Table 11. Advanced 8-Bit Microcontrollers

Feature	8051AH	80C51BH	8751H	8031AH	80C31BH	8052AH	8032AH	8044H‡
Program Memory (Bytes)	4K	4K	4K EPROM	—	—	8K	—	4K
RAM Memory (Bytes)	128	128	128	128	128	256	256	192
Program Memory Expansion (Off Chip) (Bytes)	64K	64K	64K	64K	64K	64K	64K	64K
Data Memory Expansion (Off Chip) (Bytes)	64K	64K	64K	64K	64K	64K	64K	64K
Max. Clock Frequency (MHz)	12	12	12	12	12	12	12	12
Typical Instruction Time (μs)	1	1	1	1	1	1	1	1
16-Bit Timer/Counters	2	2	2	2	2	3	3	2
Serial Communications	Synchronous Mode Asynchronous Modes, 9 or 10-Bit Programmable							HDLC/SDLC
No. of I/O Lines	32	32	32	16	16	32	16	32
Interrupt Sources (Two Priority Levels)	5	5	5	5	5	6	6	5
Power Requirements (ICC MAX mA)	125	24	250	125	24	175	175	200
Programmable Power Modes Idle Power Down	—	4.0 mA 50 μA	—	—	4.0 mA 50 μA	—	—	— 30 mA
Development Support	See Development Systems, Page 64, and Software, Page 72.							

*Products designated with a "C" (i.e., 80C51BH) are CHMOS devices.
‡For details refer to Page 52, Table 26.

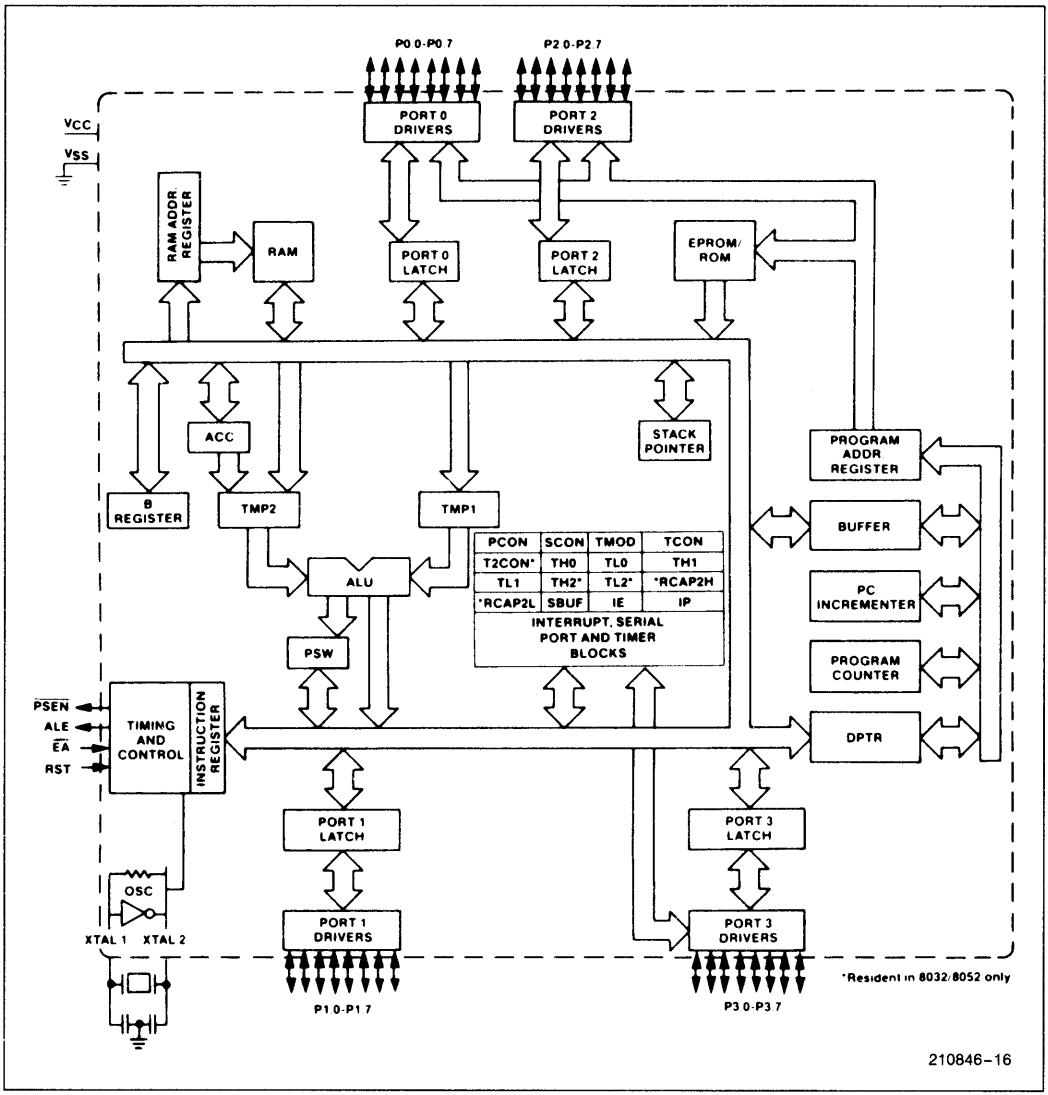
ADVANCED 16-BIT MICROCONTROLLERS

Intel's MCS-96 family is based on the state-of-the-art 8096 device. This 16-bit microcontroller offers the highest level of systems integration ever achieved on a single chip controller. The 8096 provides board level performance through a wide range of sophisticated I/O facilities and peripherals integrated onto the same piece of silicon with a powerful 16-bit CPU. The integration of these subsystems offers a single chip solution to many control problems which have previously required multiple chip solutions. Development support includes high-level language support, assembler support and emulation hardware support. The list of main features includes:

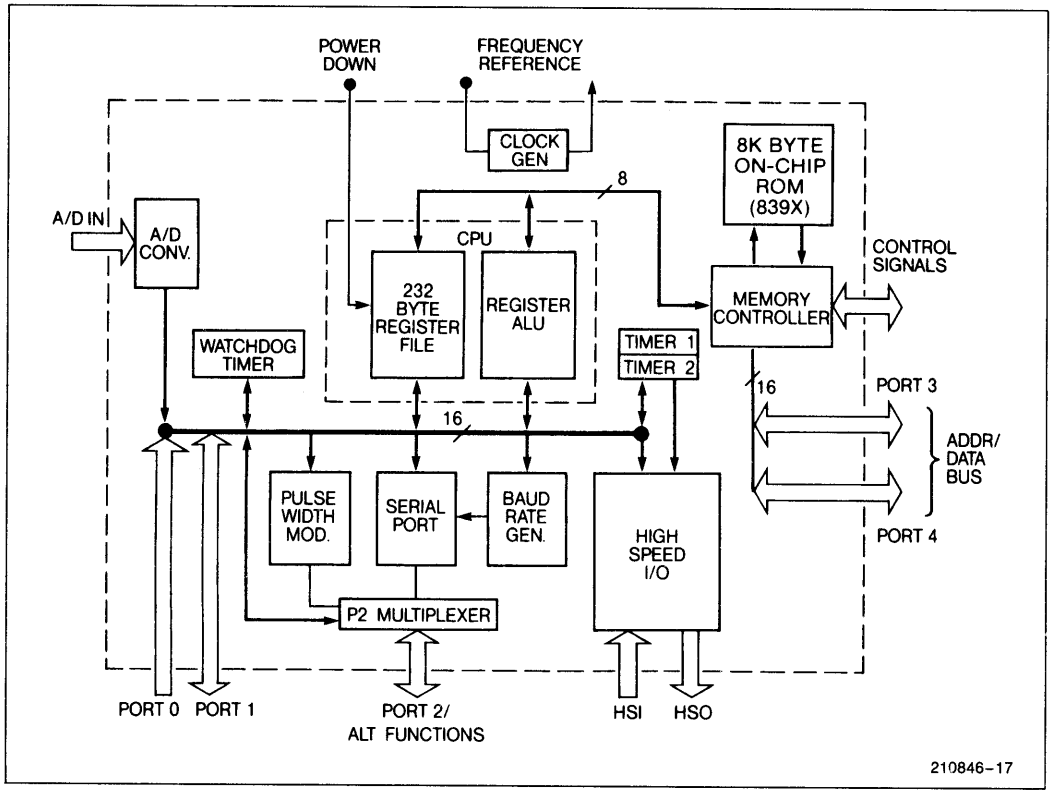
- 16-Bit CPU
- 8K Byte Mask Programmable ROM
- 256K Bytes RAM (24 Bytes Special Function)
- 16-Bit Timer/Event Counters
- High Speed Inputs/Outputs
- Pulse Width Modulated Output
- 10-bit A/D Converter (8 Channels)
- 40 Digital I/O Lines
- Watch Dog Timer
- Full Duplex Serial Port
- Flexible, 8 Source Interrupt System
- 16-Bit Multiplexed Bus

ADVANCED 8-BIT MICROCONTROLLERS

Intel's MSC-51 family is the industry standard for 8-bit high performance microcontrollers. The family architecture is optimized for control oriented and real-time processing applications. They are available in several versions—with on-board ROM, on-board EPROM, and CPU only to better fit your specific application needs. MCS-51 products are available either on Intel's advanced HMOS or CHMOS III processes offering higher performance and reliability while consuming less power.



MCS®-51 Block Diagram



MCS®-96 Block Diagram

Table 12. Advanced 16-Bit Microcontrollers

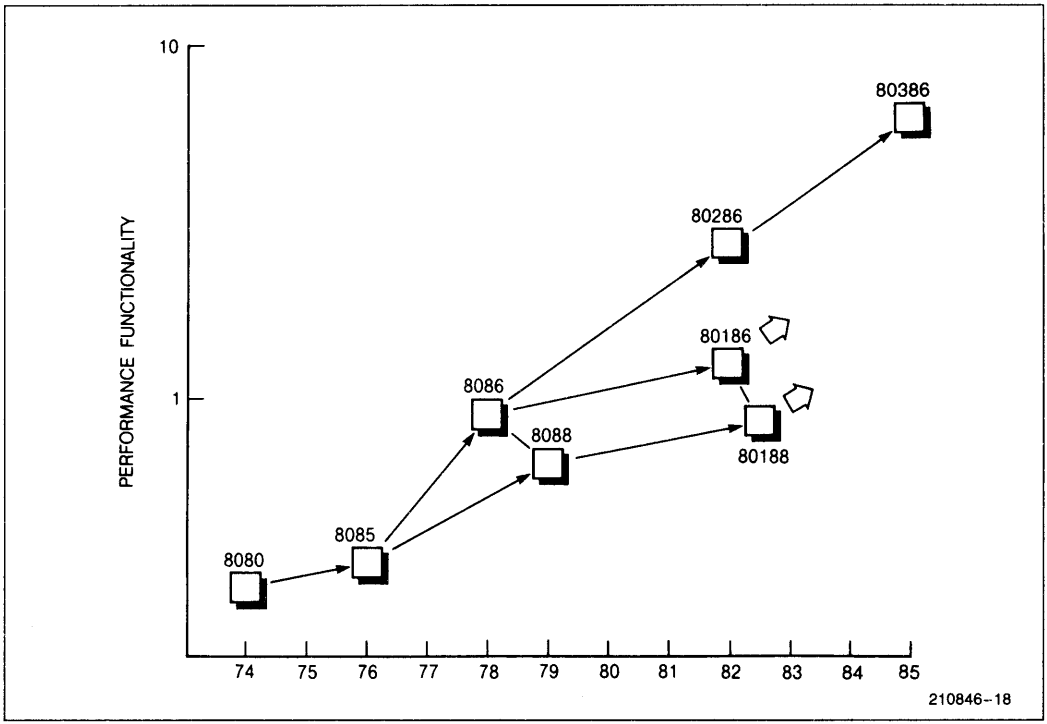
Features	8095	8097	8395	8397	8094	8096	8394	8396
Program Memory	—	—	8K	8K	—	—	8K	8K
Digital I/O	29	40	29	40	33	48	33	48
Analog I/C Inputs	4	8	4	8	—	—	—	—
Package	48 Pin Dip	68 Pin Flatpack/ Pin Grid Array	48 Pin Dip	68 Pin Flatpack/ Pin Grid Array	48 Pin Dip	68 Pin Flatpack/ Pin Grid Array	48 Pin Dip	68 Pin Flatpack/ Pin Grid Array

AUTOMOTIVE-DIRECTED COMPONENTS

This Automotive-Directed product line takes Intel's commitment to Microcontroller and Memory technologies one step closer to the needs of the automotive customer. Microcontrollers and Memories characterized in their respective sections in this Product Guide are available with automotive temperature ranges, special packaging, customer-defined features, and customized testing. Success depends on a close partnership from design concept, through prototyping, and finally production. For details, contact your local Intel Sales Office.

MICROPROCESSORS

The Intel 8-bit microprocessor product line consists of the original 8080, 8085, the industry standard 8088, 80C88 and the highly integrated 80188 microprocessors. Our 16-bit microprocessor line consists of the industry standard 8086 and 80C86, the cost-effective, highly integrated 80186 and the powerful 80286 microprocessor with advanced multi-tasking and memory management capabilities. Our newest addition, the 80386 32-bit high performance CHMOS microprocessor offers such capabilities as demand paging, on-chip MMU and multi-tasking support.



