

All About Minicomputers

Minicomputers constitute one of the most widely discussed and written-about subjects in the EDP world today. The steadily decreasing costs and increasing capabilities of these compact, versatile computers are leading nearly every wide-awake businessman and scientist to wonder whether a minicomputer might represent the key to solving some or all of his information processing problems.

But what, exactly, is a minicomputer? Where are they being used? What are the significant features and drawbacks of these machines? How can you tell whether a minicomputer will fit into your own data processing plans? And, if so, which of the many available models represents the best overall choice for you? This report is designed to answer these questions and bring you up to date on the rapidly advancing state of the art in minicomputers. The current offerings of 48 manufacturers are summarized in the accompanying minicomputer comparison charts.

WHAT MAKES A MINI A MINI?

There is some disagreement within the industry as to just what constitutes a minicomputer. Some insiders reserve the minicomputer designation for machines whose mainframes sell for less than \$20,000 (or some other arbitrary figure), and—in keeping with the current fashion terminology—use “midicomputer” for the machines that range from \$20,000 on up to about \$50,000 in purchase price.

Throughout this report, we'll simplify the picture by using the single term “minicomputers” for the whole class of stored-program digital computers which are suitable for general-purpose applications and are priced below \$50,000. Excluded from this survey are the general-purpose data processing systems which are described in detailed reports in the Computer section of DATAPRO 70, as well as the electronic accounting machines which are described in our Feature Report 70F-420-01, *All About Small Accounting Computers*. Conversely, for the sake of completeness, we've included a number of larger computers designed primarily for real-time control and/or communications functions, even though their mainframe prices exceed the \$50,000 mark.

Although the currently available minicomputers exhibit a wide variety of characteristics and capabilities, there are enough similarities and common traits to make it possible to define a “typical minicomputer” whose characteristics are reasonably representative of most of the machines on the market today.

The typical minicomputer is a parallel, binary processor with a 16-bit word length (though 8-bit, 12-bit, 18-bit,

Small, low-cost computers with surprisingly high speeds are proliferating as a result of recent advances in semiconductor and magnetic technologies and mass production techniques. This report describes the characteristics, applications, features, and drawbacks of the current minicomputers. Comparison charts summarize the capabilities of 107 computers from 48 manufacturers.

and 24-bit word lengths are also common). It uses integrated circuits and is housed in a compact cabinet suitable for either tabletop use or mounting in a standard 19-inch rack. It weighs less than 50 pounds, consumes less than 500 watts of standard 115-volt electric power, and requires no special air conditioning. It offers from 4,096 to 32,768 words of magnetic core storage with a cycle time of 0.8 to 1.5 microseconds. Parity checking and storage protection are available as extra-cost options. ➤



The first two members of Interdata's "New Series" exemplify many of the current trends in minicomputer design. Model 70 (bottom) uses a 1-microsecond core memory, while the faster Model 80 employs a 240-nanosecond MOS main memory. Both models utilize LSI circuits and are controlled by microprograms in fast bipolar read-only memories.

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➤ Today's typical minicomputer uses a one-address instruction format and has two accumulators, a single index register, and a multi-level indirect addressing facility. The add time for 16-bit operands is 1 to 3 microseconds. Hardware multiply/divide instructions are optional, as are power-failure protection and a real-time clock or timer. Floating-point arithmetic requires the use of software subroutines.

Input/output operations in the typical minicomputer are facilitated by an optional direct memory access (DMA) channel, which accommodates I/O data rates of up to about 1,000,000 words per second. The typical complement of standard peripheral equipment consists of a disk storage unit, magnetic tape drive, card reader, paper tape reader and punch, line printer, and an assortment of interfaces for communication and control applications.

Software support for today's typical minicomputer is limited to a symbolic assembler, a Basic FORTRAN compiler, a simple batch-mode operating system or real-time monitor, and a modest assortment of utility routines. And the list purchase price of the basic system, including 4,096 words of core storage, is likely to be under the \$5,000 mark, with liberal discounts available to quantity purchasers. By all previous standards of value in the computer field, it's a truly impressive little package of computing power for the price.

THE MINICOMPUTER INDUSTRY

Estimates of the current worldwide minicomputer market volume range from about \$300 million to \$450 million a year. These figures include peripheral equipment and software; minicomputer mainframes alone are believed to account for \$75-100 million. Precise figures are nearly impossible to obtain because of the widespread differences of opinion as to what constitutes a minicomputer.

Nearly 40,000 minicomputers are already in use around the world, and more than 80% of these are in the United States. International Data Corporation estimates that 11,600 "dedicated application computers"—mostly minis—were shipped worldwide during 1971, and looks for this figure to increase to 17,000 in 1972.

Minicomputers still represent only a small slice of the \$13 billion total U.S. market for computer-related products and services, but the minicomputer segment is expected to continue its rapid growth. Estimates of worldwide minicomputer market volume in 1975 range from \$700 million to an even \$1 billion.

Digital Equipment Corporation, the company that started the minicomputer boom in the mid-sixties with its highly successful PDP-8 line, is still the undisputed king of the minicomputer field. DEC has delivered more than 19,000 computers to date and still commands roughly a 35

percent share of the minicomputer market. Rounding out the "big five" among the minicomputer builders are Honeywell, Hewlett-Packard, Varian, and Data General. Each of these companies has already delivered more than 2000 minicomputers—and Data General managed the unprecedented feat of delivering its 2000th computer less than three years after shipping its first computer, the Nova, in February 1969.

In the second echelon of minicomputer makers are aggressive, innovative young companies such as Computer Automation, General Automation, Interdata, and Microdata. Minicomputers are also being built by divisions of large, well-established companies such as Bendix, General Telephone and Electronics, Lockheed, Raytheon, Texas Instruments, and Westinghouse. And then there are dozens of comparatively small, unproven companies whose survival will depend upon their ability to back up their imaginative hardware ideas with effective marketing, production, software, and customer support.

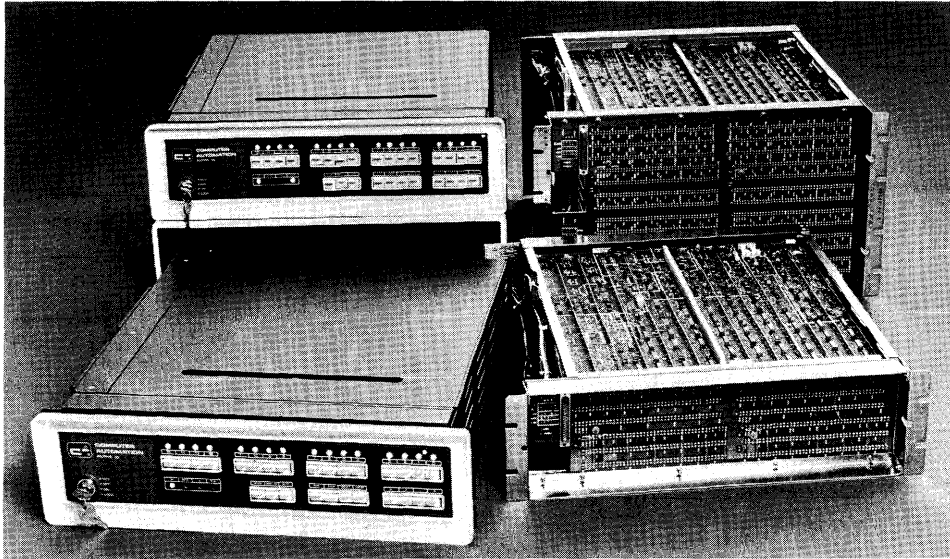
IBM—the undisputed leader in most other segments of the computer field—is still playing only a minor role in the minicomputer market. The IBM System/7, announced in October 1970, is a fast 16-bit machine that features a semiconductor main memory. Although the System/7 has the hardware capabilities of typical general-purpose minicomputers, IBM is marketing it only for "sensor-based" applications in data acquisition, process control, and laboratory and plant automation. No peripheral equipment or software to support the System/7's use in general-purpose scientific or business applications has been announced to date.

In all, approximately 50 companies are now marketing minicomputers in the United States. The current offerings of 47 of these manufacturers are summarized in the accompanying comparison charts.

Minicomputer builders are gradually realizing that the buyers for their wares generally fall into three basic categories:

- Original equipment manufacturers, who incorporate the minicomputers into their own products or systems and are primarily interested in adequate performance at minimum cost.
- Knowledgeable end users, who demand the availability of peripheral equipment, software, and manufacturer support that will enable them to implement their own applications.
- Comparatively unsophisticated end users, who want complete systems programmed and installed on a "turnkey" basis. ➤

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This quartet of Computer Automation minis illustrates two significant trends in minicomputer packaging. The Naked Mini 16 (right foreground) is a low-cost OEM version of the Alpha 16 at left, stripped of power supply, console, and case. The "Jumbo" versions of the Alpha 16 (left rear) and Naked Mini 16 (right rear) employ larger cabinets that can hold up to 32K words of core memory and up to 12 plug-in peripheral interface modules.

➤ Just a few years ago, nearly all minicomputer sales were to buyers in the first, or OEM, category. Now most of the minicomputer builders are placing increasing emphasis upon the end-user market, which is potentially far more lucrative—but also far more costly to enter and support.

MINICOMPUTER TRENDS

The aggressive competition for minicomputer buyers' dollars continued to drive prices downward during the past year. DEC, Data General, Electronic Associates, General Automation, GRI Computer, Interdata, Texas Instruments, and Varian all introduced new minicomputers which are program-compatible with their earlier models and feature substantially lower price-tags and/or improved performance. Many other minicomputer builders took an even more direct approach by slashing the prices of their current models. As this report went to press, there was no sign that minicomputer prices have yet reached bottom. Thus, the careful buyer will almost certainly continue to get steadily increasing power per dollar.

Another result of the highly competitive market, particularly within the OEM segment, has been the recent advent of numerous "stripped-down" or custom-tailored minicomputers.

Computer Automation's Naked Mini 8 and 16 are low-cost OEM versions of the firm's general-purpose Alpha 8 and Alpha 16 minicomputers, respectively. The Naked Minis are supplied without chassis, power supply, or console, and are designed to be "buried" within and powered by equipment produced and sold by other companies. They are offered in minimum quantities of 10 units, at a price (including 4K words of 1.6-microsecond core memory) of only \$1,975 for the 8-bit model or \$2,500 for the 16-bit model.

DEC's PDP-16 and the SYS 500, 1000, and 1500 microprocessors are custom-designed to each buyer's specifications through the use of specialized computer programs. Thus, DEC and SYS can produce programmed controllers that give each buyer exactly the hardware he needs to handle his particular application, without forcing him to pay for components he may not need. The PDP-16 can be built with a word length of 8, 12, or 16 bits, features add times in the 400 to 500 nanosecond range, and offers several types of read-only or read/write memory—or no memory at all.

Lockheed's SUE (System-User-Engineered) minicomputer is billed as a "micro-modular" computer. Each functional module—processor, memory, or device controller—is on a pluggable multilayer circuit card. The modules are independent, asynchronous, and designed with compatible interfaces that enable them to be combined in a wide variety of configurations. Three types of memory modules—core, read-only LSI, and read/write LSI—can be freely intermixed, and up to four independent processors can be used in a single system.

The long-promised concept of a "computer on a chip" moved a large step closer to reality with Intel's introduction of a line of standard LSI chips that can be combined to form computers which are extremely small in size and low in cost. The Intel MCS-4 Microcomputer is composed of only four kinds of chips. Three of these chips—a processor, shift register, and read/write memory—are standard designs, while the fourth—a read-only memory—is programmed to the user's specifications. Prices of the individual chips range from \$3 to \$30 each in lots of 100, and a complete microcomputer with 4K four-bit words of read/write memory lists for only \$900.



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Data General's SEMINAR 5 time-sharing system, based upon a 24K Nova 800 minicomputer with both fixed-head and moving-head disk storage units, can serve up to 16 simultaneous users at remote teletypewriters. Designed for high schools and colleges, it exemplifies the "packaged" systems that the larger minicomputer builders are developing to increase their penetration of end-user markets.

▷ Semiconductor main memories are being used in a number of the recently announced minicomputers, with both MOS and bipolar LSI technology in evidence. But most minicomputer builders are still exhibiting an understandable reluctance to turn away from the traditional (and highly reliable) core memories. The turning point probably came in October 1970, when IBM gave its full endorsement to semiconductor memories by employing them in both its medium-scale System/370 Model 145 computer and its System/7 minicomputer. It now appears to be only a matter of time before the continuing demand for higher performance at lower cost will cause most minicomputer builders to make the switch from core to semiconductor memories. And the industry-wide trend toward the use of LSI (large-scale integration) technology for logic circuits is certain to continue for the same reasons.

Peripheral equipment designed specifically for minicomputers continued to proliferate during the past year. DEC reinforced its position as the industry leader by adding a wide variety of new terminals, disk drives, tape

units, and other devices to its growing product line, and the other major minicomputer builders followed suit. In addition, dozens of small independent firms announced disk, drums, cassette tape units, card readers, CRT displays, and many other products whose capabilities and prices are oriented toward the minicomputer buyer's needs and budget. Here again, the careful buyer can get more for his money than ever before.

The developers of proprietary software and systems are increasingly designing their wares around minicomputers. As a result, minicomputer-based systems are now available to handle a wide range of specialized applications in both the scientific and business fields. DEC, for example, currently offers computer-based systems to handle real-time data acquisition, message switching, line concentration, signal averaging, typesetting, chromatography, numerical control, pulse-height analysis, clinical laboratory analysis, graphic displays, vocational training, accounting for office-products distributors, etc. Other minicomputer builders and independent software firms offer other "packaged" systems designed to handle these applications and many more.

Among the most popular minicomputer-based systems are the in-house time-sharing systems. Hewlett-Packard has long been the leader in this area, but now DEC, Data General, and other suppliers are also offering economical systems designed to distribute the problem-solving capabilities of a minicomputer among a number of simultaneous users seated at individual teletypewriter or CRT terminals. Many companies are discovering that these in-house time-sharing systems can satisfy their computational needs at a substantially lower cost than the commercial time-sharing services.

MINICOMPUTER APPLICATIONS

Most of the currently installed minicomputers are being used in industrial control and laboratory instrumentation. These are the areas where it all began. The minicomputer boom started when it became apparent that the impressive recent advances in semiconductor and magnetic technologies had made it possible to construct general-purpose computers at a lower cost than the single-purpose, hard-wired controllers which were formerly used in these specialized applications. The added flexibility of stored-program computer control was a welcome bonus that helped to ensure the rapid acceptance of the minicomputers.

