOL-80, direct interaction between data, program, and operator becomes possible. The immediate acknowledgement or rejection of user-entered data facilitates equally immediate corrections and modifications.

FEATURES

COBOL-80 ANSI Standard and GSA Validated

Because COBOL is so widely used, assurances of compatibility and portability are important to all users. The American National Standards Institute has established guidelines which provide a basis for making informed comparisons of different COBOL compilers. Elements of the COBOL language are allocated to twelve different functional processing modules, at two different levels. Microsoft COBOL combines the most useful Level 1 and Level 2 features.

The United States government, through the General Services Administration (GSA), tests COBOL compilers to validate their compatibility and their implementation of the ANSI 74 standard. Microsoft COBOL for the CP/M operating system has been validated by GSA as a low-intermediate implementation of the ANSI 74 standard. Microsoft COBOL is approved for federal government installations, plus you have assurance that Microsoft COBOL will perform to specifications.

COBOL-80 supports such special features as:
- Advanced verbs: STRING, UNSTRING, COMPUTE, SEARCH, PERFORM (VARYING/UNTIL)
- Abbreviated and compound conditions
- Sequential, Relative, and Indexed files
- ASCII, packed and binary data formats
- Runtime assignment of file names
- Full COPY facility
- Line Sequential files
- Trace style debugging
- COMP-3 data format
- Program CHAIN
- Program Segmentation
- Formatted screen ACCEPT/DISPLAY with a single command
Program Structuring

COBOL’s unique suitability to the business environment is due in large part to the structuring capabilities built into the language. COBOL-80 programs have a natural, logical organization which reflects the nature of commercial data. This efficient, clean, top-down design makes COBOL-80 programs faster to write and easier to maintain than those written in other computer languages.

0000-MAIN-LINE.
PERFORM 1000-INITIALIZE.
PERFORM 2000-ENTER ORDER UNTIL END-SESSION.
IF REPORT-REQUIRED
   PERFORM 3000-PRINT SUMMARY.
PERFORM 4000-TERMINATE.
CHAIN "MAINMENU".

1000-INITIALIZE.
DISPLAY SIGN-ON-SCREEN.
ACCEPT SIGN-ON-SCREEN.
PERFORM 1100-CHECK-SECURITY-CODE.
MOVE ZERO TO ORDER-COUNT ERROR-CODE.
SESSION TOTAL.

Data Structuring

The data in COBOL programs is arranged hierarchically. Information is stored in a logical structure with direct interconnection between related pieces of data. (Note here how COBOL’s PICTURE specification allows exact decimal arithmetic for precise representation of any dollar amount.)

05 TRANSACTION
   10 TRAN-REF. PIC X(12).
   10 TRAN-DATE.
      15 TRAN-MM PIC XX.
      15 TRAN-DD PIC XX.
      15 TRAN-YY PIC XX.
   10 POST-DATE.
      15 POST-MM PIC XX.
      15 POST-DD PIC XX.
      15 POST-YY PIC XX.
   10 TRAN-AMOUNT PIC S9(8)V99.
   10 TRAN-AMOUNT PIC X(4).

Once this structure has been coded it can be stored in a file and used in any program. Only one statement is needed to retrieve it: COPY TRANSDEF.COB.

COBOL-80 obviates the need to recode every program in a system when a single definition is added or changed. Any chance of inconsistencies between programs is eliminated. At execution, each item in a COBOL-80 data structure may be referenced individually, or grouped items may be manipulated as easily. Processing code accesses the structure at any appropriate level:

MOVE JOURNAL-TRAN TO TRANSACTION.
MOVE CURRENT-DATE TO POST-DATE.
IF TRANS-AMOUNT < 0
   MOVE TRANSACTION TO CR-TRAN.
ELSE
   MOVE TRANSACTION TO DB-TRAN.

Screen Handling

COBOL’s move from the batch environment to online applications has brought a new emphasis to the interaction between the application and the terminal operator. COBOL-80 provides a SCREEN SECTION for the definition of formatted screens. Special syntax is available for cursor positioning, protected and unprotected fields, highlighting, full and partial screen erase, and for defining connections between fields defined on the screen and data source/destination fields in WORKING-STORAGE. Data entry forms, menus, reports and other screens are ACCEPTed or DISPLAYed with a single command, so coding is simple. At execution time, related data items can be keyed, viewed together, and corrected before being entered into the program.