Microprocessor Families

8080/8085 8-BIT MICROPROCESSORS

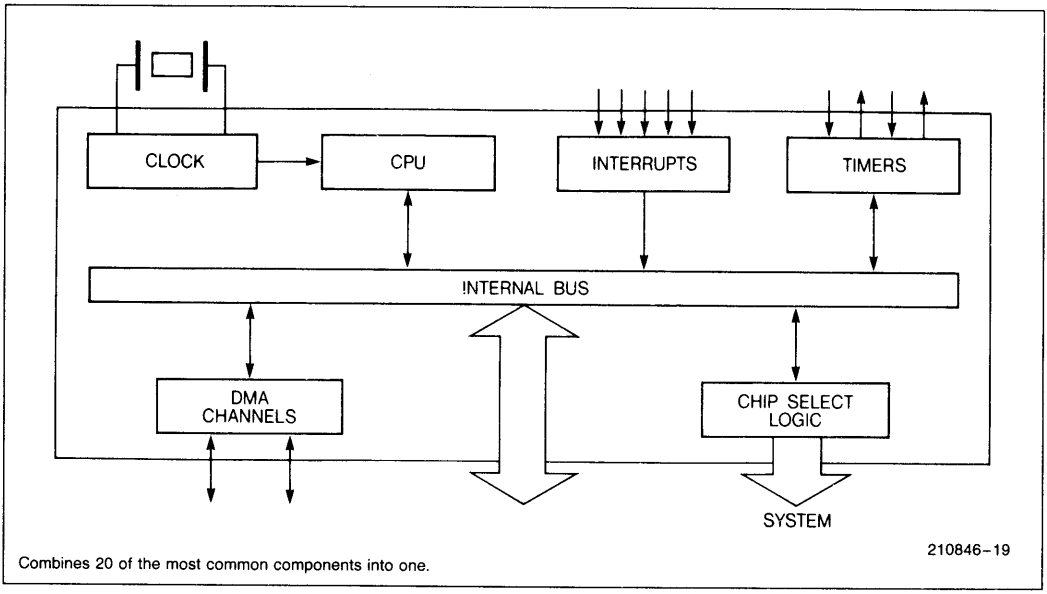
The 8080/8085 product line is the industry standard for first generation 8-bit computing with five second sources and a 9-year track record of production and availability. The 8085A has kept up with advances in silicon technology and is now manufactured as the 8085AH on Intel's state-of-the-art HMOS process.

8086/8088 (CHMOS and HMOS)

The 8086/8088 includes the 8086/80C86 (16-bit bus) and the 8088/80C88 (8-bit bus) CPUs plus a complete set of supporting devices. Because the 8086 and the 8088 share the same 16-bit internal architecture, they are completely software-compatible and can use the same support components. This allows complete and full migration of software from 8- to 16-bit, and 16- to 8-bit systems. The 8086/8088 have achieved industry standard status with a 5-year track record of production and availability and numerous second sources. This family is fully compatible with Intel's complete line of coprocessors, a unique set of VLSI devices that allow system level architecture and performance customization. The 8086/8088 is also available in low-power CHMOS type.

80186/80188

The Intel 80186/80188 are highly integrated 16/8-bit microprocessors. The 80186/80188 effectively combine 15 to 20 of the most common 8086/8088 system components onto one device. The 80186/80188 8 MHz provide two times greater throughput than the standard 5 MHz 8086/8088. The 80186/80188 are upward compatible with 8086 and 8088 software and add 10 new instruction types to the existing set.

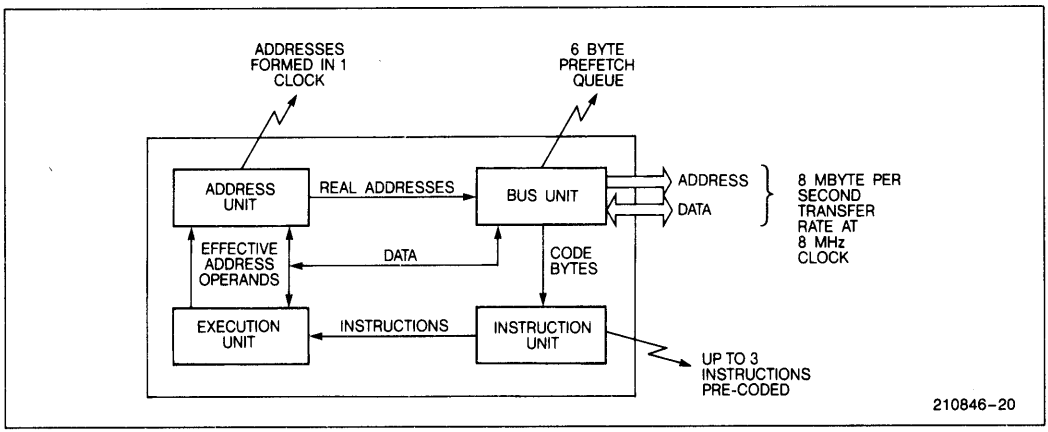


80186/80188 Block Diagram
A CPU Board On a Single Silicon Chip

These highly integrated microprocessors offer significantly higher system reliability, save board space and provide cost effective solutions for very cost sensitive applications. They share the same coprocessor family as the 8086 and 8088.

80286

The 80286 CPU is an advanced high performance 16-bit microprocessor with on-chip memory management and protection and hardware support for multiuser, multitasking systems. The pipelined architecture of the 80286, an 8 Mb/sec bus and a 3.5 μs interrupt response time, at a clock frequency of 8 MHz gives it six times the performance of a standard 5 MHz 8086. The on-chip memory management and protection scheme is flexible, sophisticated and easy to use. It supports virtual memory of up to 1000 M Bytes/user. The four-level protection model provides task/task and user/operating system protection. The 80286 is also upward compatible with 8086/8088 and the 80186/80188 and has a numeric processor extension (80287) that is compatible with the 8087 and an advanced DMA controller, 82258 (ADMA) for I/O processing.



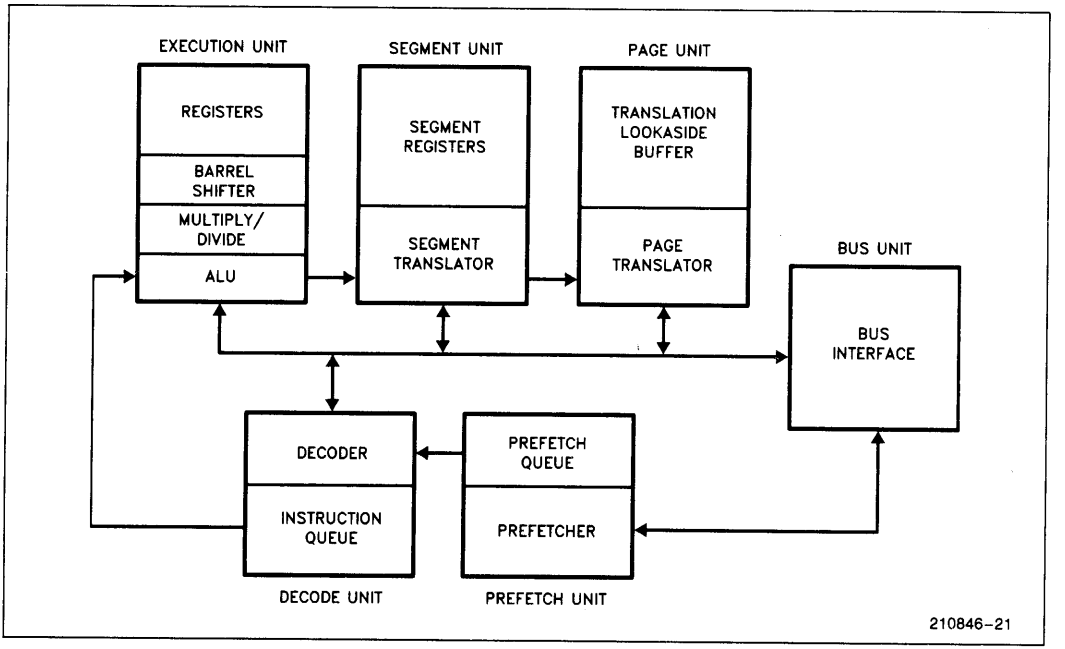
80286 Pipelined Microarchitecture

The 80286 is binary compatible with the 8086/8088, 80186/80188 to allow simple migration of the large base of software for those machines to the 80286. The 80286 also has its own complete line of coprocessors for system architecture and performance optimization.

80386

The 80386 is an advanced 32-bit microprocessor designed for applications needing very high performance and optimized for multi-tasking operating systems. The 32-bit registers and data paths support 32-bit addresses and data types. The processor addresses up to four gigabytes of physical memory and 64 terabytes (2^{46}) of virtual memory. The integrated memory management and protection architecture includes address translation registers, advanced multitasking hardware and a protection mechanism to support operating systems. In addition, the 80386 allows the simultaneous running of multiple operating systems.

Instruction pipelining, on-chip address translation, and a high bus bandwidth ensure short average instruction execution times and high system throughput. The 80386 processor is capable of execution at sustained rates of between 3 and 4 million instructions per second.



80386 Pipelined Microarchitecture

Object-code compatibility with all 8086 family members (8086, 8088, 80186, 80188, 80286) means the 80386 offers immediate access to the world's largest microprocessor software base. Of special interest is the 80386's unique virtual machine capabilities which allows direct execution of 8086 family software under new 32-bit operating systems.

The 80386 offers new testability and debugging features. Testability features include a self-test and direct access to the page translation cache. Four new breakpoint registers allow conditional or unconditional breakpoint traps on code execution or data accesses, for powerful debugging of even ROM-based systems.

Table 13. Microprocessors

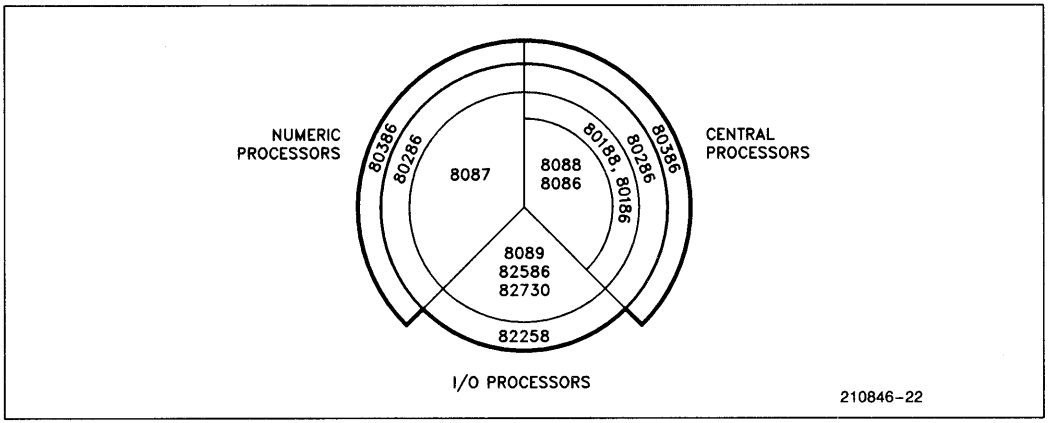
Features		Microprocessors							
		8080A (MCS-80)	8085AH (MCS-85)	8086/80C86	8088/80C88	80186	80188	80286	80386
A. ARCHITECTURE									
Bus Interface (Bits)		8	8	16	8	16	8	16	32
Internal Data Path (Bits)		8	8	16	16	16	16	16	32
Clock Frequency (Speed Selection)		2, 2.6, 3 MHz	3, 5, 6 MHz	5, 8, 10 MHz	5, 8 MHz	8, 10, 12.5 MHz	8, 10 MHz	6, 8, 10, 12.5 MHz	12.5, 16 MHz
Bus Band Width (Max)		0.75M bytes/s	1.5M bytes/s	5M bytes/s	2M bytes/s	6.25M bytes/s	3.12M bytes/s	12.5M bytes/s	32M bytes/s
Register to Register (Min) Add Time (μs/data word)		1.3 μs	0.67 μs	0.3 μs	0.38 μs	0.2 μs	0.3 μs	0.125 μs	0.125 μs/ dataword
Interrupt Response Time (min)		7.3 μs	2 μs	6.1 μs	8.6 μs	3.36 μs	6.2 μs	2.5 μs	3.5 μs
Memory Addressability		64 KB	64 KB	1 MB	1 MB	1 MB	1 MB	16 mB	4 Gigabyte
Virtual Memory		No	No	No	No	No	No	Yes 1G byte/task	Yes 64 Terabyte /task
On-Chip Memory Management and Protection		No	No	No	No	No	No	Yes	Yes w/demand paging
I/O Addressability		256 Bytes	256 Bytes	64 KB	64 KB	64 KB	64 KB	64 KB	64 KB
Addressing Modes		5	5	24	24	24	24	24	28
Coprocessor Interface		No	No	Yes	Yes	Yes	Yes	Yes	Yes
No. of Registers	Arithmetic	1	1	8	8	8	8	8	8
	Index	1	1	4	4	4	4	4	8
	Segment	0	0	4	4	4	4	4	6
	General Purpose	6	6	8	8	8	8	8	8
Code Compatibility		8080A Code		8086 Code					8086/80286

Table 13. Microprocessors (Continued)

Features	Microprocessors								
	8080A (MCS-80)	**8085AH (MCS-85)**	**8086/80C86**	**8088/80C88**	**80186**	**80188**	**80286**	**80386**	
B. SOFTWARE SUPPORT									
High Languages	See Software Section								
Operating Systems	See Software Section								
C. DEVELOPMENT SUPPORT: See Development Systems and Software Section									
D. KEY PERIPHERAL SUPPORT CHIPS: See Peripherals Section, Page 41									
Clock Generator	8224	On-Chip	8284A	8284A	On-Chip	On-Chip	82284	82384	
System Controller	8228	On-Chip	8288	8288	On-Chip	On-Chip	82288	TTL or PAL	
Interrupt Controller	8259A	8259A	8259A	8259A	On-Chip	On-Chip	8259A	8259A	
DMA Controller	8257	8237A	82258	8237/ 82258	On-Chip/ 82258	On-Chip 82258	82258	82258	
Timer-Counters	8253	8253/8254	8253/8254	8253/8254	On-Chip	On-Chip	8253/8254	8253/8254	
Data Bus Transceiver	8216/8226	8286/8287	8286/8287	8286/8287	On-Chip	On-Chip	8286/8287	8286/8287	
DRAM/Controller	8203/82C03	8203/82C03	8207/8208	8207/8208	8207/8208	8207/8208	8207/8208	PAL	
Chip Select/Wait State Logic	TTL	TTL	TTL	TTL	On-Chip	On-Chip	TTL	TTL or PAL	
Math Processor			8087	8087	8087	8087	80287	80287 or 80387	
E. GENERAL									
Package	Pins	40	40	40	40	68	68	68	PINS 132
	Type	DIP (P&D)	DIP (P&D)	DIP (P&D)	DIP (P&D)	LCC (Leadless) PLCC (Leaded) PGA	LCC (Leadless) PLCC (Leaded) PGA	LCC (Leadless) PGA	Type PGA
Power Supply		±5V, 12V	5V	5V	5V	5V	5V	5V	5V
Military/Express	See Military and Express Sections								

COPROCESSING—A NEW ARCHITECTURAL CONCEPT

The 8086 family brought with it a new architectural concept called "coprocessing". Basically, the task to be handled is partitioned into functional areas such as central processing, I/O processing and numerics support. For each functional area there is a device that extends the CPU's register and instruction sets. In this way, the cost of the specialized hardware is incurred only when required, and the chip-set is optimized for specific applications.



