Microcomputer Handbook

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Intel Single Board Computer SBC 80/20 Introduction

Intel Corporation again asserts its leadership

Intel offers the SBC 80/20, an 8-bit unit using its 8080A MOS chip to bring out a 6 3/4-by-12-inch board that holds 2 kilobytes of RAM and 4 kilobytes of ROM and has programmable I/O lines. By adding a package (power supply, front panel, and so on) to these units, they become one-board computers. The SBC 80/10 is pictured in Figure A.1, and the SBC 80/20 in Figure A.2. Schematics of these are not shown, but brief discus-

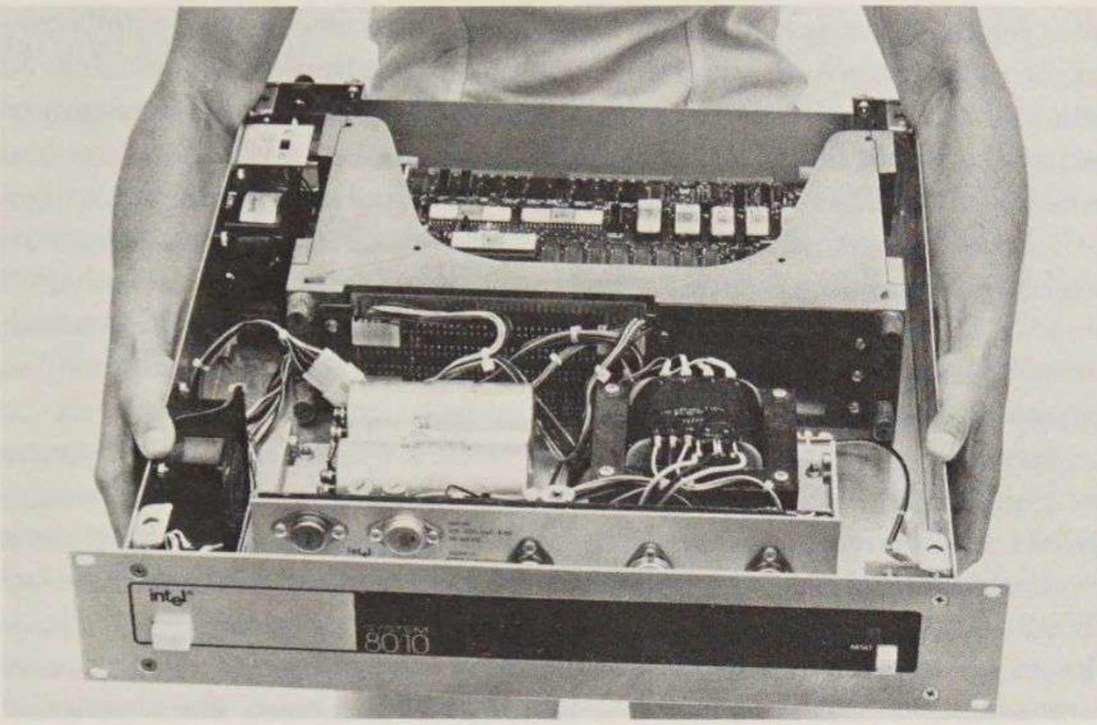
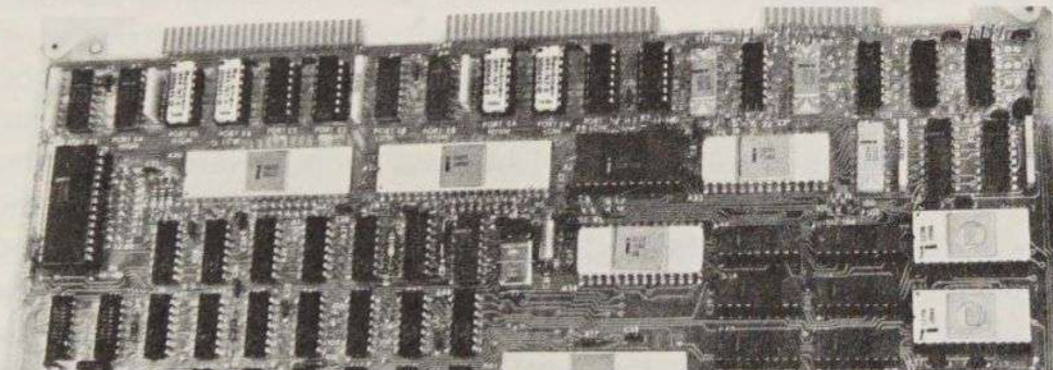