During the past five years, the capabilities of the minicomputers have been steadily increasing, while their costs have been decreasing in equally rapid fashion. The proliferation of these small, economical, and surprisingly fast computers has led to an ever-widening range of applications for them. ▷

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➤ Among the largest current markets for minicomputers are industrial control, research, data communications, and education. Specific applications in which minicomputers are already being widely and successfully used include:

- Process control
- Numerical control of machine tools
- Direct control of machines and production lines
- Automated testing and inspection
- Telemetry
- Data acquisition and logging
- Control and analysis of laboratory experiments
- Analysis and interpretation of medical tests
- Traffic control
- Shipboard navigation control
- Message switching
- Communications controllers for larger computers
- Communications line concentrators
- Programmable communications terminals
- Peripheral controllers for larger computers
- Control of multistation key-to-tape/disk systems
- Display control
- Computer-aided design
- Typesetting and photocomposition
- Computer-assisted instruction
- Engineering and scientific computations
- Time-sharing computational services
- Business data processing

MINICOMPUTERS FOR THE BUSINESSMAN

Conventional business data processing applications, which represent by far the largest potential market for the minicomputers, have thus far proved to be an elusive target. Theoretically, the minicomputer's capabilities and economy should make it an ideal solution to the information processing needs of nearly every small business. In retail stores of all kinds, a minicomputer could handle the bookkeeping, inventory control, labeling, billing, payroll, and a variety of other useful functions—and it could do all this at roughly the cost of a single clerk. Yet minicomputers have barely begun to make a significant impact in the business world.

The problem, of course, is software. Despite claims to the contrary, programming for the minicomputers is no easier than programming for the larger, general-purpose data processing systems. In fact, the minicomputers' short word lengths, limited storage capacities, and lack of sophisticated software aids tend to make the program-

mer's job even more difficult. As a result, it is common in minicomputer applications for programming costs to far exceed the cost of the hardware itself.

Even if small businessmen were willing to pay the price of the software required to solve their problems, they would find it hard to get from most of the current minicomputer builders. In general, the manufacturers have oriented their marketing efforts toward the comparatively sophisticated engineering and scientific markets, which are equipped to design the systems and write the programs required to accomplish their goals with a minimum of assistance from the manufacturer. In fact, the great majority of minicomputers are still being sold in quantity, on an OEM (original equipment manufacturer) basis, to other companies which incorporate them into a wide variety of devices and systems for various end-user markets. It's no secret that mass production is the key to success for the minicomputer builders, and OEM sales represent the quickest route to maximum volume with a minimal investment in marketing, software development, and customer support. As a result, the businessman who is interested in buying a single minicomputer won't receive much encouragement or aid from many of the manufacturers.

But help for the poor businessman is definitely on the way, in the form of three significant recent trends.

First, several manufacturers have introduced minicomputer systems designed primarily for business data processing applications. The Cascade 80, the Clary Datacomp 404, the Eldorado 140/200, and the Qantel Q Series are all capable of performing arithmetic on variable-length operands and feature business-oriented software. It is likely that more of the minicomputer builders will recognize the great potential of the business data processing market and develop systems with a similar design orientation.

Second, the larger minicomputer builders are directing an increasing proportion of their marketing efforts toward the end-user market. It has become clear that their potential for growth and profitability will be severely limited until they can supply the peripheral equipment, software, and service required to support individual user installations in the same manner as IBM and the other major computer makers. Therefore, DEC, Varian, Hewlett-Packard, Data General, and other manufacturers are strengthening their support staffs and developing peripheral devices and software facilities that equip their computers to serve in a variety of specific applications, including business-oriented ones.

Third, the availability of the minicomputers has led to the emergence of a new group of computer entrepreneurs: "middlemen" who use the minicomputers as the central components of integrated hardware/software systems designed to handle specific applications. Dozens of com- ➤

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▷ Companies have entered this business within the past three years; most of them, unfortunately, are quite small, young, and unproven. They offer packaged systems to handle a wide range of applications, such as general accounting, billing, order processing, inventory control, payroll, text editing, hospital data processing, credit authorization, stock brokerage accounting, and many more. These middlemen are accelerating the minicomputer boom by penetrating new markets and making it easier for unsophisticated users to get started in EDP.

These trends, together with the steadily decreasing price-tags of the minicomputers themselves, make it clear that the minicomputers will soon be making their presence felt in the business data processing world. At the same time, enough problems remain to be solved to make it safe to predict that the widely-discussed day when there will be a computer in every store—and perhaps in every household as well—is still quite a few years away.

MINICOMPUTER CHARACTERISTICS

The key functional characteristics of 107 commercially available minicomputers from 48 manufacturers are presented in the accompanying comparison charts. Nearly all of the information in the charts was supplied and/or verified by the 48 manufacturers during April and May of 1972; their close cooperation with the Datapro Research staff in the preparation of these charts is greatly appreciated.

The chart entries and their significance to potential minicomputer users are explained in the following paragraphs, together with some useful guidelines for selecting the most suitable minicomputer for your application.

Data Formats

Probably the single most important distinguishing characteristic of a minicomputer is its *word length*; i.e., the number of bits (binary digits) that can be stored in or retrieved from main storage during a single cycle. In general, the longer the word length, the greater the efficiency and accuracy of a computer's internal operations—and the higher its price tag. Most of the minicomputers currently on the market have a 16-bit word length; this size neatly accommodates two 8-bit characters and has been shown to yield an attractive balance between economy and performance for many applications. Other widely used models have word lengths of 8, 12, 18, or 24 bits. The 8-bit minicomputers are suitable for many functions where low cost is more important than high precision or sophisticated instruction repertoires—and they can be particularly effective when extensive manipulation of 8-bit bytes must be performed.

For most minicomputers, the *fixed-point operand length* is the same as the word length. Some machines, however, have “extended precision” facilities which enable them to handle arithmetic operands two or more words in length. For many applications, extended precision arithmetic is a valuable feature that helps to overcome the limitations upon number range and accuracy which are otherwise imposed by the short word lengths used in most minicomputers. Some of the 8-bit minicomputers are really byte-oriented machines, designed for efficient processing of variable-length operands composed of one or more 8-bit bytes.

Instruction length is one word in most computers, but some are capable of using instructions which are two or more words in length. In most two-word instruction formats, the first word defines the operation to be performed and the second word contains the address of the required operand. The use of two-word instructions greatly increases the number of storage locations that can be directly addressed. This in turn simplifies programming—but the simplification is usually gained at the expense of two words of storage space to hold each instruction and two memory cycles for each instruction retrieved for processing.

Main Storage

The storage type used in the great majority of the current minicomputers is magnetic cores. Though semiconductor memories began to appear in commercially available minicomputers late in 1970, most minicomputer designers are continuing to choose core storage because of its demonstrated ability to satisfy all reasonable requirements for performance, reliability, and economy. It is likely, however, that the demand for higher performance at lower cost, together with forthcoming improvements in semiconductor technology, will accelerate the trend toward the use of semiconductor memories.

In addition to, or in place of, their standard, alterable main storage units, some minicomputers use read-only memories for one of two functions: to provide fast-access, indestructible storage for vital programs, or to hold the microprograms which define the instruction repertoires of some machines. Where read-only memories are used, their characteristics and functions are described in the “Comments” entries at the bottom of the comparison charts.

The *cycle time* for a storage device is the minimum time interval that must elapse between the starts of two successive accesses to any one storage location. Main storage cycle times for the minicomputers shown in our charts span the range from approximately 0.2 to 3 microseconds. Though cycle time ranks with word length as one of the most significant individual indicators of a computer's performance potential, it is definitely *not* safe ▷

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▷ to assume that the computer with the fastest cycle time will be the best overall performer in a particular application. Other parameters that have an important effect on a minicomputer's performance include the flexibility and power of its instruction repertoire, the number of storage cycles it requires to execute each instruction, its input/output capabilities, etc.

Our comparison charts show the amount of main storage available for each computer in terms of the *minimum capacity* and *maximum capacity*, expressed in words. In the great majority of cases, storage is available in all the usual binary increments of capacity. Thus, if a computer has minimum and maximum storage capacities of 4,096 and 32,768 words, respectively, it's safe to assume that capacities of 8,192 and 16,384 words are also available.

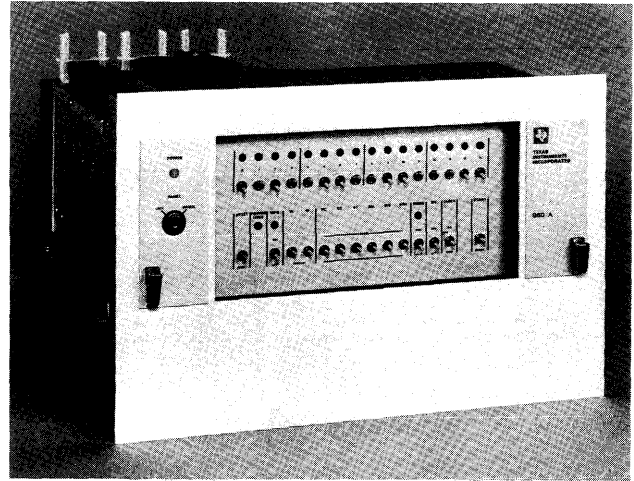
The indicated price differentials between similar computers equipped with 4K and 8K words of storage make it clear that core storage is one of the costliest elements of the current minicomputers. Therefore, it's important to choose the right storage capacity: enough to hold your largest program and all associated subroutines and data, but not too much more than that. It's also wise to make sure that your computer's main storage capacity can be expanded if necessary, preferably by simply plugging in an additional storage module.

Parity checking is a standard feature of some minicomputers and an extra-cost option for others. In still other cases, the manufacturers maintain—with some justification—that the reliability of modern magnetic core memories is so high that parity checking is an unnecessary luxury unless absolute accuracy is a must. Parity checking requires the addition of one more bit to each main storage location. This added bit is set to the appropriate value (0 or 1) whenever a word is written into main storage and checked each time the word is read out; the technique permits detection of most, though not all, read and write errors.

Storage protection is a feature that prevents unauthorized writing in certain areas of main storage. The protection can be accomplished by hardware means, software means, or a combination of both. Though unnecessary in simple dedicated systems, an effective storage protection scheme is an essential element in multiprogramming and time-sharing environments.

Central Processor

Although there are many variations in their internal architecture, the great majority of currently available minicomputers use parallel, binary processors with single-address instructions and fixed word lengths of 8, 12, 16, 18, or 24 bits.



A price/performance leader among the current crop of minicomputers is the 16-bit Model 960A from Texas Instruments. Its price, with 4096 words of 750-nanosecond semiconductor main memory, is just \$2,850 in quantities of 1 to 100.

In single-address computers, *the number of accumulators* can have a significant effect upon internal flexibility and processing power. An accumulator is a register that holds one operand and permits various arithmetic and logical operations to be performed upon it (e.g., a second operand might be added to the operand contained in the accumulator, with the sum replacing the first operand in the accumulator). In computers with multiple accumulators, instructions involving operands in two of the accumulators can often be executed more rapidly than instructions which require the retrieval of an operand from main storage.

Indexing is an important form of address modification in which the contents of a special register called an index register are added to the machine address contained in an instruction prior to its execution. An effective indexing scheme is particularly desirable in minicomputers, since it can help to compensate for their limited direct addressing capabilities. The *number of index registers* serves as an indication of a computer's programming flexibility and efficiency. Prospective buyers should note, however, that there are wide variations in the indexing schemes used in current minicomputers. It is important to determine whether the index registers are separate hardware registers or simply reserved locations in main storage, whether special instructions are provided for loading, incrementing, and testing the index registers, and how much additional time (if any) indexing adds to the instruction execution times. It should also be noted that many of the current computers use "general registers" which can serve as either accumulators or index registers. ▷

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Digital Computer Controls caused a stir in the minicomputer world by building machines that offer both plug and program compatibility with the popular DEC PDP-8 and Data General Nova computers. The D-112 shown here is a direct replacement for the PDP-8, while the D-112H offers higher speeds and an expanded instruction set.

➤ The number of directly addressable words of main storage is an important characteristic that may require some explanation if you're investigating minicomputers for the first time. The problem is that the short word lengths impose serious limitations upon the number of bits that can be assigned to hold the address part of each instruction. A typical 16-bit minicomputer instruction might consist of three parts: operation code, address mode field, and the address itself. If 6 bits are assigned to hold the operation code (permitting up to 64 distinct operations) and 2 bits are used to designate the addressing mode (permitting specification of indexing and/or indirect addressing), then only 8 bits are left to hold the address field. Since these 8 bits permit direct addressing of only 256 distinct memory locations, it is clear that other means will need to be employed to access most regions of the computer's main storage. The most common solutions to the problem are the use of multi-word instructions, indexing, and/or indirect addressing.

Indirect addressing is an address modification technique in which the address part of an instruction specifies a storage location that contains another address rather than the desired operand itself. This second address may in turn be either the address of the desired operand or another indirect address; the latter case is called multi-level indirect addressing. Indirect addressing permits the use of an entire word to hold an operand address. It can also simplify programming and speed up execution times in some applications by making it possible to change the effective addresses of numerous instructions by altering

the indirect address in a single storage location. Each level of indirect addressing, however, usually requires one additional storage cycle of execution time.

Although it is undeniably dangerous to make inferences about a computer's overall performance capability on the basis of instruction execution times, our charts show the basic *add time* to give a first-level indication of fixed-point arithmetic speeds. In general, the indicated add times are the times required to retrieve a one-word operand from main storage and add it to another operand already contained in an accumulator, with no indexing or indirect addressing. Comparisons based on add times can easily be misleading, however, because of differences in word lengths and instruction repertoires.

Hardware multiply/divide facilities are standard in some minicomputers and optional in others. When no hardware facilities are present, multiplication and division must be performed by means of programmed subroutines at a significant reduction in execution speeds. Many minicomputer applications, however, impose little or no need for multiplication or division operations, and in these cases the hardware facilities would be superfluous.

Hardware floating point facilities are quite rare in the currently available minicomputers, despite the fact that floating point arithmetic is highly desirable, if not essential, in many scientific applications. Where available, these facilities can dramatically reduce the execution times for certain programs by eliminating the need for time-consuming floating point subroutines.

Hardware byte manipulation is the ability to conveniently process information expressed in the 8-bit character codes which are rapidly becoming an industry standard. Obviously, most of the 8-bit minicomputers are effective byte manipulators, and many of the 16-bit machines offer special instructions that permit either half of a word to be addressed and processed as an 8-bit byte.

Immediate (literal) instructions in some minicomputers permit savings in both storage requirements and execution times. An immediate instruction uses its address field to hold the operand itself rather than the address of the operand, thereby saving both the storage space that would normally be required to hold the operand and the time required to access it.

Power failure protection is a vital feature in many real-time applications. This facility provides for a safe shutdown of the computer, without destruction of the contents of its main storage or hardware registers, whenever a power failure occurs. Power failure protection is often combined with an automatic restart capability that enables the computer to get back into operation without human intervention when the power supply is restored.

