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Microprocessors: Where do they fit?

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IN THIS COLUMN, we would like to discuss what a microprocessor is and how it fits into the general scheme of controllers and computers that exists today. Eadie! has defined the term *data processor* as ''A digital device that processes data. It may be a computer, but in a larger sense it may gather, distribute, digest, analyze, and perform other organization or smoothing operations on data. These operations, then, are not necessarily computational. Data processor is a more inclusive term than computer." A *microprocessor* is a single integrated circuit chip that contains at least 75% of the power of a computer. It usually cannot do anything without' the aid of support chips and memory and therefore can be distinguished from a *microcomputer,* which is a full operational system based upon a microprocessor chip. The microcomputer contains memory, latches, counters, input/output devices, buffers, and a power supply, in addition to the microprocessor chip. A microcomputer may be a "black box" with only a single switch: OPERATE/RESET. The 8080 microprocessor chip, a 4o-pin LSI chip, is shown in *Figure* 1. A typical system based upon this chip is shown in *Figure* 2; the 8080 chip is located on the CPU board on the left.

A microcomputer possesses all of the minimum requirements of a computer. For example:

1. It can input and output data, which are usually in the form of digital electronic signals. Common I/O devices include Teletypes, CRT displays, paper tape readers, floppy disks, magnetic tapes, cassette tapes, laboratory instruments, and process control devices.

2. It contains an arithmetic/logic unit (ALU) that can perform arithmetic and/or logic operations such as add, subtract, compare, rotate left, rotate right, AND, OR, negation, and exclusive OR.

3. It contains a mirumum amount of "fast" memory, such as RAM, ROM, pROM, or core, but usually not cards or paper tape, in which data and program instructions are stored. The data and instructions are stored as 4-bit, 8-bit, 12-bit, or l e-bit words.

4. It is programmable. The data and program instructions can be ar-

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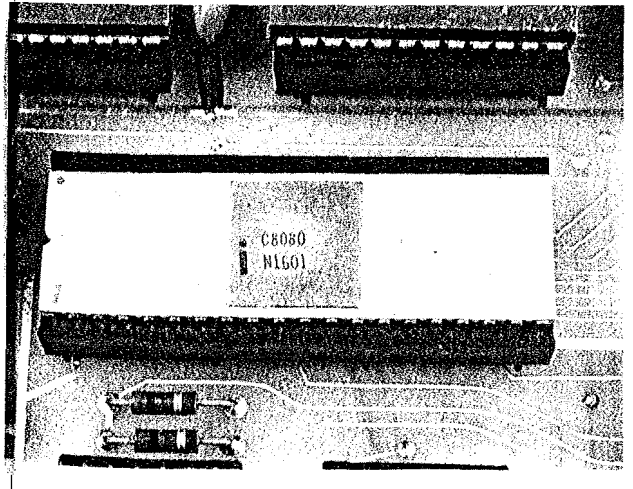

Figure 1 *The 8080 microprocessor chip.*

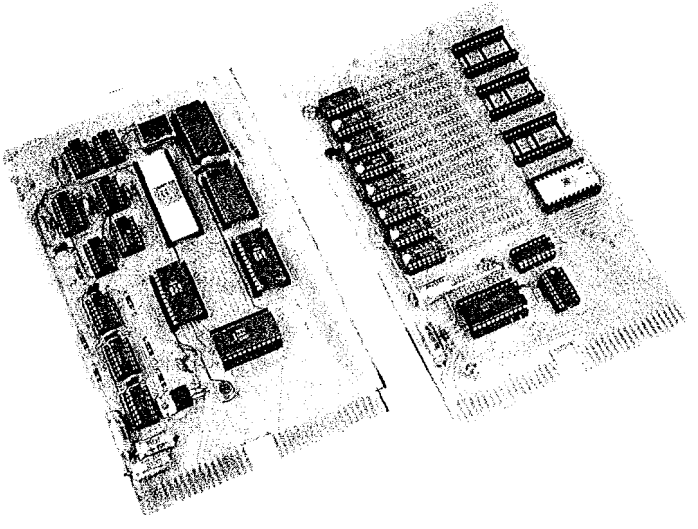

Figure 2 *A typical microcomputer system. Shown on the left is the central processing unit, which consists of input/output buffer chips and miscellaneous control logic. Shown on the right is the microcomputer memory, in this case,* 1 *K of RAM and* 256 *words of ROM. Decoder chips permit the memory to be located anywhere within* 65 *K of microprocessor addressable memory.*