COBOL-80’s screen handling facilities are Data General compatible, and learning to use the features is easy. Data descriptions are generally of the same form as in other sections of the Data Division. The screen section allows full screen descriptions without forcing allocation of WORKING-STORAGE space for unused portions of the screen.

On output, COBOL’s extensive formatting capabilities provide neat, precise reports with minimal effort.

Program Chaining

COBOL-80’s CHAIN verb facilitates interactive systems. Any number of separately coded applications or application segments can be reached through a main menu. These menu-driven applications which make ideal use of COBOL-80’s interactive capabilities, allow smooth transfer of control from one program to another. With CHAIN, control is transferred from the menu program to any executable module as specified at runtime. COBOL-80 programs can also CALL COBOL-80 subprograms or Microsoft FORTRAN-80 or assembly language subroutines.
File Handling

COBOL-80 aims for simplicity and speed in data retrieval. COBOL-80 offers four kinds of files, so data storage can aptly correspond to the application for which it will be used. Each file type has unique characteristics:

Sequential
The fastest possible access to test, packed, and binary data in any combination.

Line Sequential
Text data in line format. Compatible with the files generated by many text editors.

Relative
Random access by record number. Direct disk access makes relative files extremely fast, yet data can be accessed in any sequence, deleted or updated interactively, and cross-referenced by key across files.

Indexed Sequential
The most powerful data access method available from any data processing language in any environment. A field within each record is chosen as a key, and the value of this key identifies a record to be read, written, updated, or deleted.

Segmentation

COBOL-80’s program segmentation capability makes maximum use of memory when large programs are executed. Segmentation brings individual program sections into memory as they are needed. This allows execution of programs whose size may exceed machine memory by several times. Program segmentation is easily implemented by assigning a single number to each program section which indicates whether the section is to be resident in memory or overlaid during execution. Any section to be overlaid is automatically read into a preallocated section of memory during execution.

Microsoft COBOL-80 and the ANSI Standard

<table>
<thead>
<tr>
<th>Module</th>
<th>Features of Microsoft COBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleus</td>
<td>All of Level 1, plus these features of Level 2: CONDITIONS: Level 88 conditions with value series or range Use of logical AND/OR/NOT in conditions Use of algebraic relational symbols (&lt;,&gt;,=) Implied subject, or both subject and relation, in relational conditions Sign Test Nested IF statements; parentheses in conditions</td>
</tr>
</tbody>
</table>

VERBS:
Extensions to the functions of ACCEPT and DISPLAY for formatted screen handling ACCEPTance of data from DATE/DAY/TIME STRING and UNSTRING statements COMPUTE with multiple receiving fields PERFORM VARYING

IDENTIFIERS:
Mnemonic-names for ACCEPT or DISPLAY devices Procedure-names consisting of digits only Qualification of names (in Procedure Division statements only)
Utility Software Package

COBOL-80 includes the Microsoft Utility Software Package. The Utility Software Package includes the MACRO-80 macro assembler, the LINK-80 linking loader, and the CREF-80 Cross-Reference Facility. Refer to the description of the Utility Software Package for full details.

M/SORT

The COBOL-hosted version of M/SORT (M/SORT-C) is a record-sorting facility available to the programmer through the 1974 ANSI COBOL SORT/MERGE statements. For M/SORT-C, the source of the input records may be one or a set of disk files; or, records may be constructed in memory by a user-written COBOL procedure and RELEASED to M/SORT one at a time.

Similarly, the sorted output records may be automatically written to a disk file; or, records may be left in memory for processing by a user-written OUTPUT PROCEDURE within the COBOL program. M/SORT-C can load an indexed sequential file.

M/SORT-C provides for a special SORT STATUS register which can collect and return any errors encountered during a sort.

SPECIFICATIONS

Operating Environment

COBOL-80 requires about 40K bytes of user memory in addition to the operating system’s space. COBOL object programs will run on systems as small as 32K bytes.