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➤ A *real-time clock or timer* is another essential element in most "time-conscious" systems. A real-time clock enables the program to determine the time of day, while an interval timer usually indicates the amount of time that has elapsed since the occurrence of some significant event. In many cases the timer can trigger an interrupt signal when a predetermined interval of time has elapsed.

Input/Output Control

I/O word size is the "width" of a computer's input/output data channels in terms of the number of bits of data which are transferred in parallel. In most cases this is the same as the machine's basic word length. *I/O word size* can have an important effect upon the cost and complexity of interfacing non-standard peripheral devices to a minicomputer. The machines with an 8-bit *I/O word size* can interface conveniently with most of the input and output devices on the market today.

A *direct memory access channel (DMA)* permits direct transfers of *I/O data* between main storage and a peripheral controller. When a DMA channel is used, the *I/O data* bypasses the computer's main hardware registers, and the *I/O operation* proceeds independently of program control once it has been initiated by the program. In minicomputers that lack a DMA channel, *I/O data* transfers are generally carried out under direct program control, with each word being transferred by way of the processor's registers. Generally speaking, the DMA channel has two significant advantages over program-controlled *I/O*: it can accommodate higher *I/O data* rates, and it causes far less interference with internal processing operations. Regardless of the type of *I/O control* they employ, most minicomputers can accommodate multiple *I/O devices* and include appropriate facilities for addressing the desired device.

Maximum I/O data rate, expressed in words per second, is a measure of each computer's potential ability to transfer data to and from peripheral devices or other external sources. In machines equipped with a DMA channel, the maximum *I/O rate* frequently equals the cycling rate of the main storage unit. These maximum *I/O rates*, however, can be quite deceptive in the case of minicomputers. In general, their storage capacities are limited, their capabilities for simultaneous input/output operations are restricted, and fairly complex programming is associated with *I/O operations*. For all these reasons, *I/O data rates* approaching the indicated maximum rates can usually be handled only in short bursts, if at all.

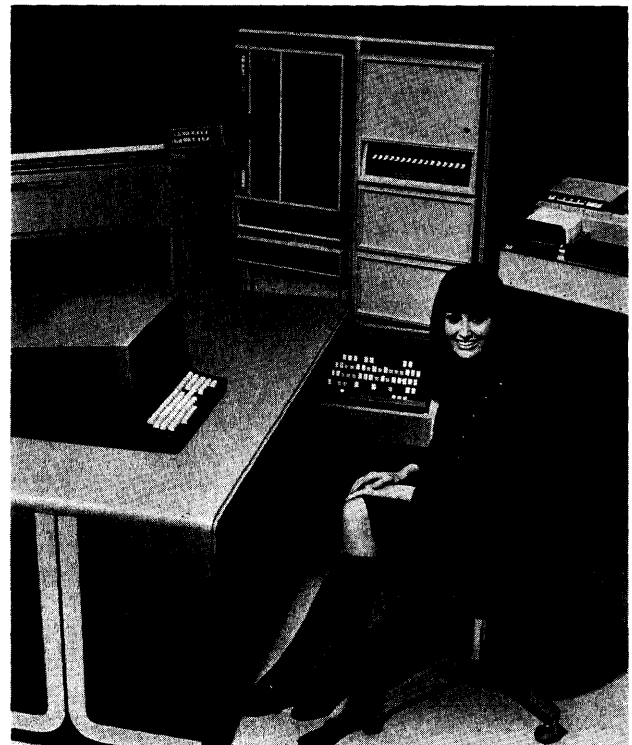
An effective *program interrupt* facility is a requirement for virtually all applications of a real-time nature. An interrupt is a signal that causes a temporary suspension of normal program execution so that the particular condition that caused the interrupt can be dealt with. Interrupts fall into two basic categories: internal and external. Internal interrupts are usually triggered by conditions such as a

memory parity error, an illegal instruction, or a power failure. External interrupts usually indicate that a particular peripheral device requires attention or has completed an *I/O operation*. An interrupt usually results in automatic storage of the current contents of the instruction counter, followed by a transfer of control to a software routine that determines the cause of the interrupt and initiates the appropriate action.

The *number of external interrupt levels* provides a reasonable indication of the power of a minicomputer's interrupt system. It shows the number of different external devices whose interrupt signals can be identified by the processor—though it should be noted that this identification process may require a fairly complex and time-consuming sequence of instructions. Many of the minicomputers offer additional external interrupt levels as extra-cost options, and in these cases our charts show the available range, from minimum to maximum.

Peripheral Equipment

The comparison charts summarize the standard peripheral devices that are available for each minicomputer. (Space limitations preclude a detailed treatment of minicomputer peripheral equipment in this report; comprehensive coverage of this important area will be provided by a series of forthcoming DATAPRO 70 Feature Reports which are now in preparation.) ➤



More than a minicomputer, Hewlett-Packard's HP 3000 is a disk-based multiprogramming system that can handle time-sharing, real-time processing, and conventional batch processing simultaneously. System prices range from about \$100,000 to \$300,000.

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▷ Users who are accustomed to larger general-purpose computer systems will find that the term “standard peripheral device” often has a somewhat different meaning when used by a minicomputer manufacturer. Since few of the minicomputer makers produce their own peripheral equipment, the indicated availability of a given type of device may simply mean that an appropriate interface is available to couple the computer with a peripheral unit supplied by some other manufacturer. Therefore, prospective buyers should ask these questions about each item of peripheral equipment they will need:

- Has it actually been installed and used with the computer of interest?
- If so, what has the users' experience been?
- What software support is available?
- Who will provide service for the device, and under what conditions?

The charts indicate the availability of three different types of disk and drum storage units. *Disk pack storage* is now the most popular type of random-access storage in larger computer systems; the interchangeable disk packs are suitable for either random or sequential processing. *Non-interchangeable disk storage* frequently provides larger on-line storage capacities at a lower cost per bit, though it lacks the operational flexibility of the interchangeable disk packs. *Drum storage* tends to provide faster access times and data transfer rates than the disk units, usually at a higher cost per bit.

Disk and drum storage units can greatly expand the scope of practical applications for the minicomputers by compensating for their limited main storage capacities. Cost, however, is likely to be a serious problem, since most of the currently available disk and drum units cost more than the minicomputers themselves. What's more, software support for the available disk and drum units is still fairly rare.

Magnetic tape speed is expressed in characters per second for those minicomputers that offer magnetic tape I/O. Most of the available tape units use standard 1/2-inch tape in IBM-compatible 9-track and/or 7-track formats, though there is also a growing trend toward inexpensive cassette units.

Punched card input and output speeds for standard 80-column cards are expressed in cards per minute. (Readers and punches for IBM's compact new 96-column cards have not yet found much acceptance among minicomputer builders or buyers.)

Where paper tape I/O devices faster than the ever-present Teletype ASR units are available, these *high-speed paper*

tape input and output speeds are expressed in characters per second.

Other standard peripheral devices, such as line printers, plotters, and display units, are briefly identified on the charts. Space does not permit listings of the extensive lines of communications interfaces, real-time interfaces, and analog/digital and digital/analog converters offered by many of the minicomputer builders.

Software

This section of the comparison charts summarizes the major software items offered by the manufacturer of each minicomputer. In addition to the items listed in the charts, most manufacturers also offer utility routines to handle input/output operations, mathematical functions, program loading, and diagnostic operations. Software packages for specific applications, however, are still quite rare. Prospective buyers should carefully note whether the software they will require is included in the basic price of the computer or offered at extra cost.

An *assembler* is the one essential software item that is available for nearly every minicomputer. The assembler simplifies machine-language programming by permitting the use of mnemonic operation codes and symbolic addresses. Most assemblers also provide pseudo-instructions which control the assembly process and allocate storage space for constants and data.

One-pass and two-pass assemblers each offer certain advantages. A “pass” generally means a scan of the full source program during the assembly process. A one-pass assembler saves assembly time, but certain programming restrictions are imposed by the fact that all storage must be allocated at the beginning of the assembly process. A two-pass assembler builds a symbol table during the first pass and generates the machine-language object program during the second pass; this technique tends to be slower but more powerful. Both one- and two-pass assemblers are available for some machines.

A *macro assembler* is an assembler with the added capability to substitute a predetermined sequence of machine instructions for each “macro instruction” that appears in the source program. Macro facilities can simplify programming by making it easy to include subroutines to handle input/output, evaluation of functions, and other frequently encountered operations.

A *compiler* converts source programs written in a procedure-oriented language such as FORTRAN into machine-language object programs. Although compilers can greatly reduce programming time requirements for many applications, they have not been widely used with minicomputers to date for two principal reasons. First, most minicomputers have been used in specialized appli- ▷

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➤ cations where relatively few programs are required but where high operational efficiency (which is difficult to achieve with compilers) is important. Second, the compilation process itself requires more storage space than many of the minicomputers provide. The trend toward ever more diversified applications for the minicomputers, however, is leading to steadily increasing use of compilers. Most of the available compilers are batch-oriented, but a few are designed for interactive, conversational-mode operation.

FORTRAN is by far the most widely implemented compiler language for the current minicomputers. FORTRAN has been the most popular scientific programming language for more than a decade, and it has been successfully used for many business applications as well. There are many different versions of the FORTRAN language, but conversions of FORTRAN programs from one version to another are usually comparatively simple.

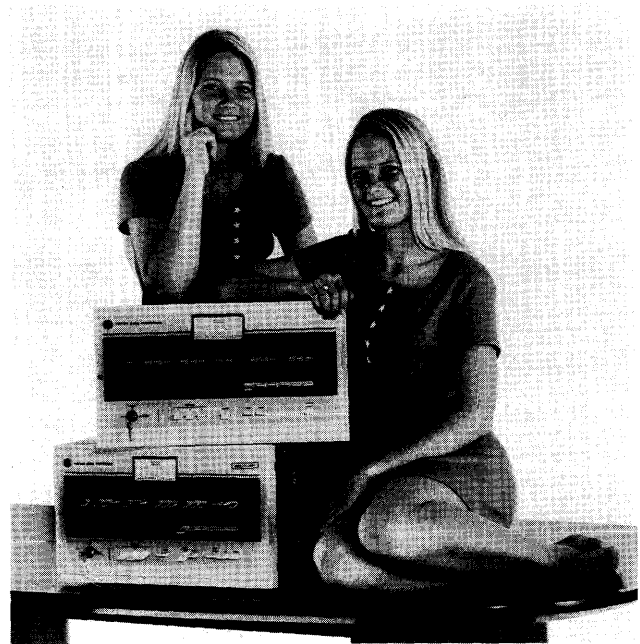
Other compilers, for programs written in languages such as ALGOL, BASIC, and COBOL, are listed on the charts where available.

An *operating system* facilitates the operation of a computer by handling functions such as: (1) scheduling, loading, and supervising the execution of programs; (2) allocating storage and I/O devices; (3) initiating and controlling I/O operations; (4) analyzing interrupt signals and dealing with errors; (5) handling communications between the system and its human operator; and (6) controlling multiprogramming or time-sharing operations. Most of the current minicomputer operating systems are real-time monitors, designed primarily for use in a dedicated real-time environment. Facilities for multiprogramming and time-sharing are rarely provided.

Pricing and Availability

The comparison charts show the *prices of basic systems* equipped with 4,096 and 8,192 words of main storage but no peripheral equipment. The indicated prices for each machine include all of the features listed as "standard," but none of the "optional" features. Because of the wide variations in availability and pricing of optional features and peripheral equipment, comparisons such as these can provide only a first-level indication of the overall pricing relationships among competitive minicomputers. And, of course, prices have been falling steadily and are likely to continue to do so. Therefore, the only reliable source of detailed, up-to-date pricing information is the manufacturers themselves.

If you'll need two or more minicomputers, it's also worth noting that most of the manufacturers offer sizeable discounts from their list prices on orders for multiple computers. Discounts of up to 40 percent are not unusual on large orders.



Twin minis are the latest models in Varian's popular 620 line: the economical 620/L-100 (top) and the high-performance 620/f-100. Software support includes Vortex, a new real-time operating system that provides concurrent foreground/background processing capabilities—at a separate pricetag of \$3,000.

Date of first delivery indicates when the first production model of each minicomputer was delivered (or is scheduled to be delivered) to a customer.

Number installed to date shows how many computers of each type had been delivered to customers as of May 1, 1972. All figures were supplied by the manufacturers themselves, and the entry "NA" (Not Available) appears in all cases where the manufacturers chose not to release this information.

Comments at the bottom of the charts describe significant or unusual features, capabilities, or applications which are not reflected in the standard entries.

MINICOMPUTER MANUFACTURERS

Listed below, for your convenience in obtaining additional information, are the full names and addresses of the 48 manufacturers whose products are summarized in the comparison charts.

Bailey Meter Co., 29801 Euclid Avenue, Wickliffe, Ohio 44092. Telephone (216) 943-5500.

Bendix Corporation, Navigation & Control Division, Teterboro, New Jersey 07608. Telephone (201) 288-2000.

Cascade Data, Inc. (an APECO affiliate), 3000 Kraft Avenue S.E., Grand Rapids, Michigan 49508. Telephone (616) 949-8850.

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Cincinnati Milacron Company, Process Controls Division, Lebanon, Ohio 45036. Telephone (513) 494-1200.

Clary Datacomp Systems, Inc., 404 Junipero Serra Drive, San Gabriel, California 91776. Telephone (213) 283-9485.

Computer Automation Incorporated, 895 West Sixteenth Street, Newport Beach, California 92660. Telephone (714) 642-9630.

Control Data Corporation, 8100 34th Avenue South, Minneapolis, Minnesota 55440. Telephone (612) 888-5555.

Data General Corporation, Southboro, Massachusetts 01772. Telephone (617) 485-9100.

Datacraft Corporation, 1200 N.W. 70th Street, P.O. Box 23550, Fort Lauderdale, Florida 33307. Telephone (305) 974-1700.

Datamate Computer Systems, Inc., P.O. Box 310, Big Spring, Texas 79720. Telephone (915) 267-6353.

Digital Computer Controls, Inc., 23 Just Road, Fairfield, New Jersey 07006. Telephone (201) 227-4861.

Digital Equipment Corporation, Maynard, Massachusetts 01754. Telephone (617) 897-5111.

Digital Scientific Corporation, 11455 Sorrento Valley Road, San Diego, California 92121. Telephone (714) 453-6050.

Eldorado Electrodata Corporation, 601 Chalomar Road, Concord, California 94518. Telephone (415) 696-4200.

Electronic Associates, Inc., West Long Branch, New Jersey 07764. Telephone (201) 229-1100.

Electronic Processors Incorporated (a subsidiary of the Samsonite Corporation), 5050 South Federal Boulevard, Englewood, Colorado 80110. Telephone (303) 798-9305.

EMR Computer (a division of Weston Instruments, Inc.), 8001 Bloomington Freeway, Minneapolis, Minnesota 55420. Telephone (612) 888-9581.