Processing—Function Partitioning

For numeric intensive applications, the 8087, 80287 and 80387 numeric coprocessors extend the base architecture by adding 8 eighty-bit registers and about 70 instructions. By executing floating point routines in hardware, performance is improved up to 100X. Eighty-bit precision maximizes accuracy while conforming to the proposed IEEE standard for floating point execution.

I/O intensive applications are supported by the 82258 (ADMA). This device enhances system performance by taking I/O load off the CPU. The 82258 is a 16-bit, high speed (8M Byte/sec transfer rate in 8 MHz 80286 systems) DMA as processor with on-chip bus interface for the whole 8086 architecture (8086/88, 80186/188, 80286, 80386). Four independently programmable channels, including a multiplex or channel supporting 32 subchannels, can handle a large number of I/O devices.

The 82586 LAN Coprocessor is an I/O coprocessor that concurrently processes the ISO open system interconnect model levels 1 and 2 for local area networks with various topologies, framing techniques, contention detection schemes and carrier methods.

The 82730 Text Coprocessor is an I/O coprocessor that concurrently processes text manipulation tasks. It interprets pointer table linked list data structures, allowing high resolution text displays to modified "instantaneously" without loading the microprocessor. Display formats are very flexible, allowing system designers to program displays to satisfy their unique requirements.

Table 14. Numeric Processors

Device Number	Function	Description	CPU	Speed	Package Type/ No. of Pins
8087	Numeric Processing	Performs arithmetic, logical and transcendental operations on 32-, 64-, 80-bit floating point operands, 32- and 64-bit integers and 18-digit BCD operands to greatly enhance speed of system. Floating point operations are approximately 100x faster than equivalent CPU/software routines. Accuracy is extended to 80 bits. Meets proposed IEEE standard (#754).	8086/8088 80186/ 80188	With 5 MHz clock 14/18 μs 32 Bit Multiply: 19 μs 64 Bit Multiply: 27 μs Divide 39 μs With 8 MHz clock 32 Bit Multiply: 11.9 μs 64 Bit Multiply: 16.9 μs	Ceramic 40
80287	Numeric Processing	Performs arithmetic, logical and transcendental operations on 32-, 64-, 80-bit floating point operands, 32- and 64-bit integers and 18-digit BCD operands to greatly enhance speed of system. Floating point operations are approximately 100x faster than equivalent CPU/software routines. Accuracy is extended to 80 bits. Meets proposed IEEE standard (#754). Has an asynchronous interface to the 80286 which allows the 80286 and 80287 to operate at different speeds in a system.	80286 80386	With 5 MHz clock 14/18 μs 32 Bit Multiply: 19 μs 64 Bit Multiply: 27 μs Divide 39 μs With 8 MHz clock 32 Bit Multiply: 11.9 μs 64 Bit Multiply: 16.9 μs	Ceramic 40
80387	Numeric Processing	Supports all operations of the 80287 plus additional functions such as simultaneous sine and cosine. Overall performance is 4 to 6 times 80287's (5 MHz).	80386	12.5 MHz and 16 MHz	68 Pin PGA

Table 15. I/O Processors

Device Number	Function	Description	CPU	Speed	Package Type/ No. of Pins
82586	Local Area Network Coprocessor	Implements Ethernett and IEEE 802.3 specifications, manages transmission/reception processes w/o CPU intervention including command and data buffer chaining network management and diagnostic functions.	8085AH 8086/8088 80186/80188	8 MHz	CC/48
82730	Text Coprocessor	Provides high quality text display, proportional spacing, superscript/ subscript, etc. High performance text manipulation-onboard DMA, high-level commands and table driven linked list data structure. Programmable bus interface—8 or 16 bit data and 16 or 32 bit addressing. Flexible display formats programmable at screen and row level. Simultaneous display of independent data bases.	ALL	8 MHz-Bus 10 MHz-Character	C/68
82258	Advanced DMA Processor	16 bit, 4 channel DMA controller with on-chip bus interface for the whole 8086 architecture (8086/ 8088, 80186/80188, 80286 and 80386). Provides high speed DMA transfers. Increases system performance because of its I/O processing capabilities through command and data chaining. Large number of medium to slow speed devices can be handled by the multiplex or channel supporting 32 subchannels. Data manipulation is done through "On the Fly" compare, translate and assembly/disassembly operations. Remote mode of operation allows modular designs.	8086/88 80186/188 80286 80386	8M Byte/sec in 8 MHz 80286 systems 4 MByte/sec in 8 MHz 8086/80186 systems. 16 MByte/sec in 80386 systems	LCC/68

PERIPHERALS

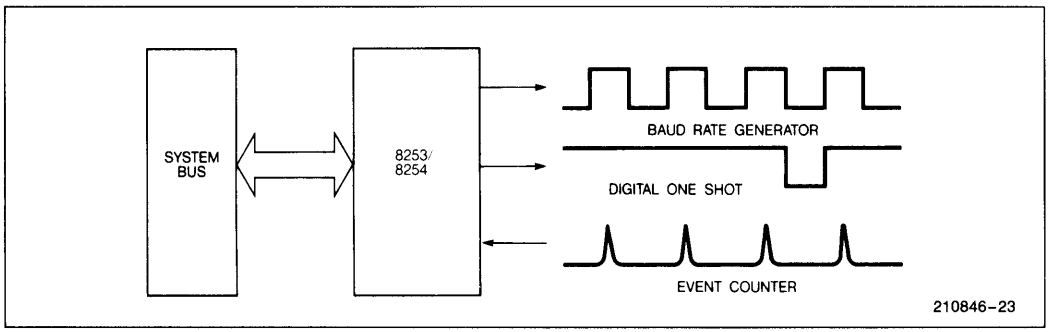
Intel offers an extensive set of peripheral devices to augment microprocessor capabilities. The six major families of peripherals include: support peripherals, memory conrollers, CRT display controllers, slave processors, math processors, and data communication controllers.

SUPPORT PERIPHERALS

Intel's support peripherals are designed with a consistent bus interface that makes them compatible with the entire Intel microprocessor line, from 8 to 16 bits. As a result, the user can leverage previous design and learning investments with each microprocessor upgrade. This support includes the following products.

Timer-Counters, Parallel I/O, Keyboard Controllers

These devices are used for baud rate generation, event counting, motor controls and real-time clock functions.



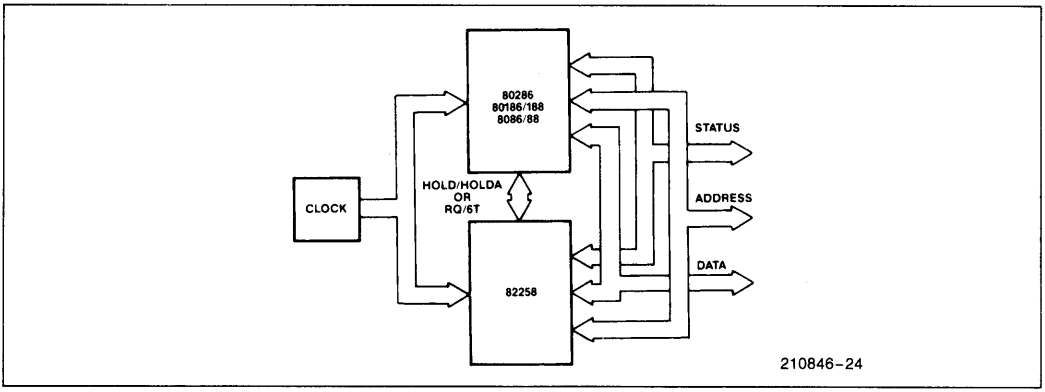
8253/8254 Time/Counter

Table 16. Timer-Counters, Parallel I/O, Keyboard Controllers

Device Number	Function	Description	CPU	Speed	Package Type/ No. of Pins
8253	Timer/Counter	3 Independent 16-Bit Counters	ALL	2.6 MHz Count Rate	P,D/24
8254	Timer/Counter	3 16-Bit Counters—Superset of the 8253	ALL	10 MHz Count Rate	P,D/24
82C54	Timer/Counter	CHMOS, 3 16-Bit Counters Compatible with 8254	ALL	10 MHz Count Rate	P,D/24 PR/28
8255A	Parallel I/O	24 TTL—Compatible I/O Lines	ALL	—	P,D/40
82C55A	Parallel I/O	CHMOS, 24 TTL Compatible I/O Lines	ALL	—	P,D/40 PR44
8256AH	All Basic Support Functions	Serial I/O + Parallel I/O + Timer/ Counters + Interrupt Control (8251A + 8253 + 8255A + 8259A)	ALL	UART: 1 MB/s Counters: 0.5 MHz	P,D/40
7279	Keyboard Controller	64-key keyboard and display scan control	ALL	—	P,D/40

DMA Controllers

These devices are designed to offload the CPU while speeding up data transfers in the system by allowing external devices to directly transfer data to or from system memory.



82258 in an Intel Advance Processor Architecture System

Table 17. DMA Controllers

Device Number	Function	Description	CPU	Speed	Package Type/ No. of Pins
80287	Numeric Processing	Performs arithmetic, logical and transcendental operations on 32-, 64-, 80-bit floating point operands, 32- and 64-bit integers and 18-digit BCD operands to greatly enhance speed of system. Floating point operations are approximately 100x faster than equivalent CPU/software routines. Accuracy is extended to 80 bits. Meets proposed IEEE standard (#754). Has an asynchronous interface to the 80286 which allows the 80286 and 80287 to operate at different speeds in a system.	80286	With 5 MHz clock 14/18 μs 32 Bit Multiply: 19 μs 64 Bit Multiply: 27 μs Divide 39 μs With 8 MHz clock 32 Bit Multiply: 11.9 μs 64 Bit Multiply: 16.9 μs	LCC/40
8089	2-channel intelligent I/O Processor with DMA	Two I/O channels offer flexible, intelligent DMA operations and I/O program execution. In "local mode," the 8089 is closely coupled with an 8088 or 8086 CPU to add DMA capabilities with minimum chip count. In "remote mode," the 8089 serves as an I/O subsystem to maximize performance and flexibility.	8086 8088 Local Mode ALL Remote Mode	1.25 Mbytes/sec (5 MHz)	D/40
8237A	High Performance DMA Controller	4 independent DMA channels, can be cascaded to support any number of channels, additional feature of memory-to-memory transfer.	ALL	1.6 Mbytes/sec	P,D/40
8257	DMA Controller	4 channel DMA controller.	8080A 8085AH	960 Kbytes/sec (3 MHz)	P,D/40

Interrupt Controllers

These provide faster response to real-time events in a large system without requiring the processor to poll for the source of peripheral service requests.

Table 18. Interrupt Controllers

Device Number	Function	Description	CPU	Package Type/ No. of Pins
8259A	Programmable Interrupt Controller	8 Vectored Interrupts, Cascadable to 64	ALL	P,D/28

Multiplexed Memory Components

These Components can communicate over the multiplexed address/data bus of the MCS®-85, 8088 or 80188 processors eliminating the need for address latching.