FIGURE A. 1 Intel's new System 80/10 is a completely packaged microcomputer system for OEM applications. Based on the popular SBC 80/10 Single Board Computer, the system also includes a power supply, cooling and OEM front panel. Up to three memory and I/O expansion boards can also be used in the system.

FIGURE A.2 SBC 80/20 System. Intel's second generation Single Board Computer is a complete computer system on a 6.75 by 12 inch printed circuit card. The card contains the central processor, system clock, read/write memory, non-volatile program memory, I/O ports, serial communications interface, multi-master bus arbitration logic, priority interrupt logic, two programmable timers, and expansion drivers. Multiple SBC 80/20's can be interconnected as a multi-processor or distributed processing system.



sions relating to their capabilities follow. The importance of these units cannot be underestimated, and a deep analysis is required. Intel has achieved some extraordinary densities on its basic microprocessor component groups and a very strong line of peripheral chips. It manufactures all the key components on the SBC 80 family and supports the line with development systems, emulators, resident, relocatable and linkable compilers, macro assemblers, text editors, operating systems, and utility programs (see chapter 6). INSITE is the Intel software index and technical user exchange with over 200 contributed programs (in mid-1976), in-depth training courses, an international staff of field application engineers, and so on.

Generally, before the popularity of the new single-board microcomputers, original equipment manufacturers purchased "unpackaged" minicomputer board systems or "start from scratch" components to develop their own dedicated systems. Some packaged minicomputers were sold to solve OEM control problems or to develop information processing systems. However, they were generally expensive, at least for specific purposes, or represented "overkill" by not matching task to machine. The absence of LSI components to implement parallel I/O, serial I/O and bus control functions, and a host of other peripheral, timing, and communication capabilities resulted in the use of relatively complex, expensive, and sometimes unreliable multi-board systems for the most basic OEM requirements. The "start from scratch" alternative, causing the OEM to design and manufacture his own system using effective, low-cost components, is extremely beneficial when those products are manufactured in very large quantities. In this instance the OEM can take advantage of the economies of scale associated with companies that build thousands and hundreds of thousands of systems and subsystems each year, such as those used in games, appliances, calculators, and so on. Although this is attractive for high-volume OEM firms, it is not the solution for low- and medium-volume users. The one-board microcomputers have come to the rescue of these many millions of customers. Like the other one-board complete computer manufacturers, Intel, on its single 6 3/4" x 12" printed circuit boards, offers the SBC 80s that contain all critical computer system functions—the CPU, read/write memory, read-only memory, parallel I/O, and so on, including interrupt networks and bus control functions. This eliminates, for the small and medium OEM, the need to design, develop, debug, and test the total system or subsystem. When volume increases, companies like Intel make the printed circuit board artwork available to them for a minimal license fee and offer attractive volume discounts on all LSI components. The SBC 80/20, the Computer Automation LSI-3/05, General Automation 16/110, Digital Equipment LSI-11, Data General microNOVA, and others all competed with prices well below $1,000 even in single quantity orders, and all offered very heavy discounts for 100 and up.

The Intel 8080A CPU

As previously noted, a computer system's processing and control functions are handled by the central processing unit (CPU). The Intel Single Board Computers use the 8-bit, N-Channel MOS 8080A CPU, which is fabricated on a single LSI chip. The three basic function units of the 8080A—or any CPU—are registers, an arithmetic/logic unit (ALU) and control circuitry.

The 8080A contains six 8-bit general purpose registers and an accumulator. The six registers may be individually addressed or addressed in pairs, providing both single and double precision operators. A 16-bit program counter, which is a special purpose register, allows the 8080A to address up to 65,536 bytes of memory. Another special purpose register is the 16-bit stack pointer which enables the CPU to address any portion of RAM memory as a last-in/first-out stack to store or retrieve the contents of the program counter, flags, the accumulator and any of the six general purpose registers. Use of the stack pointer in conjunction with RAM memory provides subroutine nesting capability which is bounded only by memory size.