Four-Phase Systems, Inc., 10420 N. Tantau Avenue, Cupertino, California 95014. Telephone (408) 255-0900.

Foxboro Company, Foxboro, Massachusetts 02035. Telephone (617) 543-8750.

Fujitsu Limited, 680 Fifth Avenue, New York, N.Y. 10019. Telephone (212) 265-5360.

General Automation, Inc., 1055 S. East Street, Anaheim, California 92805. Telephone (714) 778-4800.

General Electric Company, Utilities and Process Automation Products Department, 40 Federal Street, Lynn, Massachusetts 01910. Telephone (617) 594-7417.

GRI Computer Corporation, 320 Needham Street, Newton, Massachusetts 02164. Telephone (617) 969-0800.

GTE Information Systems, Inc., *Tempo Computers, Inc.* (a subsidiary of General Telephone & Electronics Corp.) 4005 West Artesia Avenue, Fullerton, California 92633. Telephone (714) 523-9440.

Hewlett-Packard Company, Cupertino Division, 11000 Wolfe Road, Cupertino, California 95014. Telephone (213) 877-1282.

Honeywell Information Systems Inc. (a subsidiary of Honeywell Inc.), 200 Smith Street, Waltham, Massachusetts 02154. Telephone (617) 237-4100.

Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051. Telephone (408) 246-7501.

Interdata, Inc., 2 Crescent Place, Oceanport, New Jersey 07757. Telephone (201) 229-4040.

IBM Corporation, Data Processing Division, 1133 Westchester Avenue, White Plains, New York 10604. Telephone (213) 376-9763

Lockheed Electronics Company (a subsidiary of Lockheed Aircraft Corporation), Data Products Division, 6201 E. Randolph Street, Los Angeles, California 90022. Telephone (213) 722-6810.

Microdata Corporation, 644 East Young Street, Santa Ana, California 92705. Telephone (714) 540-6730.

Modular Computer Systems, Inc., 2709 N. Dixie Highway, Fort Lauderdale, Florida 33308. Telephone (305) 563-4392.

Nuclear Data Inc., P.O. Box 451, Palatine, Illinois 60067. Telephone (312) 529-4600.

Omnitec Corporation (a subsidiary of Nytronics Corporation), 2405 South 20th Street, Phoenix, Arizona 85034. Telephone (602) 258-8246.

Omnus Computer Corporation, 1538 East Chestnut Street, Suite E, Santa Ana, California 92701. Telephone (714) 547-8444.

Qantel Corporation, 3474 Investment Boulevard, Hayward, California 94545. Telephone (415) 783-3410.

Raytheon Data Systems Company (a division of Raytheon Company), 1415 Boston-Providence Turnpike, Norwood, Massachusetts 02062. Telephone (617) 762-6700.

Rolm Corporation, 10300 N. Tantau Avenue, Cupertino, California 95014. Telephone (408) 257-6440.

SYS Computer Corp., 17-25 DiCarolis Court, Hackensack, New Jersey 07601. Telephone (201) 488-0300.

SYSTEMS Engineering Laboratories, Inc., 6901 West Sunrise Boulevard, Fort Lauderdale, Florida 33313. Telephone (305) 587-2900.

Texas Instruments Inc., Digital Systems Division, P.O. Box 1444, Houston, Texas 77001. Telephone (713) 494-5115.

Unicom Inc., 1275 Bloomfield Avenue, Fairfield, New Jersey 07006. Telephone (201) 575-1696.

UniComp, Inc. (a subsidiary of Hoffman Electronics Corporation), 19749 Bahama Street, Northridge, California 91324. Telephone (213) 882-6313.

Varian Data Machines (a subsidiary of Varian Associates), 2722 Michelson Drive, Irvine, California 92664. Telephone (714) 833-2400.

Wang Laboratories, Inc., 836 North Street, Tewksbury, Massachusetts 01876. Telephone (617) 851-7311.

Westinghouse Electric Corporation, Computer Department, 1200 W. Colonial Drive, Orlando, Florida 32804. Telephone (305) 843-7030.

Xerox Corporation, 701 South Aviation Boulevard, El Segundo, California 90245. Telephone (213) 679-4511.

XLO Computer Products (a unit of Ex-Cell-O Corporation), 26 Olney Avenue, Cherry Hill, New Jersey 08003. Telephone 424-4400. □

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MANUFACTURER & MODEL	Bailey Meter Co. 855/15	Bendix BDX6200	Bendix BDX9000	Cascade Data Cascade 80	Cincinnati Milacron CIP/2002
DATA FORMATS					
Word length, bits	16	20	16	16 (2 bytes)	8 or 9
Fixed-point operand length, bits	16	20/40	16	16-32	8/16/24
Instruction length, bits	16	20	16	16-40	8/16
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	0.96	2.0	2.0	0.9	1.1
Minimum capacity, words	4,096	4,096	4,096	4,096	4,096
Maximum capacity, words	32,768	16,384	32,768	32,768	24,576
Parity checking	No	Optional	Optional	Optional	Optional
Storage protection	No	Optional	Optional	No	Optional
CENTRAL PROCESSOR					
No. of accumulators	16	3	16	16	Optional
No. of index registers	6	3	2	3	Optional
No. of directly addressable words	32,768	4,096	256	1,024	Optional
Indirect addressing	One-level	Multi-level	Multi-level	One-level	Optional
Add time, microseconds (full word)	0.96	4.0	4.0	8.8	Varies
Hardware multiply/divide	Standard	Standard	Standard	Standard	Optional
Hardware floating point	No	No	No	No	No
Hardware byte manipulation	Standard	No	No	Standard	Optional
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Optional
Power failure protection	Standard	Optional	Optional	No	Optional
Real-time clock or timer	Standard	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	20	16	16	8
Direct memory access channel	Standard	Optional	Optional	Standard	Optional
Maximum I/O rate, words/sec	1,040,000	500,000	500,000	416,000	909,000
No. of external interrupt levels	8-unlimited	1-64	1-64	Variable	8-64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	No
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Yes	No	No	No	No
Magnetic tape speed, cps	60K max.	Not specified	Not specified	50K max.	Not specified
Punched card input speed, cpm	400/1000	200	200	300	400
Punched card output speed, cpm	100	—	—	120	Not specified
High-speed paper tape input, cps	400	300	300	300	300
High-speed paper tape output, cps	75	120	120	120	240
Other standard peripheral units	A/D converters, communications interfaces	A/D and D/A interfaces	A/D and D/A interfaces	Line printers, mark readers, communications, displays, etc.	CRT display, communications interface
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	Optional
Macro assembler	Yes	No	No	Yes	No
FORTRAN compiler	Yes	No	No	No	No
Other compilers	No	ATLAS	No	RPG	No
Operating system	Yes	No	No	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	Not specified	On request	On request	On request	\$3,840
Price of basic system with 8K words	\$25,000	On request	On request	On request	\$4,140
Date of first delivery	May 1970	May 1970	1971	Jan. 1970	Feb. 1972
Number installed to date	NA	40	8	NA	NA
COMMENTS	480-nsec read-only memory modules are interchangeable with standard core modules.	Features 10 hardware registers and 131 register change instructions.		Byte-oriented; designed for business applications. Supported by extensive applications software.	A microprogrammable computer built around a file of 15 8-bit registers and up to 1024 words of 220-nsec read-only control memory.

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MANUFACTURER & MODEL	Cincinnati Milacron CIP/2100	Cincinnati Milacron CIP/2200	Clary Datacomp 404	Computer Automation Alpha 8	Computer Automation Naked Mini 8
DATA FORMATS					
Word length, bits	8	8 or 9	16	8	8
Fixed-point operand length, bits	8/16/24/32	8/16/24/32	16/32/48/64	8	8
Instruction length, bits	8/16	8/16	16/32	8/16/24/32	8/16/24/32
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.1	1.1	2.2	1.6	1.6
Minimum capacity, words	4,096	4,096	1,024	4,096	4,096
Maximum capacity, words	32,768	32,768	65,536	32,768	32,768
Parity checking	Optional	Optional	No	Optional	Optional
Storage protection	Optional	Optional	Optional	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	2	2	4	1	1
No. of index registers	1	1	2	0	0
No. of directly addressable words	32,768	32,768	1,024	512	512
Indirect addressing	One-level	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	6.38	Not specified	98 (15 digits)	3.2	3.2
Hardware multiply/divide	Standard	Standard	Standard	No	No
Hardware floating point	No	No	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	No	No
Power failure protection	Optional	Optional	Optional	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8/16	8/16	16	8	8
Direct memory access channel	Standard	Standard	Optional	2 standard	2 standard
Maximum I/O rate, words/sec	909,000	909,000	250,000	120,000	120,000
No. of external interrupt levels	8-64	8-64	16-256	3-64	3-64
PERIPHERAL EQUIPMENT					
Disk pack storage	No	No	No	No	No
Non-interchangeable disk storage	Yes	Yes	No	No	No
Drum storage	No	No	No	No	No
Magnetic tape speed, cps	Not specified	Not specified	25K	10K-25K	10K-25K
Punched card input speed, cpm	400	400	—	300	300
Punched card output speed, cpm	Not specified	Not specified	—	—	—
High-speed paper tape input, cps	300	300	150/300	400	400
High-speed paper tape output, cps	240	240	—	75/120	75/120
Other standard peripheral units	CRT display, communications interface	CRT display, communications interface	Line printer, CRT display, magnetic card unit	Line printer, A/D converter, data sets, etc.	Line printer, A/D converter, data sets, etc.
SOFTWARE					
Assembler	2-pass	2-pass	1-pass	1 & 2-pass	1 & 2-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	No	No	No	No	No
Other compilers	No	No	RPG II, BASIC	No	No
Operating system	Yes	Yes	Yes	No	No
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$3,975	\$4,225	\$6,475	\$2,800	\$1,975 in lots of 10-19
Price of basic system with 8K words	\$4,275	\$4,525	\$8,825	\$3,300	\$2,275 in lots of 10-19
Date of first delivery	1969	Feb. 1972	Oct. 1969	May 1972	May 1972
Number installed to date	NA	NA	NA	NA	NA
COMMENTS	Controlled by 768 to 1024 words of 220-nsec read-only memory. Software is separately priced.		Performs both decimal and binary arithmetic. Can be used as an "intelligent terminal."	Program compatible with the earlier 108, 208, and 808 computers. Has 76 instructions plus microcodes.	Low-cost OEM version of Alpha 8, less chassis, power supply, and console. Sold only in quantities of 10 or more.

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MANUFACTURER & MODEL	Computer Automation Alpha 16	Computer Automation Naked Mini 16	Control Data 1700	Control Data SC-1700
DATA FORMATS				
Word length, bits	16	16	16 + 2	16 + 2
Fixed-point operand length, bits	16	16	16	16
Instruction length, bits	16	16	16/32	16/32
MAIN STORAGE				
Storage type	Core	Core	Core	Core
Cycle time, microseconds/word	1.6	1.6	1.1	1.5
Minimum capacity, words	2,048	2,048	4,096	4,096
Maximum capacity, words	32,768	32,768	32,768	32,768
Parity checking	Optional	Optional	Standard	Standard
Storage protection	Optional	Optional	Standard	Standard
CENTRAL PROCESSOR				
No. of accumulators	2	2	2	2
No. of index registers	1	1	2	2
No. of directly addressable words	1,024	1,024	256	256
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	3.2	3.2	2.2	3.0
Hardware multiply/divide	Standard	Standard	Standard	Standard
Hardware floating point	No	No	No	No
Hardware byte manipulation	Standard	Standard	No	Optional
Immediate (literal) instructions	Standard	Standard	No	No
Power failure protection	Optional	Optional	Standard	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL				
I/O word size, bits	16	16	16	16
Direct memory access channel	2 standard	2 standard	Optional	Optional
Maximum I/O rate, words/sec	700,000	700,000	900,000	650,000
No. of external interrupt levels	3-unlimited	3-unlimited	2-16	2-16
PERIPHERAL EQUIPMENT				
Disk pack storage	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes
Drum storage	Yes	Yes	Yes	Yes
Magnetic tape speed, cps	10K-30K	10K-30K	30K max.	30K max.
Punched card input speed, cpm	300	300	330-1600	330-1600
Punched card output speed, cpm	—	—	100-460	100-460
High-speed paper tape input, cps	300	300	400	400
High-speed paper tape output, cps	75/120	75/120	120/150	120/150
Other standard peripheral units	Line printer, A/D converter, data sets, etc.	Line printer, A/D converter, data sets, etc.	Line printer, CRT displays, OCR, A/D converters, etc.	Line printer, CRT displays, OCR, A/D converters, etc.
SOFTWARE				
Assembler	1 & 2-pass	1 & 2-pass	2-pass	2-pass
Macro assembler	No	No	Yes	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes
Other compilers	BASIC	BASIC	No	No
Operating system	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY				
Price of basic system with 4K words	\$3,550	\$2,500 in lots of 10-19	\$20,000	\$15,900
Price of basic system with 8K words	\$4,750	\$3,740 in lots of 10-19	\$26,500	\$20,400
Date of first delivery	Oct. 1971	Oct. 1971	1966	1972
Number installed to date	300	125	See COMMENTS	See COMMENTS
COMMENTS	Program compatible with the earlier 116 and 216 computers. Has 156 instructions plus micro-codes.	Low-cost OEM version of Alpha 16, less chassis, power supply, and console. Sold only in quantities of 10 or more.	18-bit word includes parity and storage protection bits. More than 500 of the 1700 Series systems have been delivered to date. The CDC 1714 Computer System uses a CPU similar to the 1700.	