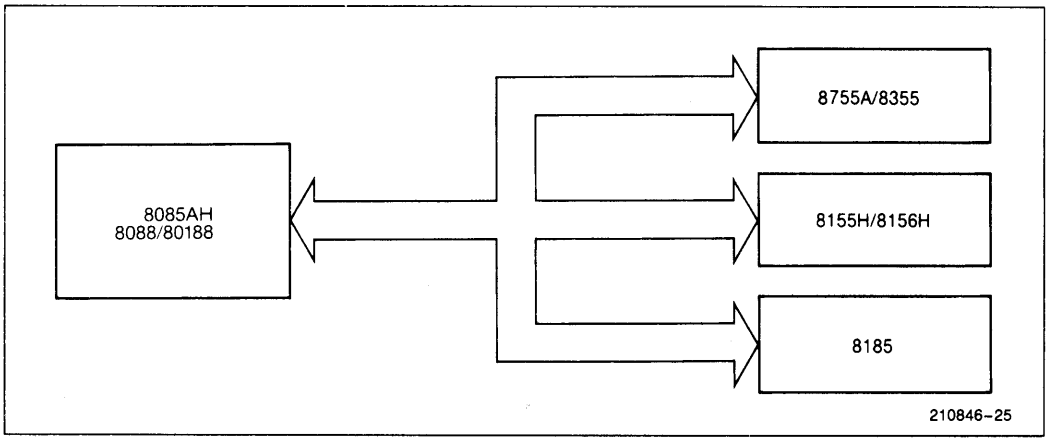


Table 19. Multiplexed Memory Components

Device Number	Function	Description	CPU	Access Time	Package Type/ No. of Pins
8155H/ 8156H	Static RAM, I/O and Timer	256 bytes RAM; 14-bit counter/ timer, 22 parallel I/O-ports; internal address latch.	8085AH 8088 80188	330 ns (−2) 400 ns (Std)	P,D/40
8185	Static RAM	1K X 8 RAM; internal address latch; low standby power requirements.	8085AH 8088 80188	250 ns (−2) 350 (Std)	P,C/18
8355	ROM and I/O	2K X 8-bit Masked ROM; Two bidirectional 8-bit ports; internal address latch.	8085AH 8088 80188	300 ns (−2) 450 ns(Std)	P,D/40
8755A	EPROM and I/O	2K X 8-bit Erasable PROM and I/O; Erasable with UV Light; Electrically reprogrammable; interchangeable with 8355.	8085AH 8088 80188	300 ns (−2) 450 ns (Std)	DB/40

Clock Generators and Bus Controllers

These devices include: clock generators, bus drivers, bus transceivers, bus controllers, bus arbiters and latches. They provide the drive, control signals and timing to directly support interfacing to the industry-standard MULTIBUS®.

Table 20. Clock Generators and Bus Controllers

Device Number	Function and Description	CPU	Package Type/ No. of Pins	Speed Selections
For MCS-80/85 Processors				
8224	Clock Generator	8080A	P,D/16	3 MHz
8228/8238	System Controller and Bus Driver	8080A	P,D/28	3 MHz
For 8086/8088 Processors				
8282/8283	Octal Latch	8086 8088	P,D/20	—
8284A	Clock Generator and Driver	8086 8087 8088 8089	P,D/18	8 MHz 10 MHz
8286/8287	Bus Transceiver	8086 8088	P,D/20	—
8288	Bus Controller	8086/8088 80186/80188 8087 8089	D/20	8 MHz
8289	Bus Arbiter	8086/8088 80186/80188 8087 8089	P,D/20	8 MHz
For 80286				
82284	Clock Generator	80286	D/18	8 MHz
82288	Bus Controller	80286	D/20	8 MHz
82289	Bus Arbiter	80286 82258 (ADMA)	D/20	8 MHz
For I/O Coprocessors				
82285	Clock Generator	82586 82730	D/18	8 MHz

MEMORY CONTROLLERS

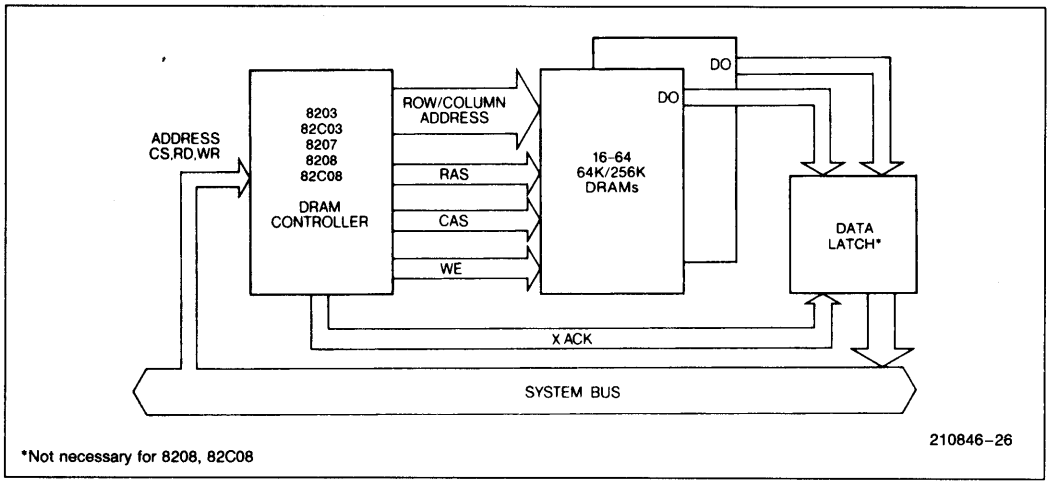
The memory controller family of peripherals integrates the logic required to interface dynamic RAM, floppy disks and Winchester disks to microprocessors.

The dynamic RAM controllers supply all three functions necessary in any dynamic RAM design: row/column address multiplexing, refresh and arbitration. A single device replaces 10-15 TTL packs and the delay line. The 8207 extends the level of integration to include support for a dual-port interface, bank interleaving and complete ECC control with the 8206. The 82C08 is a single-chip low-power solution for DRAM control. It is ideal for low-power and portable systems.

Three other memory controllers interface a microprocessor to mass storage devices. The 8271 and 8272A control single and double density floppy disk or mini floppy disk drives, while the 82062/82064 controls Winchester disk drives using the ST506/SA1000 standard interface.

Table 21. Memory Controllers

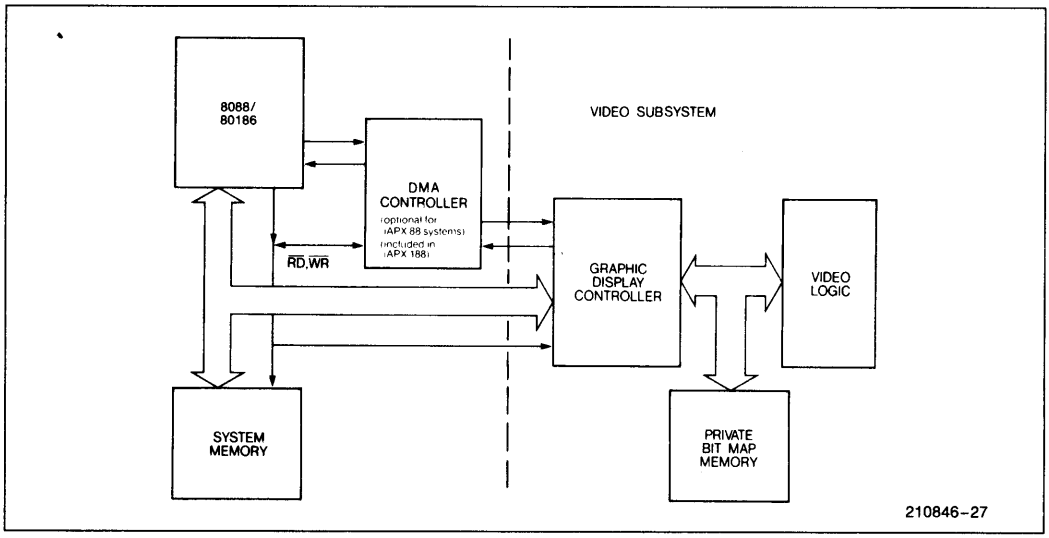
Device Number	Function	Description	CPU	Speed	Memory Size	Package Type/ No. of Pins
8203	16K/64K DRAM Controller	Provides all logic to interface 64K DRAMs to any microprocessor	ALL	0–3 Wait states	256K Bytes	D/40
82C03	16K/64K DRAM Controller	CHMOS replacement for 8202A, 8203	ALL	0–3 Wait states	256K Bytes	P/40
8206	Error Detection and Correction	Single-bit Correction Double-bit Detection	ALL	55 ns	8 bit to 80 bit words	A/R/68
8207	64K/256K DRAM Controller	Interfaces 64K/256K DRAMs while providing a dual-port interface bank interleaving and ECC control	ALL	0 Wait states	2 MBytes	A/R/68
8208	64K/256K DRAM Controller	Interfaces 64/256K DRAMs while providing bank interleaving and a high performance interface to any microprocessor	ALL	0 Wait states	1 MBytes	C/48
82C08	64K/256K DRAM Controller	Low Power CMOS 8208	ALL	0 Wait-states	1 MBytes	P/48 N/68
8272A	Single/Double Density Floppy Disk	Programmable Single or Double Density Controller for up to 4 drives	ALL	500 KB/s	8" Floppy or 5¼" Mini Floppy	P,D/40
82062	Winchester Disk Controller	Programmable Winchester Disk Controller for ST506	ALL	5 MB/s	5¼" or 8" Winchester Disk	P,D/40
82064	Winchester Disk Controller	82062 + ECC	ALL	5 MB/s	5¼" or 8" Winchester Disk	P,D/40



Dynamic RAM Subsystem

CRT DISPLAY CONTROLLERS

Intel's CRT display controllers are designed to display information on a CRT screen with a wide variety of screen formats. They are also the only chips designed to reduce the display manipulation task for the system microprocessor, improving overall system quality and performance.



CRT Display Controller Subsystem

Table 22. CRT Display Controllers

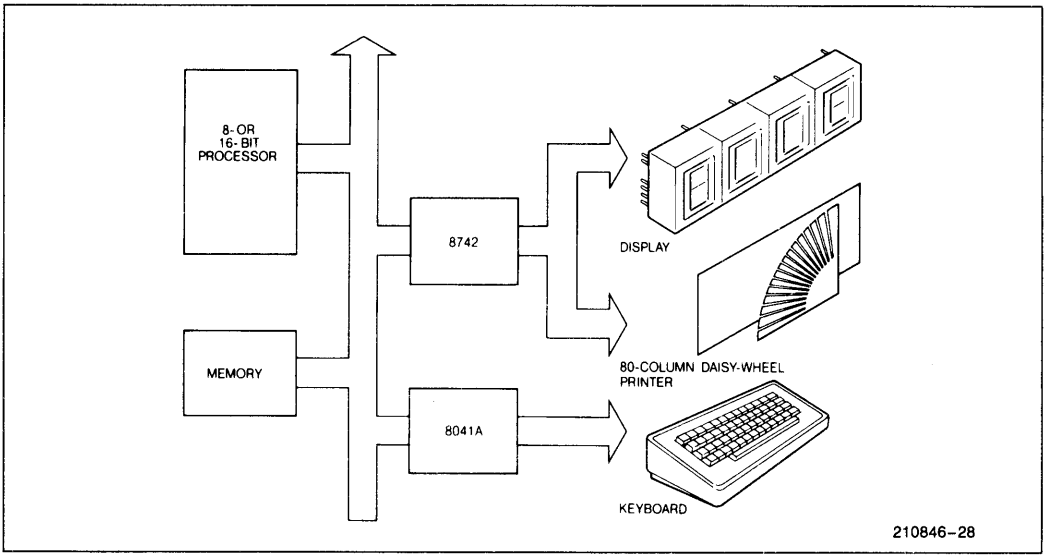
Device Number	Function	Description	CPU	Screen Formats	Display Types	Speed Selections	Package Type/ No. of Pins
8275	Programmable CRT Controller	Programmable screen and character format, 6 independent field attributes, 11 visual character attributes, cursor control, light pen capability, programmable DMA mode.	MCS 80/85 8086/8088 80186/80188 MCS-51	80 char/ row 64 rows/ frame	Alpha-Numeric	2 MHz(Std) 3 MHz(−2)	P,D/40
8276	Small System CRT Controller	Programmable screen and character format, 6 independent field attributes, cursor control, on-chip dual row buffers, cascadable up to 4 controllers.	MCS 80/85 8086/8088 80186/80188 MCS-51	80 char/ row 64 rows/ frame	Alpha-Numeric	2 MHz(Std) 3 MHz(−2)	P,D/40
82720	Graphics Display Controller	Provides microcomputer system with bit map graphics capabilities. Refreshes screen from a bit map RAM. Accepts high level commands which causes GDC to draw graphics figures into bit map memory concurrently with CPU operations.	ALL	Up to one mega pixel resolution	Alpha-Numeric; Graphic; Vector; Arc; Rectangle; Slant	4 MHz(Std) 5 MHz(−1)	CD/40
82730	Text Coprocessor	Provides high quality text and bit-map graphics display, proportional spacing, superscript/subscript, etc. High performance text manipulation-on-board DMA, high-level commands and table driven linked list data structure. Programmable bus interface—8 or 16 bit data and 16 or 32 bit addressing. Flexible display formats programmable at screen and row level. Simultaneous display of independent data bases.	ALL	Up to 200 chars/ row 2048 scan lines/frame	Alpha-Numeric Alpha-mosaic, mixed text and graphics with 82720	Separate system and video clocks, maximize overall system per-formance	CP/68
82731	Video Interface Controller	Parallel to serial data conversion on-chip dot clock generator, dot rates up to 50 MHz 16 dot wide character. Proportional spacing and attribute generation support. Works with the 82730 text coprocessor.	—	—	—	50 MHz dot rate	P,D/40
82716	Video Storage Display Device	Highly integrated, low cost display controller. Implements graphics displays with a minimum of chips. On-chip DRAM control, CRT control, video line buffers, color palette, and D/A converters. Flexible object structures support animation and windows. Can sync to external video sources for overlay.	ALL	640 x 512 pixels mono or Color	Graphics and character	20 MHz dot rate	CGA/68 PLCC/68
82786	Graphics Coprocessor	Provides high performance graphics and high quality text with advanced display control. Full support for graphics primitives at up to 2.5 million pixels per second and bit-mapped proportionally spaced text up to 25 thousand characters per second. Hardware windows, zoom, cursor, pan and scroll. Separate graphics/text and display content control units. Integral DMA and DRAM controllers. Low power CHMOS. Linked list instructions.	ALL	Up to 3.6 mega pixel resolution	Mixed text & graphics; Display selected from output by multiple applications within many windows; to 256 colors.	10 MHz system clock; 25 MHz video clock	CG/68

SLAVE PROCESSORS

Slave processors consist of a family of user programmable devices. They are "Universal Peripheral Interfaces" (UPI™), for control functions where no standard controller exists. These UPI devices are flexible single chip microcomputers with on-chip CPU, ROM or EPROM, RAM, I/O ports and a slave interface to the master system CPU. They allow the designer to integrate random control logic and to add custom control interfaces to a system.