The Arithmetic/Logic Unit (ALU) on the 8080A performs arithmetic, logical and shift/rotate operations. Arithmetic and logical instructions set and reset four testable flags, while a fifth flag provides binary coded decimal arithmetic capability. These flags are used to identify the resulting status (e.g., carry, zero, sign, parity) after an arithmetic, logical or shift/rotate operation is concluded. Subsequent program instructions can interrogate the flags and jump to a specified section of the program, depending on the condition of the flags.

Also, in brief review, we have noted that a computer system must have memory capacity for storing the system programs. Non-volatile program storage is usually a necessity, since it eliminates the need to continually reload the program each time the system is "powered up." The SBC 80 Single Board Computers contain sockets for up to 4K bytes of non-volatile read-only memory (ROM) for program storage. The OEM may select either Intel erasable and electrically reprogrammable 8708 EPROMs or masked 8308 ROMs.

Intel 8708 EPROMs provide the capability of altering system program contents during program development. EPROMs may be erased in a matter of minutes by ultraviolet light and reprogrammed. Then, when program development is completed, masked Intel 8308 ROMs may be substituted for volume production. Non-volatile memory may be added to the SBC 80 computers in 1K byte increments up to a total of 4K bytes.

Most computer systems have a requirement for read/write memory to store system data, variable parameters and subroutines that are subject to dynamic change. The SBC 80/20 provides this storage with 2K bytes of read/write (RAM) memory, and the SBC 80/10 provides 1K bytes of RAM memory storage—both using Intel static LSI random/access memories. Power for on-board RAM memory on the SBC 80/20 is provided on an auxiliary power bus, and memory protect logic is included, for battery back-up RAM requirements.

While most OEM applications are resolved with single one-board computers, Intel, like some of its competitors, has developed a variety of peripheral expansion boards designed to help increase memory, I/O requirements, and so on. Originally, six boards were available, two combination boards for read/write memory, ROM/EPROM memory and I/O, a 16K Read-Write memoryboard, and others. To further facilitate the loading, execution and debugging of programs, the System 80/10 includes a comprehensive System Monitor, which resides in two ROMs. Monitor commands include the ability to read and write hexadecimal paper tapes, execute predefined program segments, display and alter memory contents, and display and alter 8080A CPU register contents. Monitor commands and resulting information may be initiated and displayed on a CRT terminal or a teletypewriter. A full description of the SBC 80/10 is presented at this point. It is followed by notes related to the SBC 80/20 with emphasis on the versatility accomplished by adding many on-board Intel LSI peripheral circuits. For example, as is noted ahead, sixteen 80/20s can share system resources. The 80/20 has an eight-level interrupt system while the 80/10 has a single-level interrupt system. Other comparisons are noted later.

The SBC 80/10 is an efficient OEM computer system that uses LSI technology to provide all the essential computer elements—microprocessor, memory and programmable I/O—on one board. All the key components on the SBC 80/10 board are manufactured by Intel. These include the 8080A CPU and its support circuitry, 8111 static LSI RAMs, 8708 EPROMs (erasable and reprogrammable read-only memories), metal-masked 8308 ROMs, an 8251 USART (Universal Synchronous/Asynchronous Receiver/Transmitter) for serial communications interface, and Intel 8255s for parallel peripheral interfaces. Use of these volume-produced Intel LSI components on the SBC 80/10 boards (which are also produced in volume as standard, off-the-shelf computer subsystems) make possible the low unit cost of the Single Board Computers. While individual boards were available from Intel distributors at $495, SBC 80/10 prices reduced to $295 each in quantities of 100 in early 1976 (packaging extra).

Intel has used high-density LSI technology for all computer functions, including I/O and bus control. This eliminates the need for costly additional boards, normally required in computer subsystems to provide non-volatile memory capability, parallel I/O and serial I/O. Expansion is easily accomplished for those applications requiring additional memory or input-output capability. The majority of OEM applications will be solved with a single SBC 80/10 board, but five peripheral expansion boards and a standard modular backplane/card cage assembly are also available. Programs may be written using Intel's high-level language, PL/M®, or 8080 assembly language. In addition, the SBC 80/10 is fully supported with a comprehensive line of hardware and software development aids, which include the Intellec® MDS Microcomputer Development System and its unique ICE-80 In-Circuit Emulator.