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MANUFACTURER & MODEL	Data General Nova 800	Data General Nova 820	Data General Nova 1200	Data General Nova 1210	Data General Nova 1220
DATA FORMATS					
Word length, bits	16	16	16	16	16
Fixed-point operand length, bits	16	16	16	16	16
Instruction length, bits	16	16	16	16	16
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	0.8	0.8	1.2	1.2	1.2
Minimum capacity, words	2,048	2,048	2,048	2,048	2,048
Maximum capacity, words	32,768	32,768	32,768	32,768	24,576
Parity checking	No	No	No	No	No
Storage protection	No	No	No	No	No
CENTRAL PROCESSOR					
No. of accumulators	4	4	4	4	4
No. of index registers	2	2	2	2	2
No. of directly addressable words	1,024	1,024	1,024	1,024	1,024
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	0.8	0.8	1.35	1.35	1.35
Hardware multiply/divide	Optional	Optional	Optional	Optional	Optional
Hardware floating point	No	No	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	No	No	No	No	No
Power failure protection	Standard	Standard	Standard	Standard	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	16	16	16
Direct memory access channel	Standard	Standard	Standard	Standard	Standard
Maximum I/O rate, words/sec	1,250,000	1,250,000	833,000	833,000	833,000
No. of external interrupt levels	16	16	16	16	16
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	No	No	No	No	No
Magnetic tape speed, cps	30K max.	30K max.	30K max.	30K max.	30K max.
Punched card input speed, cpm	225/400	225/400	225/400	225/400	225/400
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	63	63	63	63	63
Other standard peripheral units	Line printer, A/D converters, communications, plotter, etc.	Line printer, A/D converters, communications, plotter, etc.	Line printer, A/D converters, communications, plotter, etc.	Line printer, A/D converters, communications, plotter, etc.	Line printer, A/D converters, communications, plotter, etc.
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	ALGOL, BASIC	ALGOL, BASIC	ALGOL, BASIC	ALGOL, BASIC	ALGOL, BASIC
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$6,950	\$6,450	\$5,450	\$4,350	\$5,250
Price of basic system with 8K words	\$8,350	\$7,850	\$6,850	\$5,750	\$6,650
Date of first delivery	March 1971	NA	Dec. 1970	Feb. 1972	Feb. 1972
Number installed to date	150	NA	1,300	50	20
COMMENTS					
All Nova-line computers are program-compatible. They are organized around four accumulators, two of which can be used as index registers. Models 820 and 1220 use a 10.5-inch-high chassis (optionally available for Models 800 and 1200 as well) that permits extensive expansion. Model 1210 is an economy model intended mainly for OEM use. Bipolar read-only memory is optionally interchangeable with core memory in all models.					

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MANUFACTURER & MODEL	Data General Supernova	Data General Supernova SC	Datacraft 6024/1	Datacraft 6024/3	Datacraft 6024/5
DATA FORMATS					
Word length, bits	16	16	24	24	24
Fixed-point operand length, bits	16	16	24/48	24/48	24/48
Instruction length, bits	16	16	24	24	24
MAIN STORAGE					
Storage type	Core	Semicond./core	Core	Core	Core
Cycle time, microseconds/word	0.8	0.3/0.8	0.6	1.0	1.0
Minimum capacity, words	2,048	1,024	8,192	8,192	4,096
Maximum capacity, words	32,768	32,768	65,536	65,536	65,536
Parity checking	No	No	Standard	Standard	Standard
Storage protection	Optional	Optional	Optional	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	4	4	5 or 6	5 or 6	5 or 6
No. of index registers	2	2	3	3	3
No. of directly addressable words	1,024	1,024	65,536	65,536	65,536
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	0.8	0.3/0.8	1.2	2.0	2.0
Hardware multiply/divide	Optional	Optional	Standard	Standard	Standard
Hardware floating point	No	No	Optional	Optional	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	No	No	Standard	Standard	Standard
Power failure protection	Standard	Standard	Optional	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	24 or 8	24 or 8	24 or 8
Direct memory access channel	Standard	Standard	Optional	Optional	Optional
Maximum I/O rate, words/sec	1,250,000	1,250,000	1,667,000	1,000,000	1,000,000
No. of external interrupt levels	16	16	4-72	4-24	16
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	No	No	No	No	No
Magnetic tape speed, cps	30K max,	30K max,	120K max,	120K max.	120K max.
Punched card input speed, cpm	225/400	225/400	300/600/1000	300/600/1000	300/600/1000
Punched card output speed, cpm	—	—	35-100	35-100	35-100
High-speed paper tape input, cps	300	300	300/600	300/600	300/600
High-speed paper tape output, cps	63	63	110	110	110
Other standard peripheral units	Line printer, A/D converters, communications, plotter, etc.	Line printer, A/D converters, communications, plotter, etc.	CRT display, plotter, A/D converter, com- munications	CRT display, plotter, A/D converter, com- munications	CRT display, plotter, A/D converter, com- munications
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	No	Yes	Yes	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	ALGOL, BASIC	ALGOL, BASIC	BASIC, RPG	BASIC, RPG	BASIC, RPG
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$9,600	\$14,250	Not available	Not available	\$10,900
Price of basic system with 8K words	\$10,850	\$15,500	\$51,400	\$32,800	\$13,400
Date of first delivery	April 1970	June 1971	May 1969	Feb. 1970	May 1972
Number installed to date	165	20	12	95	2
COMMENTS	Program-compatible with all other Nova-line computers.	Quoted prices include 1K bytes of 300-nsec semiconductor main memory, which is interchangeable with core.	The three Datacraft models are program-compatible. The quoted prices include a basic software package; other software is available at extra cost. Model 6024/5 fits into a standard 19" rack.		

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MANUFACTURER & MODEL	Datamate DCS 2400	Digital Com- puter Control D-112	Digital Com- puter Control D-112H	Digital Com- puter Control D-116
DATA FORMATS				
Word length, bits	24 + 3	12	12	16
Fixed-point operand length, bits	24/48	12	12	16
Instruction length, bits	24	12/24	12/24	16
MAIN STORAGE				
Storage type	Core	Core	Core/semicond.	Core
Cycle time, microseconds/word	0.75	1.2	0.9/0.2	1.2
Minimum capacity, words	8,192	4,096	256	2,048
Maximum capacity, words	32,768	32,768	32,768	32,768
Parity checking	Standard	Optional	Optional	No
Storage protection	Standard	Standard	Standard	No
CENTRAL PROCESSOR				
No. of accumulators	4	1	1	4
No. of index registers	3	8	24	2
No. of directly addressable words	32,768	256	256	1,024
Indirect addressing	No	One-level	One-level	Multi-level
Add time, microseconds (full word)	1.5	2.4	2.4	1.35
Hardware multiply/divide	Standard	Optional	Optional	Optional
Hardware floating point	Optional	Optional	Optional	No
Hardware byte manipulation	No	Optional	Standard	Standard
Immediate (literal) instructions	Standard	No	No	No
Power failure protection	Standard	Optional	Optional	Standard
Real-time clock or timer	Standard	Optional	Optional	Optional
INPUT/OUTPUT CONTROL				
I/O word size, bits	24	12	12	16
Direct memory access channel	Standard	Optional	Optional	Standard
Maximum I/O rate, words/sec	1,333,000	833,000	833,000	833,000
No. of external interrupt levels	4-255	1-64	1-64	16
PERIPHERAL EQUIPMENT				
Disk pack storage	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes
Drum storage	No	Yes	Yes	No
Magnetic tape speed, cps	30K-120K	30K	30K	30K
Punched card input speed, cpm	1000	200	200	225/400
Punched card output speed, cpm	120	100	100	100
High-speed paper tape input, cps	1000	300	300	300
High-speed paper tape output, cps	120	110	110	110
Other standard peripheral units	Line printer, process I/O	Line printer, communications interfaces, A/D converters	Line printers, communications interfaces, A/D converters	Line printer, communications interfaces, A/D converters
SOFTWARE				
Assembler	2-pass	1 & 2-pass	1 & 2-pass	2-pass
Macro assembler	Yes	Yes	Yes	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes
Other compilers	No	ALGOL, BASIC	ALGOL, BASIC	ALGOL, BASIC
Operating system	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY				
Price of basic system with 4K words	Not available	\$3,390	\$5,600	\$4,000
Price of basic system with 8K words	\$14,900	\$5,390	\$7,700	\$5,400
Date of first delivery	Not specified	Aug. 1970	April 1971	Nov. 1971
Number installed to date	NA	NA	NA	53
COMMENTS		Designed to be fully compatible with the DEC PDP-8 computers.	Offers either core or 200-nsec semi-conductor memory. Has expanded PDP-8 series instruction set.	Designed to be plug, program, and mechanically interchangeable with the Data General Nova 1200 Series computers.

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MANUFACTURER & MODEL	Digital Equipment PDP-8/E	Digital Equipment PDP-8/F	Digital Equipment PDP-8/M	Digital Equipment PDP-12	Digital Equipment PDP-15
DATA FORMATS					
Word length, bits	12	12	12	12	18
Fixed-point operand length, bits	12	12	12	12	18
Instruction length, bits	12/24	12/24	12/24	12/24	18
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.2	1.2	1.2	1.6	0.8
Minimum capacity, words	4,096	4,096	4,096	4,096	4,096
Maximum capacity, words	32,768	16,384	32,768	32,768	131,072
Parity checking	Optional	Optional	Optional	Optional	Optional
Storage protection	Optional	Optional	Optional	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	1	1	1	1	1
No. of index registers	8	6	6	8	1
No. of directly addressable words	256	256	256	1,024	4,096
Indirect addressing	One-level	One-level	One-level	One-level	One-level
Add time, microseconds (full word)	2.6	2.6	2.6	3.2	1.6
Hardware multiply/divide	Optional	Optional	Optional	Optional	Optional
Hardware floating point	Optional	Optional	Optional	Optional	No
Hardware byte manipulation	Yes	Yes	Yes	No	No
Immediate (literal) instructions	No	No	No	No	No
Power failure protection	Optional	Optional	Optional	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	12	12	12	12	18
Direct memory access channel	Standard	Optional	Optional	Standard	Standard
Maximum I/O rate, words/sec	833,000	833,000	833,000	625,000	1,000,000
No. of external interrupt levels	1-64	1-64	1-64	1-64	28-64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Special order	Special order	Special order	Special order	Yes
Magnetic tape speed, cps	36K max.	36K max.	36K max.	36K max.	60K max.
Punched card input speed, cpm	300	300	300	200	200
Punched card output speed, cpm	275 max.	275 max.	275 max.	—	—
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	50	50	50	50	50
Other standard peripheral units	DECTape, plotter, CRT displays, comm., printers, etc.	DECTape, plotter, CRT displays, comm., printers, etc.	DECTape, plotter, CRT displays, comm., printers, etc.	DECTape, plotters, A/D converters, printers, etc.	DECTape, A/D converters, real-time interfaces
SOFTWARE					
Assembler	1 & 2-pass	1 & 2-pass	1 & 2-pass	2-pass	2-pass
Macro assembler	Yes	Yes	Yes	No	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	ALGOL, BASIC, DIBOL, FOCAL	ALGOL, BASIC, DIBOL, FOCAL	ALGOL, BASIC, DIBOL, FOCAL	BASIC	FOCAL
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$4,990	\$3,990	\$3,990	\$13,400	\$15,000
Price of basic system with 8K words	\$7,740	\$6,740	\$6,395	\$17,400	\$21,000
Date of first delivery	Dec. 1970	May 1972	Jan. 1972	April 1969	Fall 1969
Number installed to date	See Comments	See Comments	See Comments	Over 600	Over 500
COMMENTS	Over 15,000 PDP-8 systems have been delivered since 1965. All models are program-compatible. Extensive software is available, as well as integrated systems for specific applications. The PDP-8/M is intended for OEM's. A host of earlier-model PDP-8's are now called "traditional products" with continuing support. The PDP-8/E includes built-in hardware for expansion.			Designed for laboratory applications; can execute PDP-8 programs; built-in CRT display.	Program compatible with the PDP-9, and has 17 new instructions.

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MANUFACTURER & MODEL	Digital Equipment PDP-11/03	Digital Equipment PDP-11/05	Digital Equipment PDP-11/15	Digital Equipment PDP-11/20	Digital Equipment PDP-11/45
DATA FORMATS					
Word length, bits	16	16	16	16	16
Fixed-point operand length, bits	16	16	16	16	16
Instruction length, bits	16/32/48	16/32/48	16/32/48	16/32/48	16/32/48
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core/semi-cond.
Cycle time, microseconds/word	1.2	1.2	0.9	0.9	0.85 (core)
Minimum capacity, words	2,048	4,096	4,096	4,096	4,096
Maximum capacity, words	16,384	32,768	32,768	124K	124K
Parity checking	Optional	Optional	Optional	Optional	Standard
Storage protection	No	No	No	No	Optional
CENTRAL PROCESSOR					
No. of accumulators	8	8	8	8	8
No. of index registers	Up to 8	Up to 8	Up to 8	Up to 8	Up to 8
No. of directly addressable words	32,768	32,768	32,768	32,768	32,768
Indirect addressing	One-level	One-level	One-level	One-level	One-level
Add time, microseconds (full word)	2.3	2.3	2.3	2.3	2.3
Hardware multiply/divide	Optional	Optional	Optional	Optional	Standard
Hardware floating point	No	No	No	No	Optional
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Standard	Standard	Standard	Standard	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	16	16	16
Direct memory access channel	Standard	Standard	Standard	Standard	Standard
Maximum I/O rate, words/sec	833,000	833,000	1,110,000	1,110,000	1,180,000
No. of external interrupt levels	Variable	Variable	Variable	Variable	Variable
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	No	No	No	No	No
Magnetic tape speed, cps	36K max.	36K max.	36K max.	36K max.	36K max.
Punched card input speed, cpm	300	300	300	300	300
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	50	50	50	50	50
Other standard peripheral units	Communications interface, CRT displays, printers, etc.	Communications interface, CRT displays, printers, etc.	DECtape, CRT displays, A/D converters, printers, etc.	DECtape, CRT displays, A/D converters, printers, etc.	DECtape, CRT displays, A/D converters, printers, etc.
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	Runs on 11/20	Runs on 11/20	Yes	Yes	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	BASIC	BASIC	BASIC	BASIC	BASIC
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$3,995 with 2K words	\$4,795	\$6,200	\$9,300	\$14,990
Price of basic system with 8K words	Not specified	\$6,495	\$8,100	\$12,900	Not specified
Date of first delivery	Not specified	Not specified	April 1971	March 1970	Not specified
Number installed to date	NA	NA	Over 1000	Over 2500	NA
COMMENTS	The PDP-11/R20 is a ruggedized version with a \$13,900 base price. The PDP-11/03, -11/05, and -11/15 are designed for OEM use; the 11/03 is particularly small. Many turnkey systems for specialized applications are available. 500-nsec read-only memory is available in 1024-word increments. Up to 32K of 450-nsec MOS and/or 300-nsec bipolar solid-state memory can be included within the 124K PDP-11/45 main memory. The 11/45 includes 2 UNIBUS structures for increased data handling capability.				