UPI products include pin-compatible ROM and EPROM versions to allow prototyping/debugging or rapid feature upgrades in production. The instruction set is based upon the industry-standard 8048.

The UPI family is supported with a line of products for code development: development systems, assembler, in-circuit emulators (ICE) and PROM programmers.



Universal Peripheral Interfaces (UPI™) for Non-Standard Control

Table 23. Slave Processors

Device Number	Function	Description	CPU	Speed	RAM	I/O Lines	Package Type/ No. of Pins
8041A	UPI 1K ROM	Programmable Peripheral	8048	6 MHz	64 Bytes	18	P,D,N/40
8741A	UPI 1K EPROM	Programmable Peripheral	8048	6 MHz	64 Bytes	18	D/40
8042	UPI 2K ROM	Programmable Peripheral	8049	12 MHz	128 Bytes	18	P,D,N/40
8742	UPI 2K EPROM	Programmable Peripheral	8049	12 MHz	128 Bytes	18	D/40
8742AH	UPI 2K EPROM	Programmable Peripheral	8049	12 MHz	256 Bytes	18	D/40
80452	UPI 4K ROM	Programmable Peripheral	8051	16 MHz	256 Bytes	40	A/68
87452	UPI 4K EPROM	Programmable Peripheral	8051	16 MHz	256 Bytes	40	A/68
8243	I/O Expansion	UPI I/O Expander adds 16 lines to UPI controller	8041A 8042 8048 8049 8050	—	—	16	P,D/40

MATH PROCESSORS

These devices process the data sent by the host CPU. Math and IEEE floating point calculations are implemented in hardware. This increases performance, reduces software overhead, and frees up the processor for other tasks.

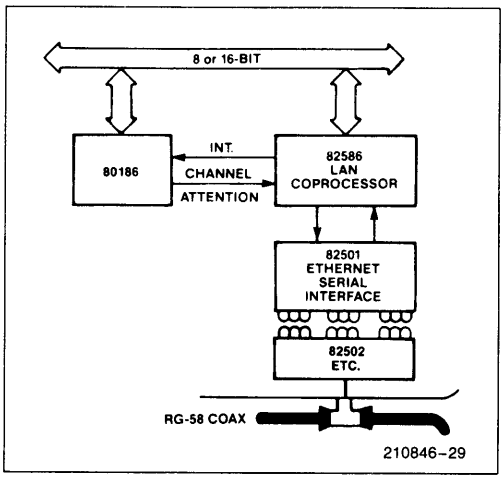
Table 24. Math Processors

Device Number	Function	Description	CPU	Speed	Package Type/ No. of Pins
8087	Numeric Processing	Performs arithmetic, logical and transcendental operations on 32-, 64-, 80-bit floating point operands, 32- and 64-bit integers and 18-digit BCD operands to greatly enchance speed of system. Floating point operations are approximately 100 x faster than equivalent CPU/ software routines. Accuracy is extended to 80 bits. Meets proposed IEEE standard (#754).	8086/8088 80186/ 80188	With 5 MHz Clock 32 Bit Multiply: 19 μs 64 Bit Multiply: 27 μs Divide 39 μs	CC/40
80287	Numeric Processing	Performs arithmetic, logical and transcendental operations on 32-, 64-, 80-bit floating point operands, 32- and 64-bit integers and 18-digit BCD operands to greatly enhance speed of system. Floating point operations are approximately 100 x faster than equivalent CPU/ software routines. Accuracy is extended to 80 bits. Meets proposed IEEE standard (#754). Has an asynchronous interface to the 80286 which allows the 80286 and 80287 to operate at different speeds in a system.	80286	With 5 MHz Clock 14/18 μs 32 Bit Multiply: 19 μs 64 Bit Multiply: 27 μs Divide 39 μs With 8 MHz Clock 32 Bit Multiply: 11.9 μs 64 Bit Multiply: 16.9 μs	LCC/40
8231A	Arithmetic Processing	16/32 Bit Integer and Floating Point Arithmetic	ALL	32 Bit Integer Multiply: 50 μs 32 Bit Floating Point Sine: 1•1 μs	

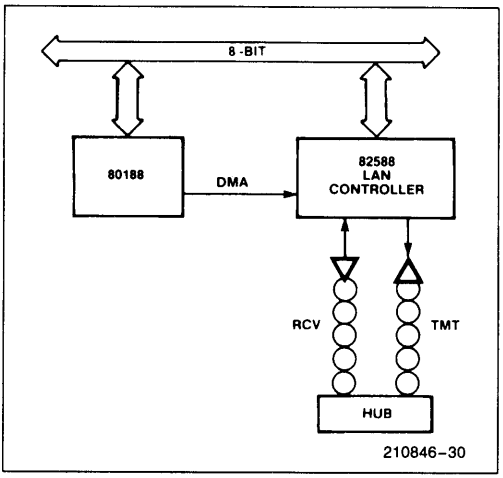
DATA COMMUNICATION CONTROLLERS

Local Area Network Controllers

Intel provides the broadest line of CSMA/CD devices available. High performance applications can utilize the 82586 LAN Coprocessor that supports IEEE 802.3 Ethernet and Cheapernet. Cost sensitive applications can use the 82588 Single Chip LAN Controller that supports emerging IEEE standards for PC networking: IBM PC Network and STARLAN. The 82586 is supported by iNA 960 Network software for quick time to market.



IEEE 802.3/Cheapernet Configuration



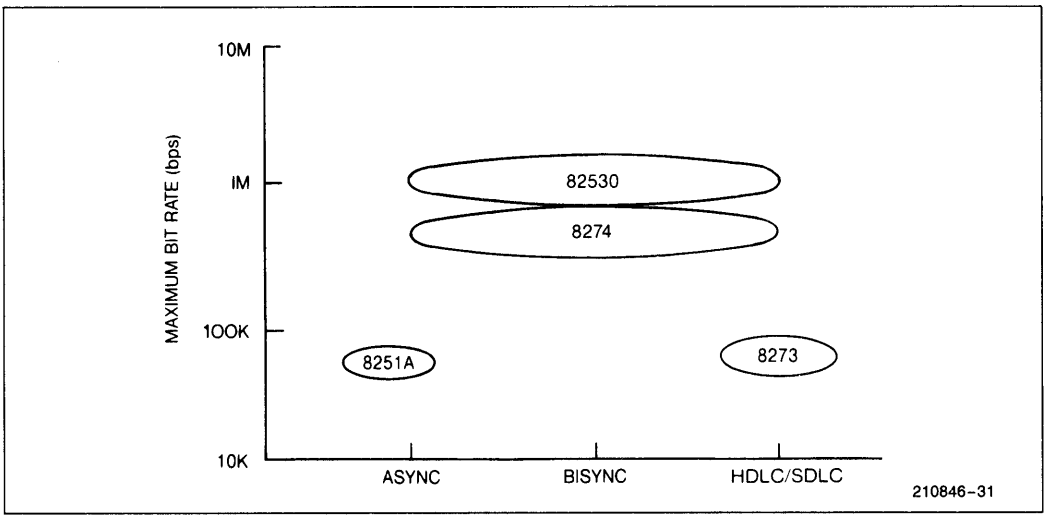
STARLAN Configuration

Table 25. Local Area Network Interface

Device Number	Function	Description	CPU	Encoding/ Decoding	Protocols	Package Type/ No. of Pins
82586	Local Area Network Coprocessor	Performs CSMA/CD Data Link Functions without CPU control. Performs memory management, and diagnostic on-chip. Programmable to be compatible with established and emerging IEEE standard. See iNA 960 Network Software.	8086 80186/ 80188	N/A	IEEE 802.3 Ethernet Cheapernet IBM PC Network STARLAN	CC/48
82588	Single Chip LAN Controller	High Integration Device that performs CSMA/CD data link control, encoding/ decoding to 2 Mbps, and logic based collision detection in a single chip. Ideal for low cost LAN applications.	8086/8088 80186/ 80188	NRZI Manchester (1–2 Mbps)	IBM PC Network STARLAN	D/28
82501	Ethernet Serial Interface	10 Mbps Manchester encoder/decoder. Drives and receives signals over 50 meter transceiver cable. Loopback capability for diagnostics. Used with 82586.	N/A	Manchester (10 Mbps)	IEEE 802.3 Ethernet Cheapernet	D/20
82502	Ethernet Transceiver	10 Mbps CMOS transceiver drives IEEE 802.3 standard 10 BASE 5 and 10 BASE 2 cable segments. Receivers from same. Provides watchdog timer function.	N/A	N/A	IEEE 802.3 Ethernet Cheapernet	D/16

Global Data Communication Controllers

The five serial communication devices support all the serial standard protocols; asynchronous, byte synchronous and bit synchronous protocols. The interconnection can be local or remote. For remote channels, modem control lines are provided.



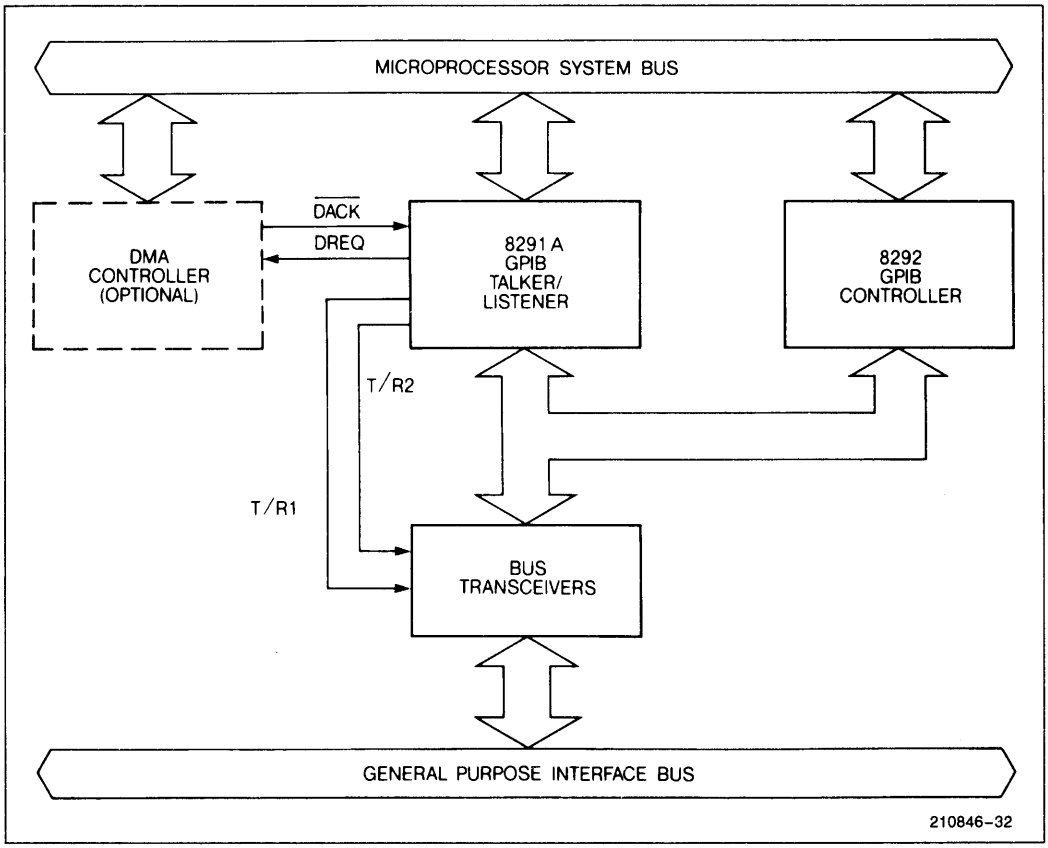
Intel Data Comm Family

Table 26. Serial Data Communication Controllers

Device Number	Function	Description	CPU	Modem Control Lines	Serial Channel	ASYNC	BISYNC	HDLC/ SDLC	Max Data Rate	Package Type/ No. of Pins
8251A	USART	Industry standard synchronous and asynchronous full duplex transmitter/ receiver. Programmable priority bit, sampling rates, break generation and detection.	8080A 8085AH 8086/8088 80186/80188 8048AH/49AH 8051/8096	4	1	X	X	—	19 2K bps (Async) 64K bps (Bisync)	D,P/28
8256AH	Multifunction UART (MUART)	Full duplex asynchronous receiver/ transmitter. Programmable baud rate generator. 16 parallel I/O lines. 8 level interrupt controller.	ALL	1	1	X	—	—	1M bps	P/40
8273	SDLC/HDLC Communications Controller	Interfaces μP to SDLC/HDLC communication lines. Implements first level driver software in hardware. On-chip DPLL. Loop mode support.	8085AH 8086/8088 80186/80188 8048AH/49AH 8051/8096	3	1	—	—	X	64K bps	D,P/40
8274	Multiprotocol Serial Controller (MPSC)	Multiprotocol device with several μP interface options. 4 independent DMA channels on-chip.	8085AH 8086/8088 80186/80188 8045AH/49AH 8051/8096	4 per channel	2	X	X	X	580K bps	D,P/40
82530	Serial Communications Controller (SCC)	Dual channel multiprotocol controller with on-chip baud rate generators, digital phase locked loops, various data encoding/ decoding schemes and extensive diagnostic capabilities.	8085AH 8086/8088 80186/80188 8048AH/49AH 8051/8096	4 per channel	2	X	X	X	1.5M bps	D,P/40
8344	High Performance 8-Bit Microcontroller with On-Chip Serial Communication Processor	8051 microcontroller core with high performance serial communication controller that can automatically respond to SDLC primary station commands. On-chip DPLL supports loop and non-loop.	—	2	1	—	—	X	2.4M bps	P/40
8044	—	8344 with 4K bytes of on-chip ROM.	—	2	1	—	—	X	2.4M bps	P/40
8744	—	8344 with 4K bytes of on-chip EPROM.	—	2	1	—	—	X	2.4M bps	C/40

GPIB Controllers

The 8291A/8292 are all the building blocks needed to implement the different types of nodes used on the GPIB (IEEE-488) parallel instrumentation bus.