Required Hardware

Intellec Microcomputer Development System
   —Model 800 or
   —Series II
   —minimum of 1 diskette drive

Required Software

CP/M+ Operating System or MP/M-II+ Operating System.

Documentation Package

One copy of each manual is provided with the software package. Additional copies may be ordered.

Part Number    Description
121801     COBOL-80 Reference Manual
121802     COBOL-80 User’s Guide
121797     Microsoft Utility Software Manual
121862     M/SORT Reference Manual
MICROSOFT* FORTRAN-80
SOFTWARE PACKAGE

- Full ANSI standard FORTRAN X3.9-1966 (except the complex data type)
- Provides numerous enhancements to the 1966 ANSI standard
- Compiles several hundred statements per minute in a single pass
- Optimizes the generated object code by common subexpression, elimination, peephold optimization, constant folding, and branch optimizations
- Provides diagnostic output: descriptive error messages, error summaries, and fully symbolic listings of generated machine language
- Supplies an extensive library of efficient subroutines
- Supports user-written non-standard I/O drivers for each logical unit number to interface non-standard devices to FORTRAN programs

Microsoft FORTRAN-80 brings the most popular science and engineering programming language to 8080/8085 microcomputers. FORTRAN-80 is comparable to FORTRAN compilers on large mainframes and minicomputers. The FORTRAN-80 package includes full ANSI Standard FORTRAN X3.9-1966 except the COMPLEX data type. With this compiler, users may take advantage of many applications programs already written in FORTRAN.

FEATURES

FORTRAN-80 enhances the 1966 ANSI Standard in several ways:

- Single-byte LOGICAL variables which can be used as integer quantities in the range +127 to -127.
- DO loops which use LOGICAL variables for tighter, faster execution of small loops.
- Mixed-mode arithmetic expressions.
- Hexadecimal constants.
- Hollerith (character) literals accepted.
- Logical operations on integer data. AND, OR, NOT, XOR, can be used for 8-bit, 16-bit, or 32-bit Boolean operations.
- READ/WRITE End-of-File or Error-Condition transfer. END=n and ERR=n (where n is the statement number) can be included in READ or WRITE statements to transfer control to the statement specified by n when an error or end-of-file is detected.
- ENCODE/DECODE for FORMAT operations to memory.
- IMPLICIT statement for redefining default variable types by specifying a type and a range of initial letters.
- INCLUDE statement for including commonly used subroutines, code, or declarations from another file.
- INTEGER*4 variables and constants using 32 bits in the range of +2,147,483,647 to -2,147,483,648.
- Support for CP/M* version 2.x providing access to a maximum of 65,535 random records in a file as large as 8 megabytes.
COMPILER DESCRIPTION

FORTRAN-80 compiles several hundred statements per minute in a single pass. It requires no more than 27K bytes of memory to compile most programs. Additional memory, when available, is used for symbol table storage and optimizations. Compiled programs are relocatable modules that are linked and loaded at runtime.

The FORTRAN-80 compiler optimizes generated object code in several ways:

- **Common Subexpression Elimination**
  Common subexpressions are evaluated once; the value is automatically substituted in subsequent occurrences of the subexpression.

- **Peephole Optimization**
  In special cases, small sections of code can be replaced by more compact code. Example: I=I+1 uses an INX H instruction instead of a DAD.

- **Constant Folding**
  Integer constant expressions are evaluated at compile time.

- **Branch Optimizations**
  The number of conditional jumps in arithmetic and logical IFs is minimized.

The compiler also provides diagnostic output. Descriptive error messages include the preceding twenty characters. At program's end, the compiler generates an error summary. A fully symbolic listing of the generated machine language is also produced. This is supplemented by tables of addresses assigned to labels, variables, and constants.