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MANUFACTURER & MODEL	Digital Scientific META 4	Eldorado Model 140/200	Electronic Associates PACER	Electronic Processors EPI-118	EMR Computer 6145
DATA FORMATS					
Word length, bits	16	8	16	18	16
Fixed-point operand length, bits	16	8/16	16	18	16/32
Instruction length, bits	32	8/16/24	16	18	16/32
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	0.90	1.2	1.0	0.9	0.65
Minimum capacity, words	4,096	8,192	8,192	4,096	32,768
Maximum capacity, words	65,536	61,440	32,768	32,768	131,072
Parity checking	Standard	No	No	No	Standard
Storage protection	Standard	No	Standard	Standard	Standard
CENTRAL PROCESSOR					
No. of accumulators	32	8	1	2	2
No. of index registers	Variable	8	1	Any no. (opt.)	3
No. of directly addressable words	65,536	61,440	512	32,768	131,072
Indirect addressing	One-level	One-level	Multi-level	One-level (opt.)	Multi-level
Add time, microseconds (full word)	2.14	Under 10 msec	2.0	See Comments	1.3
Hardware multiply/divide	Standard	No	Standard	Optional	Standard
Hardware floating point	Optional	No	Optional	No	Optional
Hardware byte manipulation	Standard	Standard	No	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	No	Standard
Power failure protection	Optional	No	Standard	Standard	Standard
Real-time clock or timer	Optional	No	Optional	Optional	Standard
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	8/16	16	18 or 21	16
Direct memory access channel	9 standard	Optional	Optional	Optional	2 standard
Maximum I/O rate, words/sec	1,000,000	833,000	1,000,000	900,000	1,667,000
No. of external interrupt levels	16	15	64	18	16-64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	No
Non-interchangeable disk storage	No	No	Yes	No	Yes
Drum storage	No	No	No	No	No
Magnetic tape speed, cps	60K max.	10K	60K max.	10K-36K	120K max.
Punched card input speed, cpm	1000 max.	300	300	—	200-1000
Punched card output speed, cpm	80 max.	—	—	—	100
High-speed paper tape input, cps	300	400	300	500	400
High-speed paper tape output, cps	50	75	120	75	63.3
Other standard peripheral units	Line printers, plotter, communications	Cassette tape, Selectric typewriter, CRT display	Line printers, cartridge tape, CRT displays, plotters, etc.	CRT display, cassette tape, A/D and D/A interfaces	Line printers, communications, A/D devices
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	Yes	No	No	Yes	Yes
FORTAN compiler	Yes	No	Yes	No	Yes
Other compilers	Yes	ESP	Op. Interpreter	BASIC	No
Operating system	Yes	Yes	Yes	No	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$21,750	Not available	Not available	\$2,790	Not available
Price of basic system with 8K words	\$25,250	\$21,050	\$15,200	\$3,990	\$135,000 with 32K words
Date of first delivery	Jan 1970	Jan. 1970	May 1972	Nov. 1970	June 1972
Number installed to date	NA	Over 100	NA	NA	0
COMMENTS	Controlled by 1K to 4K words of 90-nsec read-only memory. Can emulate the IBM 1130 and 1800.	Marketed as accounting computer system. Price includes typewriter and 3 cassette drives.	PACER is fully compatible with the earlier EAI 640, which it replaces. Uses MSI and LSI technology.	Basic add time is 2.0 microseconds per octal digit. Faster, 18-bit arithmetic unit is optional. Prices listed are to "qualified OEM users."	Designed for real-time use in communications, data acquisition and control, and seismic processing.

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MANUFACTURER & MODEL	Four-Phase Systems, Inc. System IV/70	Foxboro FOX 1	Foxboro FOX 2	Fujitsu FACOM R-E	General Automation SPC-12
DATA FORMATS					
Word length, bits	24	24	16	16	8
Fixed-point operand length, bits	24	24/48	16	16	8/12
Instruction length, bits	24	24	16/32/48	16	8/16
MAIN STORAGE					
Storage type	Semiconductor	Core	Core	Core	Core
Cycle time, microseconds/word	2.0	0.96	1.2	1.5	2.16
Minimum capacity, words	4,096	16,384	8,192	4,096	4,096
Maximum capacity, words	8,192	65,536	28,672	32,768	16,384
Parity checking	Standard	Standard	Optional	Standard	Optional
Storage protection	No	Standard	No	No	No
CENTRAL PROCESSOR					
No. of accumulators	5	2	8	1	4
No. of index registers	3	4	8	4	3
No. of directly addressable words	8,192	32,768	28,672	512	4,096
Indirect addressing	One-level	Multi-level	One-level	One-level	One-level
Add time, microseconds (full word)	16	1.92	2.3	6.0	6.48
Hardware multiply/divide	Standard	Standard	Optional	No	No
Hardware floating point	Standard	Standard	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	None	Standard
Immediate (literal) instructions	No	Standard	Standard	No	Standard
Power failure protection	No	Standard	Optional	Optional	Optional
Real-time clock or timer	Standard	Standard	Standard	Optional	Standard
INPUT/OUTPUT CONTROL					
I/O word size, bits	24	24	16	16	8/12
Direct memory access channel	Standard	Standard	Standard	Standard	Optional
Maximum I/O rate, words/sec	125,000	520,000	833,000	400,000	460,000
No. of external interrupt levels	8	12-24	Not specified	1	2-256
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	No	Yes	Yes
Non-interchangeable disk storage	No	Yes	Yes	No	Yes
Drum storage	No	Yes	Yes	Yes	Yes
Magnetic tape speed, cps	60K max.	—	—	21.6K	60K max.
Punched card input speed, cpm	300	300	300	300	400/1000
Punched card output speed, cpm	—	80	—	30	100
High-speed paper tape input, cps	—	300	300	200/400	400
High-speed paper tape output, cps	—	110	60	50/100/200	75
Other standard peripheral units	CRT displays, line printer, Data-Phone interface, IBM channel adapter	Line printer, CRT displays, A/D converters, communications	Line printer, CRT displays, A/D converters	Line printer, plotter, optical mark reader	A/D converters, communications interfaces
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	1-pass
Macro assembler	No	Yes	No	No	No
FORTRAN compiler	No	Yes	Yes	Yes	No
Other compilers	COBOL	No	IMPAC	No	No
Operating system	Yes	Yes	Yes	No	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$16,000	Not available	Not available	On request	\$2,980 to \$3,980
Price of basic system with 8K words	\$22,600	\$95,000 with 16K words	\$21,200	On request	Not specified
Date of first delivery	Feb. 1971	Oct. 1972	Sept. 1972	Not specified	Jan. 1968
Number installed to date	NA	0	0	NA	NA
COMMENTS	Specifically de- signed to sup- port up to 32 interactive CRT terminals. MOS/LSI CP consists of 12 chips on 1 card.		CPU, memory, and all I/O de- vices share a common data bus. IMPAC facilitates pro- gramming of process control functions.	Has 28 basic instructions and 5 addressing modes.	Available in three models: SPC-12/10, 12/15, and 12/20.

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MANUFACTURER & MODEL	General Automation SPC-16	General Automation System 18/30	General Electric 3010/2	GTE TEMPO I	GTE TEMPO II
DATA FORMATS					
Word length, bits	16	16	16	16	16
Fixed-point operand length, bits	16	16/32	16/32	16	16
Instruction length, bits	16	16/32	16/32	16/32	16/32
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	0.80/0.96/1.44	0.96	1.0	0.9	0.75
Minimum capacity, words	4,096	4,096	4,096	4,096	4,096
Maximum capacity, words	32,768	32,768	32,768	256,000	65,536
Parity checking	No	Standard	Optional	No	No
Storage protection	No	Standard	Optional	Optional	No
CENTRAL PROCESSOR					
No. of accumulators	16	2	16	16	16
No. of index registers	6	3	15	15	15
No. of directly addressable words	32,768	32,768	32,768	65,536	65,536
Indirect addressing	One-level	One-level	No	One-level	One-level
Add time, microseconds (full word)	0.80/0.96/1.44	2.4	1.0	1.8	1.5
Hardware multiply/divide	Optional	Standard	Standard	Standard	Optional
Hardware floating point	No	No	Standard	No	No
Hardware byte manipulation	Standard	No	Standard	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Standard	Standard	Optional	Standard	Standard
Real-time clock or timer	Standard	Standard	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	8/16	8/16	8/16
Direct memory access channel	Standard	5 standard	Standard	Optional	Standard
Maximum I/O rate, words/sec	1,040,000	960,000	1,000,000	640,000	1,100,000
No. of external interrupt levels	8-unlimited	6	255	16	8-64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	No	No	No
Drum storage	Yes	Yes	Yes	Yes	Yes
Magnetic tape speed, cps	60K max.	60K max.	20K	30K/60K	30K/60K
Punched card input speed, cpm	400/1000	400/100	200	400	400
Punched card output speed, cpm	100	100	200 max.	—	—
High-speed paper tape input, cps	400	400	300	400	400
High-speed paper tape output, cps	75	75	60	120	120
Other standard peripheral units	A/D converters, communications interfaces	A/D converters, communications interfaces	Cassette tape, line printer, process I/O, communications	Line printer, communications and computer interfaces	Line printer, communications and computer interfaces
SOFTWARE					
Assembler	2-pass	1-pass	1, 2, or 3-pass	1 & 2-pass	2-pass
Macro assembler	Yes	No	No	Yes	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	No	No	No	No	No
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$3,950 to \$8,550	\$18,950	\$10,900	Not specified	\$5,700
Price of basic system with 8K words	Not specified	\$22,950	\$14,500	\$23,600	\$7,500
Date of first delivery	May 1970	July 1969	Dec. 1971	Sept. 1969	Jan. 1972
Number installed to date	NA	NA	NA	Over 100	10
COMMENTS					
	Available in six models, offering choice of core speeds and I/O packaging. Read-only memory is interchangeable with core.	Instruction set is fully compatible with the IBM 1130 and 1800. SPC-18 is an OEM version of the 18/30.	GE specializes in utility and process automation; software is available for process monitoring and control.	TEMPO I and II are program-compatible and are used mainly for communications processing. Interfaces are available for IBM 360/370, CDC 3800, Xerox Sigma 5, and Honeywell Series 400 computers.	

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MANUFACTURER & MODEL	GRI Computer GRI-99 Model 30	GRI Computer GRI-99 Model 40	GRI Computer GRI-909 Model 10	GRI Computer GRI-909 Models 20, 30	GRI Computer GRI-909 Model 40
DATA FORMATS					
Word length, bits	16	16	16	16	16
Fixed-point operand length, bits	16	16	16	16	16
Instruction length, bits	16	16	16	16	16
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.2	1.2	1.72	1.72	1.72
Minimum capacity, words	4,096	4,096	1,024	1,024	1,024
Maximum capacity, words	32,768	32,768	4,096	32,768	32,768
Parity checking	No	No	No	No	No
Storage protection	Optional	Optional	Optional	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	1	1	1	1	1
No. of index registers	1; up to 32K	1; up to 32K	Up to 32K	Up to 32K	Up to 32K
No. of directly addressable words	32,768	32,768	32,768	32,768	32,768
Indirect addressing	One-level	One-level	One-level	One-level	One-level
Add time, microseconds (full word)	0.88/1.76	0.88/1.76	0.88/1.76	0.88/1.76	0.88/1.76
Hardware multiply/divide	Optional	Standard	Optional	Optional	Standard
Hardware floating point	Optional	Standard	Optional	Optional	Standard
Hardware byte manipulation	Optional	Standard	Optional	Optional	Standard
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Optional	Optional	Standard	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	16	16	16
Direct memory access channel	Standard	Standard	Standard	Standard	Standard
Maximum I/O rate, words/sec	568,000	568,000	568,000	568,000	568,000
No. of external interrupt levels	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Special order	Special order	Special order	Special order	Special order
Magnetic tape speed, cps	310	310	310	310	310
Punched card input speed, cpm	300	300	300	300	300
Punched card output speed, cpm	Special order	Special order	Special order	Special order	Special order
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	50	50	50	50	50
Other standard peripheral units	Cassette tape, line printers, displays, etc.	Cassette tape, line printers, displays, etc.	Cassette tape, line printers, displays, etc.	Cassette tape, line printers, displays, etc.	Cassette tape, line printers, displays, etc.
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	No	No	No	No	No
Other compilers	No	No	No	No	No
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$4,200	\$5,450	\$3,500 with 1K words	\$5,650	\$6,850
Price of basic system with 8K words	\$5,100	\$6,350	Not available	\$8,600	\$9,800
Date of first delivery	June 1972	June 1972	Jan. 1970	Jan. 1970	Jan. 1970
Number installed to date	0	0	See COMMENTS	See COMMENTS	See COMMENTS
COMMENTS	The GRI computers are based on a Universal Bus System, in which all system elements share common data buses and communicate in direct, parallel fashion. They are intended mainly for OEM use, as central control computers in larger systems. The computers and the associated assembly language are functionally rather than arithmetically oriented. About 250 of the GRI-909 computers (all models) have been delivered to date.				

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MANUFACTURER & MODEL	Hewlett-Packard 2100A	Hewlett-Packard 3000	Honeywell 316	Honeywell 516	Honeywell System 700
DATA FORMATS					
Word length, bits	16	16	16	16	16
Fixed-point operand length, bits	16	16/32	16/32	16/32	16/32
Instruction length, bits	16	16	16	16	16
MAIN STORAGE					
Storage type	Core	Core/semicond.	Core	Core	Core
Cycle time, microseconds/word	0.98	1.05/0.70	1.6	0.96	0.775
Minimum capacity, words	4,096	24,576	4,096	4,096	8,192
Maximum capacity, words	32,768	65,536	32,768	32,768	32,768
Parity checking	Standard	Standard	Optional	Optional	Optional
Storage protection	Standard	Standard	Optional	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	2	Stack	1	1	1
No. of index registers	0	1	1	1	2
No. of directly addressable words	2,048	1,024	1,024	1,024	1,024
Indirect addressing	Multi-level	One level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	1.96	1.05	3.2	1.92	1.55
Hardware Multiply/divide	Standard	Standard	Optional	Optional	Optional
Hardware floating point	No	Standard	Special order	Special order	No
Hardware byte manipulation	No	Standard	Standard	Standard	Standard
Immediate (literal) instructions	No	Standard	No	No	No
Power failure protection	Standard	Standard	Optional	Optional	Standard
Real-time clock or timer	Optional	Standard	Optional	Optional	Standard
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	16	16	16
Direct memory access channel	Optional (2)	Standard	Optional	Optional	Standard
Maximum I/O rate, words/sec	1,000,000	2,800,000	313,000	1,040,000	1,000,000
No. of external interrupt levels	Up to 56	253	1-65	1-65	Not specified
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Yes	Yes	Yes	Yes	No
Magnetic tape speed, cps	72K max.	72K max.	64K max.	64K max.	28.8K max.
Punched card input speed, cpm	200/600	600/1200	800	800	800
Punched card output speed, cpm	—	35/200	100	100	100
High-speed paper tape input, cps	500	500	300	300	300
High-speed paper tape output, cps	75/120	75	110	110	110
Other standard peripheral units	Line printers, communications interfaces, plotters	Line printers, CRT display, communications, plotters	Line printers, communications interfaces, displays, etc.	Line printers, communications interfaces, displays, etc.	300-lpm printer; communications interfaces, A/D interfaces, etc.
SOFTWARE					
Assembler	2-pass	Yes	1 & 2-pass	1 & 2-pass	2-pass
Macro assembler	No	Yes	Yes	Yes	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	ALGOL, BASIC	BASIC, SPL	BASIC	BASIC	BASIC
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$6,900	Not available	\$8,400	\$23,800	Not available
Price of basic system with 8K words	\$10,400	Not available	\$11,900	\$31,800	\$19,400 (\$570/mo.)
Date of first delivery	1971	Sept. 1972	June 1969	Oct. 1966	June 1972
Number installed to date	Over 500	0	1500	1100	0
COMMENTS	Controlled by semiconductor read-only memory. Compatible with earlier HP minicomputers.	Features stack architecture and 170 instructions. System prices range from about \$100,000 to \$300,000.	The 316 and 516 are logically identical. They form the basis of Honeywell's Series 1600 data acquisition and data communications systems. Ruggedized models, 316R and 516R, are also available.		Type 716 CPU is incorporated into 6 systems designed for a variety of sensor-based and communications applications.