GPIB Controllers

Table 27. GPIB Controllers

Device Number	Function	Description	CPU	Data Rate	Package Type/ No. of Pins
8291A	GPIB Talker/Listener	Complete talker/listener device that adheres to IEEE-488 standard. Implements all 9 talker/listener functions, on-chip programmable end of sequence register for automatic end of message.	8085AH 8086/8088 80186/80188 8048AH/8049AH 8051/8096	350K bps max	P,D/40
8292	GPIB Controller	Connects with the 8291A to form a complete IEEE-488 standard interface talker/listener/controller. Built in bus lock-up timers for high system reliability.	8085AH 8086/8088 80186/80188 8048AH/8049AH 8051/8096	N/A	P/40

CUSTOM COMPONENTS

Functional Description

The iCEL™ VLSI Design System provides users without silicon expertise the capability to design their own custom semiconductor components. All interaction with the System is accomplished through a single input media.

The user designs his component by selecting functional blocks from a standard cell library. Each cell is a well characterized circuit structure. Using the iCEL Design System software the user verifies his logic. This software then translates the design into VLSI through the automated interconnection of cells. Each cell has a corresponding data sheet. As such, an engineer designs with cells much as with standard SSI, MSI, and LSI components. In turn, the cell library contains a model for each cell that describes its functionality and performance to the iSIM logic and timing simulator. iSIM is the software "breadboard" that the designer uses to debug his design.

Through a series of software modules, the iCEL Design System supports the custom integrated circuit designer in performing logic design, verification of component performance, and generation of test programs. Intel uses additional software modules to automatically place the cells, route the interconnect and produce a layout data-base tape which is used to create photolithographic masks for semiconductor processing.

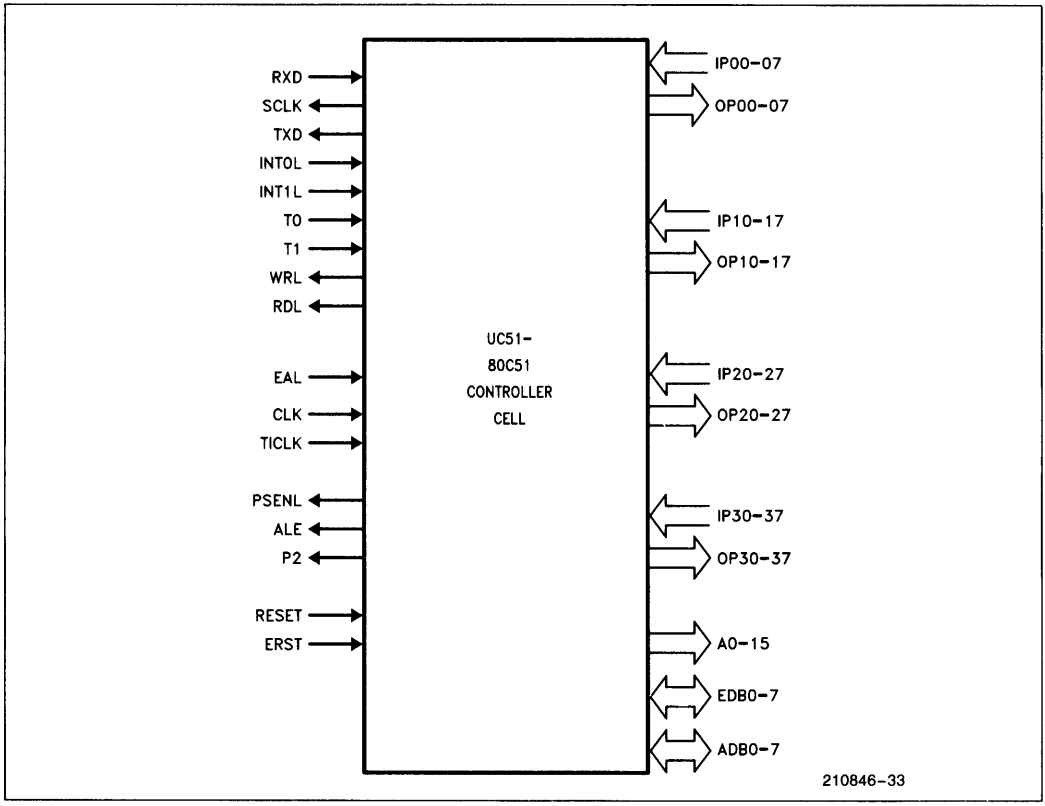
VLSiCEL-C51

The VLSiCEL-C51 is a Standard Cell version of the industry standard 80C51 microcontroller. Used in conjunction with a library of CHMOS-III Standard Cells, a designer can implement a custom integrated circuit that includes an 80C51 architecture and it support logic.

Implemented within the environment of the iCEL Design system, this VLSiCEL is supported by various design verification media. These include a behavioral simulation model that allows the UC51 (UC51 is the simulator model name) to appear as a 500 gate CPU load instead of the 6000 gate the actual device might represent. As part of the behavioral support, test patterns for application logic may be generated with assembly language 80C51 mnemonics.

The UC51, like the standard product, has 4096 bytes of on-chip Read Only Memory (ROM). On-chip ROM on the UC51 can be expanded in increments of 4K bytes in order to expand the codespace capability and in most cases alleviate any need for external program storage.

In partitioning the UC51 into a compatible Standard Cell format, the standard product's I/O drivers and pin multiplexers were eliminated. This assures compatibility with the "glue" logic library of over 100 elements, while maintaining electrical performance compatibility with the standard product. As a result, all functional pins of the standard product 80C51 are available to the UC51 user as "raw" I/O. This "raw" I/O, totaling over 112 signals, allows a design flexibility heretofore not available to MCS-51 designers.



VLSiCEL-C51 Function Pin Diagram

Manufacturing

All custom components are manufactured with Intel's industry standard CHMOS-III process. VLSiCEL-C51 wafers are run side by side with such high-volume standard products as the 80C49 and 80C51. Custom components benefit from this economy of scale (high volume = lower cost).

Packaging

Intel provides the VLSiCEL-C51 user with virtually every available standard IC package. Dual In-Line Packages up to 48 pins are available. Plastic Leaded Chip Carriers up to 68 pins can be specified. For applications requiring 68 pins or more, pin grid arrays are provided.

EXPRESS PRODUCT FAMILY

EXPRESS is a service program that allows users of Intel IC components to tailor the products' electrical test flow to their specific application requirements. The test flows are designed to suit a broad range of system and production requirements.

The EXPRESS program offers users of Intel microcomputers, RAMs, EPROMs, and peripheral component families, products that are screened to operate within two industry-standard temperature ranges, each with the option of 168 ±8 hours of dynamic burn-in (equivalent to MIL-STD-883B, Method 1015). All Intel processing technologies are included. New products will enter the program as they become available.

The key to using EXPRESS is the generic matrix. You can, by specifying a two-letter prefix, select the test flow your product requires including its operating temperature range and package type. The two operating temperature ranges are: Commercial (0°C to 70°C) and Extended (−40°C to 85°C). Products are available in both hermetic ceramic and molded plastic packages, that meet these temperature specifications. Adding the option of burn-in creates the versatile EXPRESS matrix.

Temperature Range	Burn-In Hours	
	(None)	(168 ±8)
Commercial 0°C to 70°C	Standard	Q
Extended −40 °C to 85°C	T	L

EXPRESS Prefix Definitions

Standard	High Quality Standard Products
Q	Standard product with burn-in and 100% unit post burn-in electrical screening to COMMERCIAL temperature range
T	Standard product with EXTENDED temperature screening
L	Standard product with burn-in and 100% unit post burn-in electrical screening to EXTENDED temperature range

The EXPRESS test flow first subjects 100% of all products to a stringent class electrical examination. Complete DC, AC and functional parameters are tested at operating guard band temperature(s) for compliance to published specifications. Then, at your option, the product undergoes 168 ±8 hours of dynamic burn-in at 125°C. Post burn-in screening features a 100% unit electrical retest of DC, AC and functional parameters to guarantee the product's performance over its designated operating temperature range.

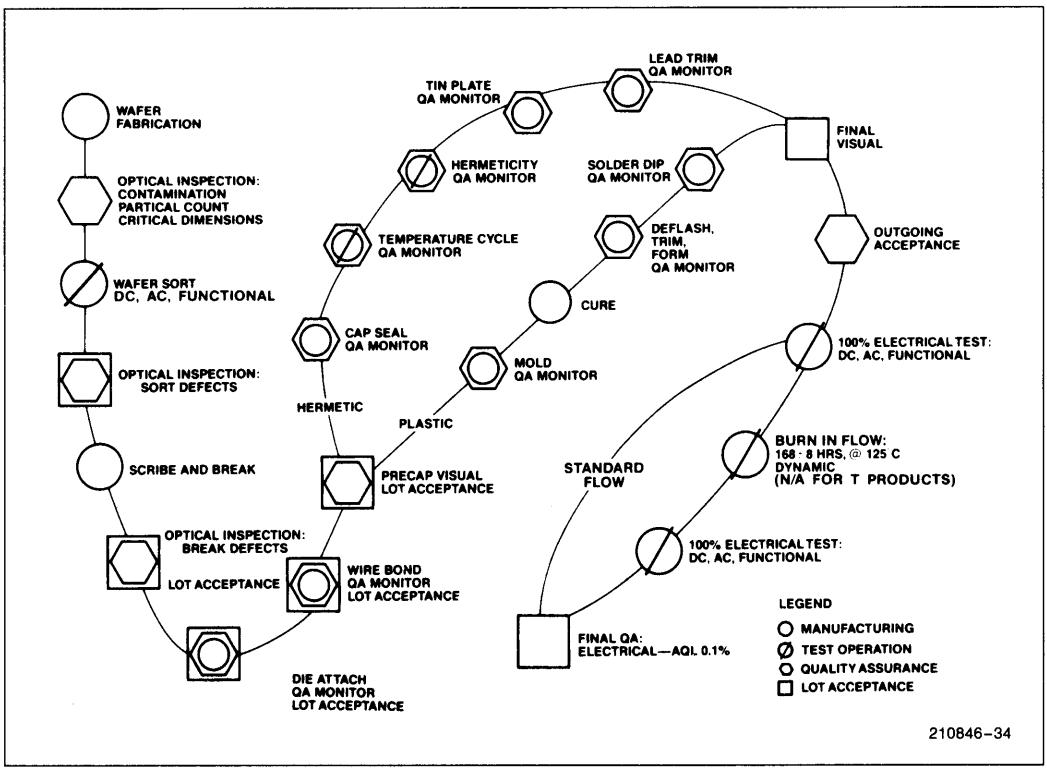
Both these product flows, independent of package type, then receive sample screening for electrical and visual parameters by Final Quality Assurance to 0.1% AQL. These standards are periodically reviewed, and tightened according to Intel's Corporate quality goals.

Table 28. EXPRESS Products

Type	Product	Description	Q	T	L
Microcontroller	8031AH	8-Bit Single Chip Computer, without ROM, Boolean Processor, 128 × 8-Bit RAM	X	X	X
	8032AH	8-Bit Single Chip Computer, without ROM, Boolean Processor, 256 × 8-Bit RAM	X	X	X
	8035AHL	8-Bit Single Chip Computer, without ROM, 64 × 8-Bit RAM	X	X	X
	8039AHL	8-Bit Single Chip Computer, without ROM, 128 × 8-Bit RAM	X	X	X
	8040AHL	8-Bit Single Chip Computer, without ROM, 256 × 8-Bit RAM	X	X	X
	8048AH	8-Bit Single Chip Computer, 1K × 8-Bit ROM, 64 × 8-Bit RAM	X	X	X
	8049AH	8-Bit Single Chip Computer, 2K × 8-Bit ROM, 128 × 8-Bit RAM	X	X	X
	8050AH	8-Bit Single Chip Computer, 4K × 8-Bit ROM, 256 × 8-Bit RAM	X	X	X
	8051AH	8-Bit Single Chip Computer, 4K × 8-Bit ROM, 128 × 8-Bit RAM, Boolean Processor	X	X	X
	8052AH	8-Bit Single Chip Computer, 8K × 8-Bit ROM, Boolean Processor, 256 × 8-Bit RAM	X	X	X
	8748H	8-Bit Single Chip Computer, 1K × 8-Bit EPROM, 64 × 8-Bit RAM	X	X	X
	8749H	8-Bit Single Chip Computer, 2K × 8-Bit EPROM, 128 × 8-Bit RAM	X	X	X
	8243	I/O Expander for Microcontrollers	X	X	X
Microprocessor	8085AH	8-Bit HMOS CPU	X	X	X
	8086	16-Bit HMOS CPU	X	X	X
	8087	Numeric Data Processor	X	X	X
	8088	8-Bit HMOS CPU, 16-Bit Internal Architecture	X	X	X
	8089	8 × 16-Bit I/O Processor	X	X	X
	80186	Highly Integrated 16-Bit CPU	X	X	
	80188	Highly Integrated 8-Bit CPU with 16-Bit Internal Architecture	X	X	
	80286	High Performance, Multitasking 16-Bit CPU	X		
	80287	High Performance Numeric Data Processor	X		
Support Product	8282	Parallel Bus Latch	X	X	X
	8283	Parallel Bus Latch	X	X	X
	8284A	Clock Generator for 8086, 8088	X	X	X
	82284	Clock Generator for 80286	X		
	8286	Parallel Bus Transceiver	X	X	X
	8287	Parallel Bus Transceiver	X	X	X
	8288	Bus Controller for 8086, 8088	X	X	X
	82288	Bus Controller for 80286	X		
	8289	Bus Arbiter for 8086, 8088	X		
	8755A	2K × 8-Bit EPROM with I/O Ports	X	X	X
Controller	8237A	High Performance Programmable DMA Controller	X		
	8257	Programmable DMA Controller	X		
	8259A	Programmable Interrupt-Controller	X	X	X