Processing power of the SBC 80/10 is sufficient for most OEM products, including industrial process control systems, subsystems of large distributed intelligence control systems, numerically controlled machine tools, automated test instruments, data communications equipment, business machines, desk-top computers, and a variety of commercial equipment. To complement the popular 8080A CPU, which is an 8-bit N-Channel MOS device on a single LSI chip, the central processor subsystem on the SBC 80/10 includes a crystal-stabilized system clock, control buffers for the one-board computer's 16-bit three-state address bus and bi-directional 8-bit three-state data bus, and high-current drivers for expanding memory and I/O via the system bus.

For storing system data, the SBC 80/10 includes eight Intel 8111 static LSI random access (read/write) memory chips. The 8111s provide 1K bytes of RAM memory. Onboard sockets are provided for non-volatile memory of up to 4K bytes. During program development, Intel 8708 EPROMs will generally be selected by the OEM. The EPROMs may be erased by ultraviolet (UV) light in minutes and then reprogrammed. When the OEM system program is firm, masked Intel 8308 ROMs may be substituted for the EPROMs to further economize for high volume production runs. The EPROM or ROM memory may be added in 1K byte increments.

SBC 80/20 single-board micro

What surprised most of the industry and thousands of customers in late 1976 was the Intel 80/20 offering with what was then considered to be "massive" power and capability—and all for about $500 in quantities of 100. Multi-processing, eight-level vectored interrupt capabilities and a host of on-board peripheral chips, with many more now in development, set a target for all others to achieve. It is the "big brother" to the SBC 80/10 that is hard to beat. We have noted that while the 80/10 has a single-level interrupt that may originate from six sources, the 80/20 provides full programmable control for up to eight levels of vectored interrupt—originating from programmable parallel I/O with a USART—or it may be received via the system bus and I/O edge connector. On the 80/20, interrupts can also originate from either of the programmable interval timers. A closer look at some of the timer and bus capabilities is in order.

The Multi-master Bus Control logic provides bus arbitration which allows up to four SBC 80/20's to share the system bus in serial (daisy chain) fashion, and up to 16 SBC 80/20's or high speed controllers may share the system bus with the addition of an external priority network. The bus controller provides its own clock which is derived independently from the processor clock. The bus clock provides a timing reference for resolving bus contention among multiple bus requests. Controllers of different speeds may share resources on the same bus, and transfers via the bus proceed asynchronously. Thus, the transfer speed is dependent on the 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 multi-processor configurations and high-speed Direct Memory Access (DMA) operations, but are by no means limited to these two.

The 8253 programmable interval timer. These timers/counters solve one of the most common problems encountered in OEM computer systems, the generation of accurate time intervals under software control. The usual problems associated with efficient monitoring of external asynchronous events and timing have been virtually eliminated. A fully programmable interval timer, the new 8253 consists of three independent BCD and binary 16-bit counters programmed as I/O peripheral ports. Each of the three counters in the 8253 is initialized via software with the mode and length of the timing desired. On command—the timer counts out the interval and interrupts the CPU when it has completed its task. By assigning interrupt levels to different counters, real time clocks are easily implemented. The third clock serves as the software-selectable baud rate generator. The Programmable Interval Timer is treated by the system software as an array of I/O ports—three serving as counters and a fourth used as a control register for programming. All operational modes are programmable by the systems software.

The 8259 programmable interrupt controller. Another on-board feature of the SBC 80/20 is the new Intel 8259 Programmable Interrupt Controller. This vectored interrupt capability is extremely useful when interrupt service speed is critical. The 8259 can handle up to eight levels of interrupt requests. Programmed by system software as an I/O peripheral, the 8259 allows the user to define interrupt priorities via the system software, so that the manner in which requests are processed by the controller can be configured to match OEM system requirements. The priority assignments and algorithms can be changed or reconfigured dynamically at any time during the main program. This allows the OEM to define his complete interrupt structure as required, based on the total system environment.