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MANUFACTURER & MODEL	IBM System/7	Intel MCS-4 Microcomputer	Intel MCS-8 Microcomputer	Interdata Model 70	Interdata Model 80
DATA FORMATS					
Word length, bits	16	4/8	8	16	16
Fixed-point operand length, bits	16	4	8	16/32	16/32
Instruction length, bits	16/32	8/16	8/16/24	16/32	16/32
MAIN STORAGE					
Storage type	Semiconductor	Semiconductor	Semiconductor	Core	Semiconductor
Cycle time, microseconds/word	0.4	10.8	10 to 20	1.0	0.24
Minimum capacity, words	2,048	256	256	4,096	8,192
Maximum capacity, words	16,384	5,376	16,384	32,768	32,768
Parity checking	Standard	No	No	Optional	Optional
Storage protection	No	No	No	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	4 groups of 1	1	1	16	16
No. of index registers	4 groups of 7	16 (4-bit)	6 (8-bit)	15	15
No. of directly addressable words	16,384	4,096	16,384	32,768	32,768
Indirect addressing	No	One-level	One-level	No	No
Add time, microseconds (full word)	0.8	10.8	10 to 20	1.0	0.45
Hardware multiply/divide	No	No	No	Standard	Standard
Hardware floating point	No	No	No	Standard	Standard
Hardware byte manipulation	No	No	Standard	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Optional	No	No	Optional	Optional
Real-time clock or timer	Standard (2)	No	No	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	4	8	8/16	8/16
Direct memory access channel	Standard	No	No	Optional	Optional
Maximum I/O rate, words/sec	500,000	10,000	5,000	1,000,000	4,500,00
No. of external interrupt levels	64	None	1	255	255
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	—	—	Yes	Yes
Non-interchangeable disk storage	Yes	—	—	No	No
Drum storage	No	—	—	Yes	Yes
Magnetic tape speed, cps	—	—	—	20K	20K
Punched card input speed, cpm	—	—	—	200	200
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	—	—	—	300	300
High-speed paper tape output, cps	—	—	—	60	60
Other standard peripheral units	Analog and digital I/O interfaces, communications interface	—	—	Cassette tape, digital I/O	Cassette tape, digital I/O
SOFTWARE					
Assembler	1-pass	2-pass	2-pass	1 & 2-pass	1 & 2-pass
Macro assembler	Yes	No	No	No	No
FORTRAN compiler	No	No	No	Yes	Yes
Other compilers	No	No	No	No	No
Operating system	Limited	No	No	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$16,795	\$900	\$900	\$6,800	Not available
Price of basic system with 8K words	\$27,820	Not available	\$1,400	\$9,500	\$14,900
Date of first delivery	Nov. 1971	June 1971	Jan. 1972	Dec. 1971	July 1972
Number installed to date	NA	NA	NA	210	0
COMMENTS	Designed for sensor-based applications. Can be used on-line with IBM 1130, 1800, 360, and 370 computers.	Consists of 4 kinds of LSI chips: processor, shift register, R/W memory, and ROM. The ROM modules are programmed to user spec's.	CPU is a single MOS chip that can be combined with various R/W memory, ROM, and shift register modules.	Controlled by microprograms in 80-nanosecond bipolar read-only memory. Compatible with earlier Interdata computers.	Features 240-nanosecond MOS main memory. Controlled by microprograms in 60-nanosecond bipolar read-only memory.

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MANUFACTURER & MODEL	Lockheed Electronics MAC 16	Lockheed Electronics MAC Jr.	Lockheed Electronics SUE-1110	Microdata Micro 400	Microdata Micro 800
DATA FORMATS					
Word length, bits	16	16	16	8	8
Fixed-point operand length, bits	16	16	16	8	Variable
Instruction length, bits	16	16	16/32	8/16	16
MAIN STORAGE					
Storage type	Core	Core	Core/ROM/RAM	Core	Core
Cycle time, microseconds/word	1.0	1.0	0.85/0.20/0.25	1.6	1.1
Minimum capacity, words	4,096	4,096	4K/1K/1K	1,024	0
Maximum capacity, words	65,536	65,536	32K/30K/30K	65,536	32,768
Parity checking	Optional	Optional	Optional	No	No
Storage protection	Optional	Optional	Optional	No	No
CENTRAL PROCESSOR					
No. of accumulators	1	1	7	2	15
No. of index registers	8-64	4-16	7	1 or 2	0
No. of directly addressable words	1,024	1,024	32,768	4,096	32,768
Indirect addressing	Multi-level	Multi-level	Multi-level	No	No
Add time, microseconds (full word)	2.0	2.0	2.79	1.6	0.22
Hardware multiply/divide	Optional	Optional	Optional	No	No
Hardware floating point	No	No	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	No	Standard
Power failure protection	Standard	Optional	Standard	Optional	Optional
Real-time clock or timer	Standard	Optional	Standard	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8/16	8/16	8/16	8	8
Direct memory access channel	Standard	Optional	Standard	Optional	Optional
Maximum I/O rate, words/sec	1,000,000	1,000,000	5,000,000	625,000	910,000
No. of external interrupt levels	8-64	4-16	4-64	1-64	1-64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	No	Yes	Yes
Drum storage	Yes	Yes	No	No	Yes
Magnetic tape speed, cps	20K	20K	36K	20K	20K
Punched card input speed, cpm	300	300	300	300	400
Punched card output speed, cpm	—	—	35	—	—
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	75	75	75	75	75
Other standard peripheral units	Line printer, cassette tape, communications, displays	Line printer, cassette tape, communications, displays	Line printer, cassette tape, communications, displays	Communications interfaces	Line printers, CRT displays, communications interfaces
SOFTWARE					
Assembler	2-pass	2-pass	1-pass	2-pass	2-pass
Macro assembler	Yes	Yes	Yes	No	No
FORTRAN compiler	Yes	Yes	Yes	No	No
Other compilers	No	No	RPG II	No	No
Operating system	Yes	Yes	Yes	No	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$9,500	\$6,500	\$3,895	\$3,195	\$4,875
Price of basic system with 8K words	\$11,750	\$8,750	\$5,495	\$4,690	\$5,875
Date of first delivery	Feb. 1969	Jan. 1971	Feb. 1972	Jan. 1970	Jan. 1969
Number installed to date	310	640	25	100	650
COMMENTS	Optional Multi-plex Data Channel handles up to 16 concurrent I/O operations.	Program-compatible with MAC 16. Optional channel handles up to 16 concurrent I/O operations.	Highly modular packaging; three types of memory can be inter-mixed. Up to 4 processors can be used in a system.	Only 3.5" high by 17.5" wide by 21" deep; weighs 23 pounds.	A micro-programmable computer built around a file of 16 registers and a 220-nsec read-only control memory.

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MANUFACTURER & MODEL	Microdata Micro 810	Microdata Micro 820	Microdata Micro 1600	Microdata Micro 1600D	Microdata Micro 1600/21
DATA FORMATS					
Word length, bits	8	8	8	8	8
Fixed-point operand length, bits	8/16/24/32	8/16/24/32	Variable	Variable	8/16/24/32
Instruction length, bits	8/16/24/32	8/16/24/32	16	16	8/16/24/32
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.1	1.1	1.0	1.0	1.0
Minimum capacity, words	4,096	4,096	0	8,192	4,096
Maximum capacity, words	32,768	32,768	65,536	65,536	32,768
Parity checking	No	No	No	No	No
Storage protection	No	No	No	No	No
CENTRAL PROCESSOR					
No. of accumulators	2	2	30	60	3
No. of index registers	1	1	Up to 30	Up to 60	1
No. of directly addressable words	32,768	32,768	65,536	65,536	32,768
Indirect addressing	One-level	One-level	No	No	One-level
Add time, microseconds (full word)	11	11	0.20	0.20	5.0
Hardware multiply/divide	No	Optional	No	No	Standard
Hardware floating point	No	Optional	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Optional	Optional	Standard	Standard	Standard
Real-time clock or timer	Optional	Optional	Standard	Standard	Standard
INPUT/OUTPUT CONTROL					
I/O word size, bits	8	8	8	8	8
Direct memory access channel	Optional	Optional	Standard	Standard	Standard
Maximum I/O rate, words/sec	910,000	910,000	1,000,000	1,000,000	1,000,000
No. of external interrupt levels	2-32	2-32	1-64	4-128	2-64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Yes	Yes	No	No	No
Magnetic tape speed, cps	20K	20K	20K	20K	20K
Punched card input speed, cpm	400	400	300	300	300
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	75	75	75	75	75
Other standard peripheral units	Line printers, CRT displays, communications interfaces	Line printers, CRT displays, communications interfaces	Line printers, CRT displays	Line printers, communications interfaces	Line printers, communications interfaces
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	No	No	No	No	No
Other compilers	BASIC	BASIC	No	No	BASIC
Operating system	Yes	Yes	Yes	No	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$5,875	\$5,875	\$4,995	Not available	\$5,820
Price of basic system with 8K words	\$6,875	\$6,875	\$5,745	\$8,295	\$6,145
Date of first delivery	Jan. 1969	Dec. 1969	July 1971	June 1972	Dec. 1971
Number installed to date	400	290	35	0	15
COMMENTS					
	A micro-programmed adaptation of the Micro 880; price includes 768 words of read-only control memory.	Features stack processing and character and string manipulation; price includes 768 words of read-only control memory.	A micro-programmable computer built around a file of 31 registers and a 200-nsec read-only control memory.		A micro-programmed adaptation of the Micro 1600.

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MANUFACTURER & MODEL	Modular Comp. Systems Modcomp I	Modular Comp. Systems Modcomp II	Modular Comp. Systems Modcomp III	Nuclear Data ND812	Omnitec BIT 483
DATA FORMATS					
Word length, bits	16	16	16	12	8-bit byte
Fixed-point operand length, bits	16	16/32	16/32/48	12	1-64 bytes
Instruction length, bits	16/32	16/32	16/32	12/24	16/32
MAIN STORAGE					
Storage type	Core, semicond.	Core, semicond.	Core, semicond.	Core	Core
Cycle time, microseconds/word	0.8	0.8	0.8	2.0	0.98
Minimum capacity, words	512	2,048	4,096	4,096	1,024
Maximum capacity, words	32,768	65,536	65,536	16,384	65,536
Parity checking	Optional	Optional	Standard	No	Optional
Storage protection	No	No	Optional	No	Standard
CENTRAL PROCESSOR					
No. of accumulators	3	15	15	2	1
No. of index registers	3	7	7	2 (core)	0
No. of directly addressable words	32,768	65,536	65,536	16,384	512
Indirect addressing	No	One-level	One-level	One-level	One-level
Add time, microseconds (full word)	0.8	0.8	0.8	2/4	2.3
Hardware multiply/divide	Optional	Optional	Optional	Standard	Optional
Hardware floating point	No	No	Optional	No	Optional
Hardware byte manipulation	Standard	Standard	Standard	No	Standard
Immediate (literal) instructions	Standard	Standard	Standard	Standard	No
Power failure protection	Optional	Optional	Standard	Standard	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	16	12/24	8
Direct memory access channel	Standard	Optional	Optional	Standard	Standard
Maximum I/O rate, words/sec	1,250,000	1,250,000	1,250,000	500,000	1,020,000
No. of external interrupt levels	1-5	3-16	4-32	256-4,096	8-32
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	No
Drum storage	No	No	No	No	Yes
Magnetic tape speed, cps	10K/60K	10K/60K	10K/60K	36K	20K-30K
Punched card input speed, cpm	300/1000	300/1000	300/1000	—	225
Punched card output speed, cpm	100	100	100	—	150
High-speed paper tape input, cps	625	625	625	125/300	300
High-speed paper tape output, cps	110	110	110	50/110	60
Other standard peripheral units	Line printers, A/D converters	Line printers, A/D converters	Line printers, A/D converters	Line printer, cassette tape, A/D converters	CRT display, cassette tape, line printer, plotter
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	Yes	Yes	Limited	Yes
FORTRAN compiler	No	Yes	Yes	No	Yes
Other compilers	No	No	No	NUTRAN	No
Operating system	No	Yes (3)	Yes (3)	Limited	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$4,400	\$7,400	\$9,850	\$6,950	\$6,307
Price of basic system with 8K words	\$6,200	\$9,200	\$11,650	\$9,600	\$6,665
Date of first delivery	Oct. 1971	March 1971	Dec. 1970	Nov. 1970	Jan. 1970
Number installed to date	50	15	40	200	NA
COMMENTS					
	A DMA with extended control capabilities is standard.	200-nsec read-only control memory consists of 256 to 512 40-bit words.	200-nsec read-only control memory consists of 256 to 1024 40-bit words.	Integrated circuits can be easily replaced without re-soldering.	Performs both decimal and binary arithmetic on variable-length operands.