Table 28. EXPRESS Products (Continued)

Type	Product	Description	Q	T	L
Peripheral	8042	Universal Peripheral Interface 8-Bit Microcomputer			X
	8044	High Performance 8-Bit Microcontroller with 4 KBytes of On-Chip ROM	X	X	X
	8155H	256 × 8-Bit RAM, I/O Ports, Counter	X	X	X
	8156H	256 × 8-Bit RAM, I/O Ports, Counter	X		
	8203	64K Dram Controller	X		
	8251A	Programmable Communication Interface	X	X	X
	8253	Programmable Interval Timer, 3 MHz	X	X	X
	8254	Programmable Interval Timer, 8 MHz	X	X	X
	8255A	Programmable Peripheral Interface	X	X	X
	8272A	Single/Double Density Floppy Disk Controller	X		
	8274	Multi-Protocol Serial Controller	X		
	8279	Programmable Keyboard/Display Interface	X		
	8291A	GPIB Talker/Listener	X		
	8292	GPIB Controller	X		
	8293	GPIB Transceiver	X		
	8344	High Performance 8-Bit Microcontroller with On-Chip Serial Communication Processor	X	X	X
	8741A	Universal Peripheral Interface, 64 × 8-Bit RAM	X		
	8742	Universal Programmable Interface, 128 × 8-Bit RAM	X		
EPROM	2732A	4K × 8-Bit	X	X	X
	2764A	8K × 8-Bit	X	X	X
	27128	16K × 8-Bit	X	X	X
	27256	32K × 8-Bit	X	X	X
	27512	64K × 8-Bit	X	X	X
	27513	4 × 16K × 8-Bit	X	X	X
	27C64	8K × 8-Bit	X	X	X
	87C64	8K × 8-Bit	X	X	X
	27C256	32K × 8-Bit	X	X	X
	87C256	32K × 8-Bit	X	X	X
E^2PROM	2817A	2K × 8-Bit	X	X	X
	2864A	8K × 8-Bit	X	X	X
NVRAM	2001	128 × 8-Bit	X	X	X
	2004	512 × 8-Bit	X	X	X
Static RAM	2114A	1K × 4-Bit, Three State	X	X	X
	2115A	1K × 1-Bit, Open Collector	X		
	2125A	1K × 1-Bit, Three State	X		
	2147H	4K × 1-Bit, Three State	X	X	X
	2148H	1K × 4-Bit, Three State	X	X	X
	2149H	1K × 4-Bit, Three State	X		



EXPRESS Product Manufacturing Flows

MILITARY PRODUCTS

The components included in Intel's Military product family are summarized in the table below. A more complete description of each generic device can be found in this Guide by referring to the appropriate component section or by using the Alphanumeric Index located in the front of this Guide.

Table 29. Military Products

Type	Product	Description	Maximum Clock Speed	Package Type		
				DIP	LCC	PGA
Microcontroller	M8031AH	High-Performance 8-Bit Single-Chip Computer without ROM, 128 × 8-Bit RAM, Boolean Processor	12 MHz	X	X	
	M80C31BH	High-Performance 8-Bit Single-Chip Computer without ROM, 128 × 8-Bit RAM, Low Power CHMOS, Power-Down and Idle Modes	12 MHz	X	X	
	M8035AHL	8-Bit Single-Chip Computer without ROM, 64 × 8-Bit RAM, Power-Down Mode	11 MHz	X		
	M8048AH	8-Bit Single-Chip Computer, 1K × 8-Bit Mask Programmable ROM, 64 × 8-Bit RAM, Power-Down Mode	11 MHz	X		
	M8051AH	High-Performance 8-Bit Single-Chip Computer, 4K × 8-Bit Mask Programmable ROM, 128 × 8-Bit RAM, Boolean Processor	12 MHz	X	X	
	M80C51BH	High-Performance 8-Bit Single-Chip Computer, 4K × 8-Bit Mask Programmable ROM, 128 × 8-Bit RAM, Low Power CHMOS, Power-Down and Idle Modes	12 MHz	X	X	
	M8097	High-Performance 16-Bit Microcontroller with A/D, PWM Output, HSIO, 232 Bytes RAM, 40 I/O Lines, Watch Dog Timer	12 MHz			X
	M8397	High-Performance 16-Bit Microcontroller with A/D, PWM Output, HSIO, 232 Bytes RAM, 40 I/O Lines, Watch Dog Timer, plus 8K × 8-Bit ROM	12 MHz			X
	M8748H	8-Bit Single-Chip Computer with 1K × 8-Bit EPROM, 64 × 8-Bit RAM	11 MHz	X		
	M8751H	High-Performance 8-Bit Single-Chip Computer with 4K × 8-Bit EPROM, 128 × 8-Bit RAM, Boolean Processor	8 MHz	X	X	
	M87C51	High-Performance 8-Bit Single Chip Computer with 4K × 8-Bit EPROM, 128 × 8-Bit RAM, Low Power CHMOS, Power-Down and Idle Modes	12 MHz	X	X	
	M8797	High-Performance 16-Bit Microcontroller with A/D, PWM Output, HSIO, 232 Bytes RAM, 40 I/O Lines, Watch Dog Timer, Plus 8K × 8-Bit EPROM	12 MHz			X

Table 29. Military Products (Continued)

Type	Product	Description	Maximum Clock Speed	Package Type		
				DIP	LCC	PGA
Microprocessor	J8080A	8-Bit Parallel CPU, 2 μsec Instruction Cycle, (JAN) M38510/42001 BQX	2 MHz	X		
	M8085AH	8-Bit Parallel CPU, 1.3 μsec Instruction Cycle, On-Chip Clock Generator and System Controller, DESC SID 7901001QX	3 MHz	X		
	J8086	16-Bit Microprocessor, (JAN) M38510/53001BQX	5 MHz	X		
	M8086	16-Bit Microprocessor	5 MHz, 8 MHz	X	X	
	M8087	Numeric Data Processor, Math and Floating Point Hardware for Host M8086 and M8088	5 MHz	X		
	M8088	High-Performance 8-Bit Microprocessor, 16-Bit Internal Architecture	5 MHz	X		
	M8089	8/16-Bit I/O Processor, High Speed DMA with I/O Hardware	5 MHz	X		
	M80186	High Integration 16-Bit Microprocessor	6, 8 MHz			X
	M80286	High-Performance 16-Bit Microprocessor with Memory Management and Protection	6, 8 MHz			X
Support Product	M8224	Single-Chip Clock Generator and Driver for M8080A		X		
	M8228	Single-Chip System Controller and Driver for M8080A		X		
	M8243	I/O Expander for M8035AHL/M8048AH/M8748H		X		
	M8282	8-Bit Parallel Address/Data Latch		X	X	
	M8283	8-Bit Parallel Inverting Address/Data Latch		X	X	
	M8284A	Single-Chip Clock Generator and Driver for M8086, M8088, M8087 and M8089	8 MHz	X	X	
	M8266	8-Bit Parallel Address/Data Bus Transceiver		X	X	
	M8287	8-Bit Parallel Inverting Address/Data Bus Transceiver		X	X	
	M8288	Bus Controller for M8086, M8088 and M8089, Provides Command and Control Timing Generation	8 MHz	X	X	
	M8289	Bus Arbiter for M8086, M8088 and M8089 System Busses	8 MHz	X	X	
	M82188	Integrated Bus Controller For use with M8086, M8088, and M80186-6 Systems	8 MHz	X		
Microprocessor	M80287	Numeric Processor Extension, Math and Floating Point Hardware Support for Host M80286 (6, 8 MHz)	6 MHz	X		
	M80C86	16-Bit CHMOS Microprocessor	5 MHz	X		

Table 29. Military Products (Continued)

Type	Product	Description	Maximum Clock Speed	Package Type		
				DIP	LCC	PGA
Support Product	M82C84A5	CHMOS Clock Generator and Driver for M80C86	5 MHz	X		
	M82C88	CHMOS Bus Controller for M80C86	5 MHz	X		
	M82284	Clock Generator and Ready Interface for M80286	6, 8 MHz	X		
	M82288	Bus Controller for M80286	6, 8 MHz	X		
	M82289	Bus Arbiter for M80286	6, 8 MHz	X		
Controller	M8257	4-Channel Programmable DMA (Direct Memory Access) Controller for M8080A and M8085AH	3 MHz	X		
	M8259A	Programmable Interrupt Controller, Handles Up to 8-Vectored Priority Interrupts		X	X	
Peripheral	M8155	256 × 8-Bit Static RAM with 22 Programmable I/O Ports, Binary Timer/Counter		X		
	M8185	1K × 8-Bit Static RAM with Internal Address Latch		X		
	M8231A	Arithmetic Processing Unit, High-Performance Fixed and Floating Point Arithmetic and Floating Point Trigonometric Operation	4 MHz	X	X	
	M8251A	Programmable Communication Interface, (USART)	3 MHz	X	X	
	M8254	Programmable Interval Timer, 3 Independent 16-Bit Counters	DC to 8 MHz	X	X	
	M8255A	Programmable Peripheral Interface, 24 Programmable I/O Ports		X	X	
	M8755A	2K × 8-Bit EPROM with 16 Programmable I/O Ports, $T_A = -55°C$ to $+100°C$		X		
	M8274	Multi-Protocol Serial Controller	880 Kbps	X		
	M82720	Graphics Display Controller	4 MHz	X		
	M8744	High Performance 8-Bit Microcontroller with On-Chip Serial Communication Processor	10 MHz/ 2.4 mbps	X		
	M82C54	CHMOS, 3 16-Bit Counters 8254 Compatible	8 MHz	X		
	M82C55	CHMOS, 24 TTL Compatible Parallel I/O Lines		X		

Table 29. Military Products (Continued)

Type	Product	Description	Maximum Clock Speed	Package Type		
				DIP	LCC	PGA
EPROM	M27C64-35	8K × 8 CHMOS	tCE = 350	X		
	M27C64-25	8K × 8 CHMOS	tCE = 250	X	X	
	M27C64-20	8K × 8-Bit	tCE = 200 ns			
	M27C256-25	32K × 8 CHMOS	tCE = 250			
	M2716	2K × 8-Bit, DESC SID 7802201JB	tCE = 250	X		
	M2732A-25	4K × 8-Bit, DESC SID 8001203JB	tCE = 250	X		
	M2732A-45	4K × 8-Bit, DESC SID 8001204JB	tCE = 450	X		
	M2764A-25	8K × 8-Bit, DESC SID 8200504YX	tCE = 250	X	X	
	M2764A-35	8K × 8-Bit, DESC SID 8200503YX	tCE = 350	X	X	
	M27128A-11	16K × 8-Bit	tCE = 125			
	M27128A-15	16K × 8-Bit	tCE = 150			
	M27128A-20	16K × 8-Bit, DESC SID 8202503YX	tCE = 200	X		
	M27128A-30	16K × 8-Bit, DESC SID 8202504YX	tCE = 300	X		
	M27256-17	32K × 8-Bit	tCE = 170			
	M27256-20	32K × 8-Bit	tCE = 200			
	M27256-25	32K × 8-Bit, DESC SID 8411102YX	tCE = 250	X	X	
	M27256-35	32K × 8-Bit, DESC SID 8411101YX	tCE = 350	X	X	
	M27512-25	64K × 8-Bit	tCE = 250	X		
	M27512-35	64K × 8-Bit	tCE = 350	X		
E^2PROM	M2817A-25	2K × 8-Bit	tCE = 250	X		
	M2817A-35	2K × 8-Bit	tCE = 350	X		
	M2864B-25	8K × 8-Bit	tCE = 250			
SRAM	M2114A-4	1K × 4-Bit	tAA = 200 ns	X		
	M2114A-5	1K × 4-Bit	tAA = 250 ns	X		
	J2147H	4K × 1-Bit				
		M38510/23801 BVX	tAA = 85 ns	X		
		M38510/23803 BVX	tAA = 70 ns	X		
		M38510/23805 BVX	tAA = 55 ns	X		
		M38510/23807 BVX	tAA = 45 ns	X		
	M2147H	4K × 1-Bit	tAA = 70 ns	X		
	M2147H-3	4K × 1-Bit	tAA = 55 ns	X		
	M2147H-2	4K × 1-Bit	tAA = 45 ns	X		
	J2148H	1K × 4-Bit	tAA = 70 ns	X		
		M38510/23806 BVX				
	M2148H	1K × 4-Bit	tAA = 70 ns	X		
	M2148H-3	1K × 4-Bit	tAA = 55 ns	X		
	M51C67-55	16K × 1-Bit CHMOS	tAA = 55 ns	X		
	M51C67-45	16K × 1-Bit CHMOS	tAA = 45 ns	X		
NVRAM	M2004-30	512 × 8-Bit	tCE = 300 ns	X		
	M2004-25	512 × 8-Bit	tCE = 250 ns	X		
Bubble	MBPK70A-5	1MBit Bubble Memory Subsystem Consisting of a −20° to 85°C Bubble Component and Support Circuits 20-Pin Leaded Package	50 KHz	—	—	—
Bubble Memory Controller	MD7220-5	Interfaces to M8080/M8085AH/M8086 and Other Standard Microprocessors. Three Data Transfer Modes; DMA, Polled and Interrupt	4 MHz	X		

DEVELOPMENT SYSTEMS

Intel recognizes that developing a product using advanced microprocessors creates major challenges for an engineering organization. And Intel has met these challenges with a set of development tools that let you keep your project under control. These tools help you get your product development done on time by solving problems that waste valuable engineering time.