Subroutine Library

FORTRAN-80 supplies an extensive library of efficient subroutines. Only the necessary subroutines are loaded by the linker at load time. The FORTRAN library includes the following Intrinsic Functions:

- ABS
- DATAN
- DSIN
- MAX1
- AINT
- DATAN2
- DSORT
- MIN0
- ALOG
- DBLE
- EXP
- MIN1
- ALOG10
- DCOS
- FIX
- MOD
- AMAX0
- DEXP
- FLOAT
- OUT
- AMAX1
- DIM
- IABS
- PEEK
- AMIN0
- DLOG
- DIM
- POKE
- AMIN1
- DLOG10
- DIINT
- SIGN
- AMOD
- DMAX1
- INP
- SIN
- ATAN
-DMIN1
- INT
- SNGL
- ATAN2
- DMOD
- ISIGN
- SQRT
- COS
- DSIGN
- MAX0
- TANH
- DABS

The library also contains efficient routines for 16-bit and 32-bit integer arithmetic and 32-bit and 64-bit floating point arithmetic.

Utility Software Package

The FORTRAN-80 package includes the Microsoft Utility Software Package. The Utility Software Package includes the MACRO-80 macro assembler, the LINK-80 linking loader, and the CREF-80 Cross-Reference Facility. Refer to the description of the Microsoft Utility Software Package for full details.

Custom I/O Drivers

Users may write non-standard I/O drivers for each Logical Unit Number, so interfacing non-standard devices to FORTRAN programs is straightforward.

SPECIFICATIONS

Operating Environment

The FORTRAN-80 compiler occupies approximately 24K bytes of memory, using the CP/M operating system. Most programs can be compiled within 27K bytes of additional memory. At link time, the LINK-80 linking loader occupies about 14K bytes. The Runtime Library requires 2K-14K bytes, depending on the type of program being run.

Required Hardware

Intellec Microcomputer Development System
- Model 800 or
- Series II
- minimum of 1 diskette drive

Required Software

CP/M* Operating System or MP/M-II* Operating System.
MICROSOFT* BASIC-86 INTERPRETER
SOFTWARE PACKAGE

- Compatible with other Microsoft BASIC compilers and interpreters
- Sophisticated string handling and structured programming features for applications development
- Direct transfer of BASIC programs to the 8080, 8085 and 8088
- Random and sequential file manipulation where random file record length is user-definable
- Read or write memory location capabilities
- Meets the requirements for the ANSI subset standard for BASIC, and supports many enhancements
- Extensive text editing features built-in
- Automatic line number generation and renumbering
- Supports assembly language subroutine calls
- Trace facilities for easier debugging

BASIC Release 5.0 from Microsoft is an extensive implementation of BASIC. Microsoft BASIC gives users what they want from a BASIC—ease of use plus the features that are comparable to a minicomputer or large mainframe.

BASIC-86 meets the requirements for the ANSI subset standard for BASIC, as set forth in document BSRX3.60-1978. It supports many unique features rarely found in other BASICS.

FEATURES

- Four variable types: Integer (−32768, +32767), String (up to 255 characters), Single-Precision Floating Point (7 digits), Double-Precision Floating Point (16 digits).
- Trace facilities (TRON/TROFF) for easier debugging.
- Error trapping using the ON ERROR GOTO statement.
- PEEK and POKE statements to read or write any memory location.
- Automatic line number generation and renumbering, including referenced line numbers.
- Matrices with up to 255 dimensions.
- Boolean operators OR, AND, NOT, XOR, EQV, IMP.
- Formatted output using the PRINT USING facility, including asterisk fill, floating dollar sign, scientific notation, trailing sign, and comma insertion.
- Direct access to I/O ports with the INP and OUT functions.
- Extensive program editing facilities via EDIT command and EDIT mode subcommands.
- Assembly language subroutine calls (up to 10 per program) are supported.
- IF/THEN/ELSE and nested IF/THEN/ELSE constructs.
- Supports variable-length random and sequential disk files with a complete set of file manipulation statements: OPEN, CLOSE, GET, PUT, KILL, NAME, MERGE.
### BASIC-86 Commands, Statements, Functions

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTO</td>
<td>RENUM</td>
<td>NAME</td>
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<tr>
<td>LIST</td>
<td>WIDTH</td>
<td>SAVE</td>
</tr>
<tr>
<td>NULL</td>
<td>CONT</td>
<td>EDIT</td>
</tr>
<tr>
<td>TROFF</td>
<td>MERGE</td>
<td>NEW</td>
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<tr>
<td>CLEAR</td>
<td>RUN</td>
<td>TRON</td>
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<tr>
<td>LOAD</td>
<td>DELETE</td>
<td></td>
</tr>
</tbody>
</table>