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MANUFACTURER & MODEL	Omnus Computer Corp. Omnus-1	Qantel Q Series	Raytheon 703	Raytheon 704	Raytheon 706
DATA FORMATS					
Word length, bits	16	8	16	16	16
Fixed-point operand length, bits	8/16	Variable	16	16	16
Instruction length, bits	16/32	24 or 48	16	16	16
MAIN STORAGE					
Storage type	Core	Semiconductor	Core	Core	Core
Cycle time, microseconds/word	1.2	1.5	1.75	1.0	0.9
Minimum capacity, words	2,048	4,096	4,096	4,096	4,096
Maximum capacity, words	131,072	32,768	32,768	32,768	32,768
Parity checking	No	No	No	Optional	Optional
Storage protection	Optional	No	No	Optional	Optional
CENTRAL PROCESSOR		Program- controlled			
No. of accumulators	2,049	—	1	1	1
No. of index registers	2,049	—	1	1	1
No. of directly addressable words	32,768	32,768	2,048	2,048	2,048
Indirect addressing	No	Multi-level	No	No	No
Add time, microseconds (full word)	2.4	57.5	3.5	2.0	1.8
Hardware multiply/divide	Optional	Standard	Optional	Optional	Optional
Hardware floating point	Optional	No	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	No	Standard	Standard	Standard
Power failure protection	Standard	No	Optional	Optional	Optional
Real-time clock or timer	Optional	No	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8/16	8	16	16	16
Direct memory access channel	Standard	Up to 9	Optional	Optional	Optional
Maximum I/O rate, words/sec	833,000	666,000 bytes	571,000	1,000,000	1,100,000
No. of external interrupt levels	32-256	1	1-16	1-16	1-16
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	No	Yes	Yes	Yes	Yes
Drum storage	No	No	No	No	No
Magnetic tape speed, cps	20K	10K-60K	120K max.	120K max.	120K max.
Punched card input speed, cpm	300	300	1100	1100	1100
Punched card output speed, cpm	—	—	100-400	100-400	100-400
High-speed paper tape input, cps	300	50	300	300	300
High-speed paper tape output, cps	72	50	110	110	110
Other standard peripheral units	Line printer, communications interfaces	Printers: 60 to 1800 lpm	Line printers, tape cassette, plotter, A/D converters	Line printers, tape cassette, plotter, A/D converters	Line printers, tape cassette, plotter, A/D converters
SOFTWARE					
Assembler	1 & 2-pass	2-pass	1 & 2-pass	1 & 2-pass	1 & 2-pass
Macro assembler	Yes	No	Yes	Yes	Yes
FORTRAN compiler	No	No	Yes	Yes	Yes
Other compilers	No	No	No	No	No
Operating system	No	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$6,500	\$12,315	\$12,750	\$9,200	\$19,000
Price of basic system with 8K words	\$9,950	\$14,465	\$17,500	\$12,700	\$24,600
Date of first delivery	Aug. 1971	June 1970	Oct. 1967	March 1970	May 1969
Number installed to date	1	Over 100	260	250	120
COMMENTS	Features 2,048 general reg- isters in core memory and single-bus architecture. Read-only memory is optional.	Controlled by microprograms in 50-nsec read-only memory. Prices include I/O typewriter and desk.	All three Raytheon computers are program-compatible; a software library of over 600 routines includes a con- versational FORTRAN compiler and a Real-Time Operating System capable of controlling foreground/ background multiprogramming in 8K disk systems. An Array Transform Processor facilitates signal processing.		

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MANUFACTURER & MODEL	Rolm Corp. 1601 Ruggednova	SYS Computer Corp. SYS 500	SYS Computer Corp. SYS 1000	SYS Computer Corp. SYS 1500	SYSTEMS 71
DATA FORMATS					
Word length, bits	16	8	8	8	16
Fixed-point operand length, bits	16	8	8	8	16/32
Instruction length, bits	16	16	24	24	16
MAIN STORAGE					
Storage type	Core/semicond.	Semiconductor	Semiconductor	Semiconductor	Core
Cycle time, microseconds/word	2.6	1.0	1.0	0.5	0.85
Minimum capacity, words	256	256	256	512	8,192
Maximum capacity, words	32,768	4,096	32,768	65,536	65,536
Parity checking	No	No	Optional	Optional	Optional
Storage protection	No	Standard	Standard	Standard	Standard
CENTRAL PROCESSOR					
No. of accumulators	4	16	32	16	8
No. of index registers	2	Up to 4,096	32	Up to 4,096	2
No. of directly addressable words	1,024	Up to 4,096	256	Up to 4,096	256
Indirect addressing	Multi-level	One-level	One-level	One-level	One-level
Add time, microseconds (full word)	5.9	0.5	2.0	0.5	3
Hardware multiply/divide	Optional	No	Optional	Optional	Optional
Hardware floating point	No	Optional	Optional	Optional	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	No	Standard	Standard	Standard	Standard
Power failure protection	Standard	Standard	Standard	Standard	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	8	8	8	8/16
Direct memory access channel	Standard	Standard	Standard	Standard	Optional
Maximum I/O rate, words/sec	285,500	500,000	1,000,000	1,000,000	1,000,000
No. of external interrupt levels	16	None	None	None	0-384
PERIPHERAL EQUIPMENT					
Disk pack storage	No	No	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	No	Yes	Yes	Yes
Drum storage	No	No	Yes	Yes	Yes
Magnetic tape speed, cps	150 ips max.	Not specified	Not specified	Not specified	20K max.
Punched card input speed, cpm	400	Not specified	Not specified	Not specified	300
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	300	1,000	1,000	1,000	300
High-speed paper tape output, cps	63	1,000	1,000	1,000	120
Other standard peripheral units	Line printer, cassette tape, plotters	Line printers, cassette tape, CRT displays	Line printers, cassette tape, CRT displays	Line printers, cassette tape, CRT displays	Line printers, analog and digital interfaces, communications
SOFTWARE					
Assembler	2-pass	No	No	No	1-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	Yes	No	No	No	Yes
Other compilers	ALGOL,BASIC	No	No	No	BASIC
Operating system	Yes	No	No	No	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$13,500	On request	On request	On request	Not available
Price of basic system with 8K words	\$19,500	Not available	On request	On request	\$15,000
Date of first delivery	March 1970	June 1972	Jan. 1971	June 1972	Aug. 1972
Number installed to date	Over 75	0	300	0	0
COMMENTS	Militarized version of the Data General Nova, designed for severe environments.	The SYS "Microprocessors" are highly modular programmed controllers, designed to be mass-produced as parts of production products and systems. MOS/LSI read-only memory is programmed to each customer's specifications. All sequential logic is performed by firmware.			All-core-memory version of the SYSTEMS 72.

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MANUFACTURER & MODEL	SYSTEMS 72	Texas Instruments Model 960A	Texas Instruments Model 980	Unicom CP-8	UniComp COMP-18
DATA FORMATS					
Word length, bits	16	16	16	8	18
Fixed-point operand length, bits	16/32	16	16	8	18
Instruction length, bits	16	32	16/32	8/16	18
MAIN STORAGE					
Storage type	Core/disk	Semiconductor	Core	Core or ROM	Core
Cycle time, microseconds/word	0.85	0.75	1.0	1.75	0.88
Minimum capacity, words	8,192 (core)	4,096	4,096	512	4,096
Maximum capacity, words	65,536 (core)	65,536	65,536	32,768	262,144
Parity checking	Optional	Standard	Standard	Standard	No
Storage protection	Standard	Standard	Standard	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	8	16	2	1	1
No. of index registers	2	16	1	1	6
No. of directly addressable words	256	65,536	65,536	4,096	1,024
Indirect addressing	One-level	One-level	One-level	32,768	One-level
Add time, microseconds (full word)	3	3.2	2.0	3.5	2.25
Hardware multiply/divide	Optional	Optional	Standard	Optional	Optional
Hardware floating point	No	No	No	No	Optional
Hardware byte manipulation	Standard	Standard	No	No	Optional
Immediate (literal) instructions	Standard	Standard	Standard	Yes	Standard
Power failure protection	Standard	Standard	Standard	Optional	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8/16	1 to 16	16	8	18
Direct memory access channel	Optional	Standard	Standard	Optional	Standard
Maximum I/O rate, words/sec	1,000,000	1,000,000	1,000,000	45,000	1,100,000
No. of external interrupt levels	0-384	2-2049	3	4	1-128+
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	No	Yes
Non-interchangeable disk storage	Standard	Yes	Yes	No	Yes
Drum storage	Yes	No	No	No	Yes
Magnetic tape speed, cps	20K max.	300K max.	300K max.	2 ips	36K
Punched card input speed, cpm	300	300	300	—	300
Punched card output speed, cpm	—	100	100	—	60
High-speed paper tape input, cps	300	300	300	500	625
High-speed paper tape output, cps	120	60	60	500	75
Other standard peripheral units	Line printers, analog and digital interfaces, communications	Line printers, communications interfaces, A/D converters, etc.	Line printers, communications interfaces, A/D converters, etc.	CRT display, page printer, cassette tape	Line printer, A/D converters, communications interfaces
SOFTWARE					
Assembler	1-pass	2-pass	2-pass	2-pass	1 & 2-pass
Macro assembler	No	Yes	Yes	Yes	No
FORTRAN compiler	Yes	Yes	Yes	No	Yes
Other compilers	BASIC	No	No	No	BASIC
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	Not available	\$2,850	\$6,800	\$3,200	\$11,000
Price of basic system with 8K words	\$23,500	\$4,350	\$11,400	\$4,600	\$13,700
Date of first delivery	Aug. 1970	Nov. 1971	May 1968	March 1970	Aug. 1970
Number installed to date	NA	NA	NA	NA	30
COMMENTS	Features virtual memory; quoted prices include memory map and 65K memory expansion disk.	Designed for efficient manipulation of individual bits and bit fields; has 16 general registers.	Real-time Monitor can handle foreground/background multi-programming.	Avail. with either read-only or read/write memory; prices are for Model CP-8C with read/write core memory.	Hardware sq. root, Fourier transform, and coordinate converter are available; 48-word read-only memory holds bootstrap loader.

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MANUFACTURER & MODEL	Varian 620/f	Varian 620/f-100	Varian 620/L	Varian 620/L-100	Varian R-620/L
DATA FORMATS					
Word length, bits	16	16	16	16	16 (18 opt.)
Fixed-point operand length, bits	16	16	16	16	16
Instruction length, bits	16/32	16/32	16/32	16/32	16/32
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	0.75	0.75	1.8	0.95	1.8
Minimum capacity, words	4,096	4,096	4,096	4,096	4,096
Maximum capacity, words	32,768	32,768	32,768	32,768	32,768
Parity checking	Optional	No	No	No	No
Storage protection	Standard	Standard	Optional	No	No
CENTRAL PROCESSOR					
No. of accumulators	2	2	2	2	2
No. of index registers	2	2	2	2	2
No. of directly addressable words	2,048	2,048	2,048	2,048	2,048
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	1.5	1.5	3.6	1.9	3.6
Hardware multiply/divide	Standard	Standard	Standard	Standard	Optional
Hardware floating point	No	No	No	No	No
Hardware byte manipulation	No	No	No	No	No
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Standard	Standard	Standard	Standard	Optional
Real-time clock or timer	Standard	Standard	Standard	Standard	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	16	16	16
Direct memory access channel	Standard	Standard	Standard	Standard	Optional
Maximum I/O rate, words/sec	1,330,000	1,330,000	200,000	383,000	200,000
No. of external interrupt levels	0-64	0-64	0-64	0-64	0-64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Yes	Yes	Yes	Yes	Yes
Magnetic tape speed, cps	20K max.	20K max.	20K max.	20K max.	20K max.
Punched card input speed, cpm	300	300	300	300	300
Punched card output speed, cpm	35	35	35	35	35
High-speed paper tape input, cps	150/300	150/300	150/300	150/300	150/300
High-speed paper tape output, cps	75	75	75	75	75
Other standard peripheral units	Line printer, CRT displays, A/D converters, plotters, etc.	Line printer, CRT displays, A/D converters, plotters, etc.	Line printer, CRT displays, A/D converters, plotters, etc.	Line printer, CRT displays, A/D converters, plotters, etc.	Line printer, CRT displays, A/D converters, plotters, etc.
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	BASIC, RPG	BASIC, RPG	BASIC, RPG	BASIC, RPG	BASIC, RPG
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	\$10,500	\$10,500	\$5,400	\$6,400	\$16,900
Price of basic system with 8K words	\$13,000	\$13,000	\$7,700	\$8,700	\$23,300
Date of first delivery	June 1970	June 1972	May 1971	June 1972	June 1969
Number installed to date	NA	0	NA	0	NA
COMMENTS					
All 620 Series computers are program-compatible with one another and with the original Varian 620/i. The R-620/i is a ruggedized version designed for reliable operation in severe environments. Varian offers three operating systems: BEST is a real-time monitor and scheduler, MOS is a batch-processing monitor, and VORTEX is a separately priced multi-programming system with real-time capabilities.					

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MANUFACTURER & MODEL	Wang Laboratories WANG 3300	Westinghouse 2500	Xerox Data Systems CF16A	XLO Computer Products XLO-Eight
DATA FORMATS				
Word length, bits	8	16	16	8
Fixed-point operand length, bits	16/32	16	16	8
Instruction length, bits	16	16	16	8/16
MAIN STORAGE				
Storage type	Core	Core	Core	Core
Cycle time, microseconds/word	1.6	0.75	1.6	1.8
Minimum capacity, words	4,096	4,096	1,024	1,024
Maximum capacity, words	65,546	65,536	32,768	32,768
Parity checking	No	Optional	No	Optional
Storage protection	No	Optional	Optional	No
CENTRAL PROCESSOR				
No. of accumulators	2	2	1	16 per page
No. of index registers	0	2	1	1
No. of directly addressable words	768	256	768	256
Indirect addressing	One-level	One-level	Multi-level	No
Add time, microseconds (full word)	4.8	1.5	3.2	2.0
Hardware multiply/divide	No	Standard	No	No
Hardware floating point	No	Optional	No	No
Hardware byte manipulation	Standard	No	Standard	Standard
Immediate (literal) instructions	Standard	No	Standard	Standard
Power failure protection	Standard	Standard	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Standard
INPUT/OUTPUT CONTROL				
I/O word size, bits	8	16	16	8
Direct memory access channel	Standard	Optional	Optional	No
Maximum I/O rate, words/sec	500,000	1,000,000	666,000	500,000
No. of external interrupt levels	8	120	3-64	8
PERIPHERAL EQUIPMENT				
Disk pack storage	No	Yes	No	Yes
Non-interchangeable disk storage	No	Yes	Yes	No
Drum storage	No	No	No	No
Magnetic tape speed, cps	—	Not specified	20K	Wide range
Punched card input speed, cpm	—	300/600/1000	300	300
Punched card output speed, cpm	—	35/100	—	120
High-speed paper tape input, cps	30	300	300	500/750
High-speed paper tape output, cps	—	110	60	120
Other standard peripheral units	Dual cassette tape drives	Line printer, CRT display, communications, A/D converters	A/D converters, Communications interfaces	Line printers, modem, generalized interface
SOFTWARE				
Assembler	2-pass	2-pass	1 & 2-pass	2 & 3-pass
Macro assembler	No	Yes	No	No
FORTRAN compiler	Yes	Yes	Yes	No
Other compilers	BASIC	BASIC, RPG	No	No
Operating system	Yes	Yes	No	No
PRICING & AVAILABILITY				
Price of basic system with 4K words	\$4,950	\$9,950	\$10,000	\$4,200
Price of basic system with 8K words	\$6,450	\$13,350	\$13,800	\$5,720 now (\$4,500 soon)
Date of first delivery	April 1971	April 1971	Nov. 1970	Jan. 1971
Number installed to date	45	51	Over 35	40
COMMENTS	Designed mainly for time-sharing; handles up to 16 BASIC or FORTRAN users simultaneously.	Features 16-high speed IC registers. Used in Westinghouse 2550 programmable terminal system.	Can be equipped with read/only memory and/or 400-nsec IC "scratchpad" memory.	64 to 32,768 bytes of read-only memory; architecture facilitates string processing; several cross-assemblers; turnkey systems available.