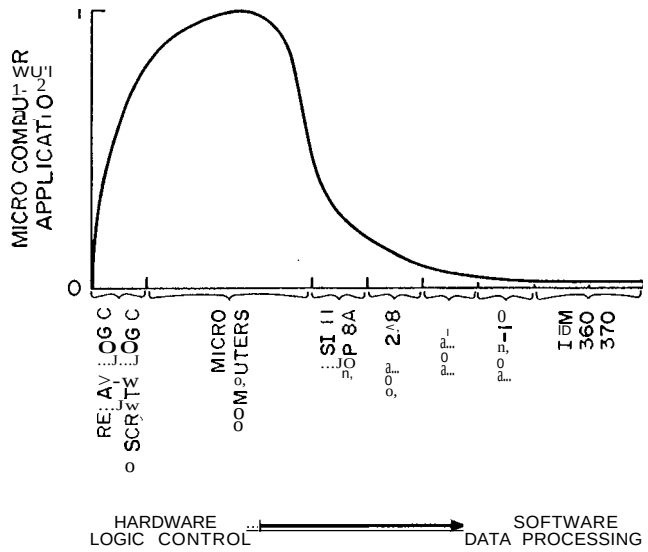

Figure 3 *Where microcomputers fit: between relay and discrete logic and minicomputers.*

ranged in any sequence desired, in contrast to the programmable calculator, in which the precise manner that a keyboard function is executed cannot be changed by the operator,

5. It is fast, with an ability to execute a simple instruction in 10 /lsec or less. All existing microcomputers are digital and TIL compatible, where logic 0 corresponds to ground potential and logic 1 corresponds to +5 v.

There appears to be some misunderstanding concerning the role of current microprocessors and microcomputers relative to other types of computers. The temptation is great to order a modest microcomputer system and then to surround it with $5000 worth of I/O devices such as floppy disks and line printers. In the remaining part of this column, we would like to provide a bit of insight concerning the most likely role of microcomputers. We will do so with the aid of *Figure* 3, which depicts schematically where microcomputer applications fit today, and *Table* 1,* which depicts the spectrum of computer-equipment complexity from simple hard-wired systems to high-performance general data processing equipment.

Microprocessor and microcomputer applications fall between relay logic and discrete random logic (gates and flip-flops) on one hand and inexpensive minicomputers such as the PDP 8A and the LSI II on the other. Microcomputers fabri-

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Table 1

Spectrum of computer-equipment complexity

Word length		2	4	8	16	32	64
Complexity	Hard-wired logic	Programmed logic array	Calculator	Micro-processor	Mini-computer	Large computer	
Application		Control		Dedicated computation		Low-cost general data processing	High-performance general data processing
Cost	Under $100	$1000				$10,000	$100,000 and up
Memory size	Very small, 0-4 words	Small, 2-10 words		Medium, 10-1000 words		Large, 1000-1 million words	Very large, more than 1 million words
Program	Read-only						Reloadable
Speed constraints	Real time	Slow		Medium			Th roughput-oriented
Input-output	Integrated	Few simple devices		Some complex devices			Roomful of equipment
Design	Logic	Logic + microprogram		Microprogram macroprogram			Macroprogram high-level language software system
Manufacturing volume	Large						Small

cated from microprocessor chips are not as sophisticated as some of the popular minicomputers and cannot easily perform certain types of data processing problems. They are simply not set up at this moment to run FORTRAN, COBOL, or other high-level languages. Those microcomputers that can handle high-level languages, in principle, still currently suffer in comparison with minicomputers supplied by Digital Equipment Corporation, Hewlett-Packard, Data General, Varian, and other manufacturers in the amount of high-level software available. If you desire to solve tomorrow's problem, you can consider the purchase of a microcomputer system and develop your own high-level software. If you desire to solve today's problem, pay particular attention to software support. Your time is valuable. Software costs can easily equal and exceed the total hardware costs of your data acquisition system if you are not careful.

For the moment, then, it would be more appropriate to call systems constructed from microprocessor chips *microcontrollers* or *logic processors*. They can sequence events in response to decisions upon input data. As the price of individual microprocessor chips drops from several hundred dollars per chip to ten to thirty dollars per chip, it will be clear that the dominant application for today's microprocessors will be as sophisticated control elements in instruments and machines of all types. We foresee minicomputer-microcomputer and computer-microcomputer hierarchies in which one to twenty instruments, machines, or devices, each containing its own microcomputer, will all be tied to a single minicomputer or computer.

In the next column, we will discuss the anatomy of a microcomputer based upon the 8080 microprocessor chip.

Reference

1. EADIE, D., *Introduction to the Basic Computer* (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1968).