### Program Statements

- CALL
- RANDOMIZE
- RETURN
- GOSUB
- COMMON
- WAIT
- END
- DEF FN
- ON GOSUB
- GOTO
- ERROR
- DIM
- STOP
- POKE
- FOR/NEXT/
- WHILE/
- RESUME
- STEP
- WEND
- SWAP
- IF/THEN/
- CHAIN
- DEFDBL
- ELSE
- DEF USR
- DEFSTR
- ON ERROR
- LET
- DEFSNG
- GOTO
- REM
- DEFIINT
- OPTION BASE

### Input/Output Statements and Functions

- CLOSE
- GET
- NAME
- KILL
- POS
- PUT
- OUT
- FIELD
- EOF
- RESTORE
- LSET/RSET
- SPC
- READ
- PRINT
- INKEY$
- TAB
- USING
- INPUT
- DATA
- LOC
- OPEN
- LINE
- MKI$
- CVD
- INPUT
- MKS$
- CVI
- PRINT
- MKD$
- CVS
- WRITE
- LLIST
- LPRINT
- LPOS

### Arithmetic Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Function</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>SIN</td>
<td>LOG</td>
</tr>
<tr>
<td>INT</td>
<td>CDBL</td>
<td>FIX</td>
</tr>
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<td>SGN</td>
<td>CSNG</td>
<td>COS</td>
</tr>
<tr>
<td>ATN</td>
<td>CINT</td>
<td>RND</td>
</tr>
<tr>
<td>EXP</td>
<td>SQRT</td>
<td>TAN</td>
</tr>
</tbody>
</table>

### String Functions

- ASC
- STR$
- INSTR
- LEN
- HEX$
- RIGHT$
- STR$
- OCT$
- MIDS
- CHR$
- VAL
- SPACE$
- LEFT$

### Operators

- =
- *
- XOR
- $\wedge$
- $\leq$
- NOT
- $\geq$
- EQV
- $\approx$
- MOD
- $\\sim$
- IMP
- $\div$
- OR
- $\div$
- AND

### Special Functions

- ERL
- ERR
- VARPTR
- USR
- FRE
- PEEK

### SPECIFICATIONS

#### Operating Environment

The standard disk version of Microsoft BASIC-86 occupies 32K bytes of memory. Microsoft BASIC-86 Interpreter is compatible with the CP/M-86 operating system.

#### Required Hardware

Microsoft* BASIC-86 Interpreter will operate with any currently supported configuration of CP/M-86 or MP/M-86.

#### Required Software

CP/M-86* Operating System or MP/M-86* Operating System.

#### Documentation Package

One copy of each manual is provided with the software package. Additional copies are available.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>121810</td>
<td>BASIC-86 Reference Manual</td>
</tr>
<tr>
<td>121857</td>
<td>BASIC Reference Book</td>
</tr>
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</table>

24-18
Shipping Media

(Please specify by Alpha Character when ordering.)

A—Single Density (Intellec compatible, IBM 3740/1 format)

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Order Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD203CPM86A</td>
<td>Microsoft BASIC-86 Interpreter Software Package, CP/M-86 version (Single-Density Diskette)</td>
</tr>
</tbody>
</table>

An Intel Master Software License and Amendment required.

*Microsoft is a trademark of Microsoft, Inc.*

*CP/M-86 is a registered trademark of Digital Research, Inc.*

*MP/M-86 is a trademark of Digital Research, Inc.*
JOVIAL-86
CROSS-COMPILER

- IBM 370 or DEC*10 host
- Full MIL-STD-1589B language implementation
- Extensively optimized object code
- Supports IEEE floating-point math with 8087 coprocessor
- Functional simulation capability on the host
- RAM/ROM separation of constants and code supported
- Object compatible and linkable with Intel's languages for 8086/8088
- Generates source symbols, lines and type information for debugging with ICE-86A
- Type-checking of parameters between modules optionally enforced by the timer
- Choice of silicon or software implementation for floating point
- Supports 1 MB of code space

JOVIAL was developed in the late 1950s by Jules Schwartz and colleagues to aid in programming large complex realtime systems. The language was adopted by the U.S. Air Force in 1967 and its use is now required for programming of all embedded avionics systems.