The first key to productive product development is to work on your product instead of developing and integrating tools. Intel has tools for each phase of your project, and each of them works smoothly with the other to form an effective, integrated tool set. The tools work on a variety of industry-standard systems, including Intel systems specifically built for microprocessor development.

HIGH-LEVEL LANGUAGE SUPPORT

Each Intel microprocessor and microcontroller is supported by a set of high-level languages that exhibit three important elements of well-integrated tools:

The most important integration is between the tools and the processor. Intel assemblers and compilers are optimized around the architectures they support: that means better performance for your product. And efficient compilers mean you can write more of your code in high-level languages instead of assembly language.

Effective coding generally requires a family of compatible translators so that you can draw on the most appropriate language to implement each part of a design. PL/M, Pascal, C, FORTRAN, and assembly language enjoy certain advantages over each other, depending on the application. You can link object modules from any of the Intel translators without further modifications.

The symbolic debugging power of Intel's debuggers is enhanced by communication between the translators and debuggers.

Table 30. Development Languages and Utilities

Product	Description
Assemblers	All Intel assemblers—and there's one for every major Intel component—provide full macro support.
PL/M	PL/M was the first high-level language designed expressly for microprocessors. It is a procedure-oriented language with data structuring facilities that gives the engineer full control over microprocessor-dependent architecture features. It is one of the most widely used tools in the microprocessor and microcontroller world.
C	C-86 is a true implementation of the C programming language defined by Keringhan and Ritchie. C is known for its flexibility and portability.
Pascal	Pascal-86 and Pascal-286 are supersets of ISO Pascal, with extensions for independent compilation and port I/O. They also embody advanced code optimization techniques to achieve extremely efficient programs.
FORTRAN	FORTRAN-86 and FORTRAN-286 are ANSI-77-standard compilers augmented with full 8087/80287 support and the ability to handle very large arrays (over 64 KB).
Utilities	Intel linkage utilities allow independent assembly and compilation of program modules. Library managers allow the management of standard modules and routines. In the case of 80286, a system builder is provided to allow easy configuration of a complex protected/memory-managed system.

DEBUGGERS FOR MICROPROCESSOR APPLICATIONS

Most of the unpleasant surprises that can delay a project attack in the debugging phase. Intel has made debuggers a part of each microprocessor family package, beginning with ICE 80, the world's original in-circuit emulator. Intel's debuggers have the power to let you find bugs early, while they are still cheap and easy to fix, and to find many bugs that would not otherwise be fixed without a major waste of engineering time and schedule time.

Intel's debugging product line for the 8086 and 80286 families of microprocessors features three powerful tools covering the full range of development needs:

Debugging Task	Tool
Host-resident high-level software debugging	PSCOPE
In-target high-level software debugging (80186 and 80188)	TargetSCOPE
Full-speed, transparent software-hardware integration and debug	I²ICE™ Emulator

All three share a common user interface and high-level language debugging capability. Symbolic debugging automates a task that can eat up valuable development time and introduce error into the debug process. Symbolic debugging builds on the debug records loaded from the output of Intel assemblers and compilers—yet another example of the added debugging power gained from integration of development tools. Using user-defined names, the engineer has access to memory locations and program variables (including dynamic variables and high-level-language data structures).

PSCOPE High-Level Language Debugger

PSCOPE is a host-resident debugger that lets you execute and debug programs at the source code level. You can set break and trace points, examine memory, or simply follow program flow at the instruction, statement or procedure level for programs written in PL/M, Pascal, C, FORTRAN, 8086 assembly language, or 80286 assembly language. PSCOPE even lets you make high-level language patches and store them for later use in updating source files.

The PSCOPE syntax, including debug procedures, is the same used by the I²ICE and TargetSCOPE systems, so when you move from software development to software-hardware integration, the user interface stays the same. There's no new learning curve to ascend, no lag in the development cycle.

TargetSCOPE In-target Software Debugger

The TargetSCOPE debugger lets software developers take PSCOPE high-level debugging functions and connect them directly to the target hardware. This is especially useful in checking input/output drivers, software timing programs, and other low-level routines.

TargetSCOPE's price and performance resolve the common trade-off between host-resident software debuggers and high-performance in-circuit emulators for software debug. It offers software debugging in the target hardware and maintains a common user interface with I²ICE hardware emulators.

I²ICE™ Integrated Instrumentation and In-Circuit Emulation System

I²ICE, is unmatched in its ability to kill hardware and software bugs across the entire development process.

Of course, I²ICE offers the high-level language symbolic debug expected of a software debugger. It also integrates transparent emulation support for all members of Intel's 8086 and 80286 families of microprocessors. With a Series IV host, a logic timing analyzer is available offering the most integrated solution available. I²ICE is also available for a PC host.

A full I²ICE configuration can simultaneously emulate four separate processors, stopping execution on an individual event, on an address range, on conditional events and on inter-processor events. The system then displays a trace of execution or bus activity. Full-speed execution is possible using either target system memory or up to 288 K-bytes of emulator memory for each processor.

DEBUGGERS FOR MICROCONTROLLER APPLICATIONS

Microcontroller applications are typically characterized by high performance requirements, a variety of asynchronous events, and a lot of on-chip activity. All of these characteristics add to the challenge of debugging your product. Each Intel microcontroller family has in-circuit debugging support to meet the challenges.

VLSiCE-96 In-Circuit Emulator

VLSiCE-96P is our most powerful microcontroller emulator yet. Based on our third generation bondout technology, VLSiCE-96P provides real-time, transparent debugging support for the MCS-96 family of microcontroller components. It features full symbolic debugging; 64 K-bytes of mappable ICE memory; 4096 frames of dynamic execution and data trace, including internal RAM accesses; a comprehensive break/state machine which allows stopping emulation or enabling trace on user specified combinations of execution addresses, opcodes, data addresses and values, and selected PSW bits.

iSBE 96 8096 Emulator

The iSBE 96 debugger permits programs written for the MCS 96 family of 16-bit microcontrollers to be executed and debugged within the emulator or in the user's target system.

ICE™ In-Circuit Emulators

Intel's popular ICE™ In-Circuit Emulators provide full-speed, transparent debugging for many Intel components, including the 8042, 8048, 8044, and 8051 microcontrollers. Intel ICE debuggers feature symbolic debugging, the ability to stop execution under user-determined conditions, trace collection and emulation memory for program execution.

Emulation Vehicles and iPDS™ Personal Development System

Stand-alone development, test and field support for the 8044 and 8051 microcontrollers, as well as the 8088 microcoprocessor, are also available on Intel's iPDS Personal Development System. An iPDS system hosts development languages and low-cost attachments for in-circuit emulation (emulation vehicles) and EPROM programming. Other iPDS options let it run general-purpose CP/M-80 software or use bubble memory for mass storage in harsh environment applications.

GENERAL TOOLS FOR ALL COMPONENT FAMILIES

EPROM Programming Support

Intel offers a full line of EPROM programmers for Intel devices. Through parallel development efforts, Intel is able to provide the earliest programming support for new Intel EPROMs, EEPROMs, KEPROMs and microcontrollers—with the fastest programming algorithms in the industry. The modular architecture of Intel EPROM programmers allows new support to be added with low-cost add-ons, as they become available.

EPLD Development Tools

Intel's iPLDs Programmable Logic Development System makes it easy to use an Erasable Programmable Logic Device (ELPD) in your design. The iPLDS provides all the software, programming hardware, EPLD devices and documentation needed to convert random logic into a fully optimized, tested, and documented device.

The systems software allows you to design at a level you select, from Boolean equation entry, to schematic capture to use of the Logic Builder™, an Intel tool that interactively guides you through design. There's also software for compiling, optimizing, and fitting your logic design into the final device.

AEDIT Text Editior

AEDIT is a full-screen text editor that can be either menu- or command-driven. It offers the ability to switch easily between two files or to view two files simultaneously through windows. Text entry and editing are further simplified through the use of macros, which allow you to save command clusters for later use.

DEVELOPMENT HOSTS

Intel's development tools are available on a selection of industry-standard host systems, giving users of Intel microprocessor and microcontrollers the ability to apply a combination of valuable elements in their development projects:

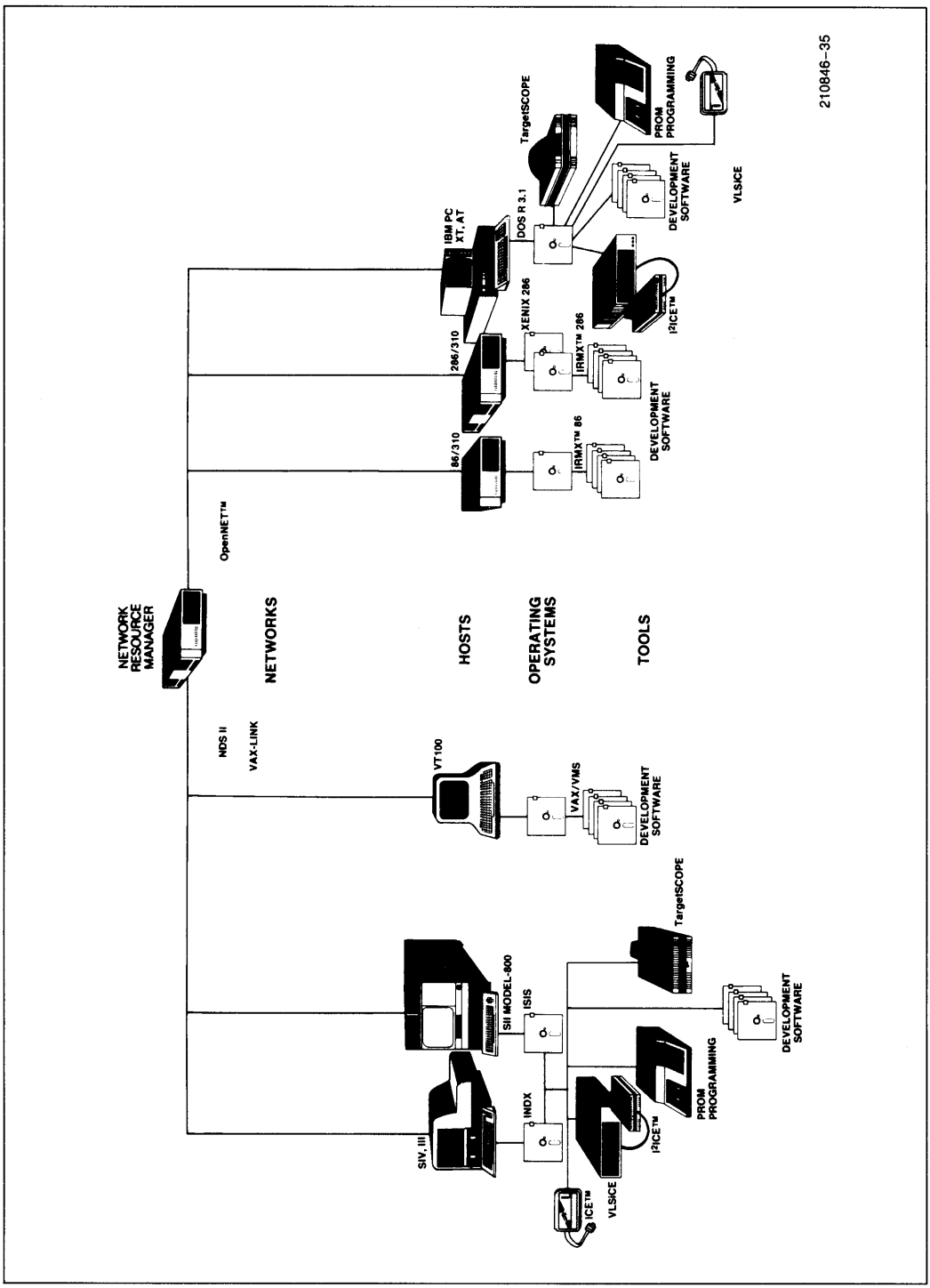
- design and debug tools built around the needs of the specific microprocessor or microcontroller.
- host systems optimized around installed equipment or the experience and needs of the development team.
- dedicated development capabilities of Intel's systems.
- versatility of other industry-standard systems.
- an open network to link tools across the various host environments.

Whether you run the Intel tools on an Intel system, a VAX minicomputer, or a PC AT or XT, the integration work is done before you install the tools on the system—you don't waste time getting the tools ready for the project.

Project Requirement	Host System
The most complete, dedicated, optimized support for Intel development tools	Series IV
Centralized development and project control for large teams, on an industry standard system	VAX/VMS
Versatile, standard, high-performance workstation	PC AT, PC XT
On-target development for system applications	Intel System 286/310 (iRMX™ or XENIX)

Intellec® Series IV

The Intellec Series IV is a new generation development system specifically designed for supporting the iAPX family of advanced microprocessors and the MCS 51 and MCS 96 microcontroller families. It also provides complete support for 8-bit microprocessors. Series IV models include the 8088 and 8085 CPUs with 640K RAM.



Tools Support on NDS II and OpenNET™ Networks