Intel's JOVIAL Compiler implements the latest published standard of this language MIL-STD-1589B for the iAPX 86/20 microprocessor. Intel's implementation of J73 offers a complete solution for programming applications in JOVIAL from compiling modules on the mainframe to downloading software to Intel's Series III development system where a host of JOVIAL-86-compatible languages, relocation and linkage software, symbolic debugger and an in-circuit emulator (ICE-86A) are available.

FEATURES

JOVIAL language was designed for programming large complex realtime systems. The language is a derivative of Algol and has borrowed compound statement and control structures from it. JOVIAL supports fixed and floating-point, signed and unsigned integers, strings, tables and status items (enumerated type) and permits items to be any length from 1 bit to 256 bytes. The language provides access to almost any configuration of logical or arithmetic values including packed structures of flexible description. The communication pool (COMPOOL) permits sharing of system data among many subprograms by providing a centralized data and procedure description which enforces uniform usage and simplifies centralized configuration management of a JOVIAL system data base.

JOVIAL COMPILER DESCRIPTION

The JOVIAL compiler operates in multiple passes. The front-end phase analyzes the input program and translates it into an intermediate language. The global optimizer phase analyzes the intermediate code and applies extensive optimizations such as constant and value folding, multiply distribution and operator reassociation for efficient address calculation, compile time short-cut booleans, unreachable code deletion, and unnecessary store suppression. The code generator phase generates relocatable object code from this intermediate code. Other functions in the final phase are responsible for generating deficient listings and COMPOOL output.

The compiler supports development of complex and large applications by providing a comprehensive cross-reference listing that identifies the statement number where the variable is set. The compiler can also generate a statistical listing showing the distribution of various symbol table classes and intermediate language operators. The assembly language output listing displays the object program in assembly mnemonics. And optionally, the compiler can produce a reformatted source program.
PROGRAM DEVELOPMENT PROCESS

The JOVIAL source programs may be developed and maintained on the mainframe IBM 370 or DEC-10, or alternately, the source programs may be created and maintained on the Intellec Series III Microcomputer Development System, sent to the mainframe for compilation and brought back to the Series III for further processing. The ONLINE utility allows the Series III to act as a terminal to the mainframe to edit and examine files, etc. The transfer of source and object files between the mainframe and the Series III is accomplished with either the 2780/3780 emulator or the upload/download software on Series III.

The object code produced by the compiler is in Intel's standard object module format and is, therefore, compatible with the standard Series III utilities like LINK86, LOC86, LIB86 and OH86. The compatibility with subprograms written in PASCAL86, FORTRAN86, ASM86 and PL/M-86 is assured by following Intel's standard parameter passing and register usage conventions. The compiler generates source program symbols, lines and type information in the object code to allow symbolic debugging with the Series III debugger and in-circuit emulator.

The compiler generates 8087 instructions for floating-point operations. In the absence of the 8087 processor, the 8087 emulator software may be linked with the JOVIAL program to execute the floating-point instructions.

SPECIFICATIONS

Operating Environment

Intel's JOVIAL compiler runs under MVS on IBM 370 and requires a 500 Kb partition. The DEC-10 version runs under TOPS-10 operating system and requires 75K words.

Required Hardware

— Intellec Series III Microcomputer Development System
— Necessary Modems and Cables for Serial Link

Required Software

— Series III Operating System
— iAPX86 Family Utilities

Optional Software

— Mainframe Link (2780/3780 Emulator)
— 8086/8087/8088 Relocatable Assembler

Documentation Package

One copy of each manual is provided with the software package. Additional copies may be ordered.

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>121886</td>
<td>JOVIAL Language Specification</td>
</tr>
<tr>
<td>121887</td>
<td>JOVIAL-86 User's Guide</td>
</tr>
</tbody>
</table>

Shipping Media

One (1) Phase encoded, 1600 B.P.S. Magnetic Tape
One (1) Single-density Diskette (Intellec Compatible)
One (1) Double-density Diskette (Intellec Compatible)

ORDERING INFORMATION

Order Code Description

Availability: Second Quarter 1982

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