# All About Minicomputers

Minicomputers represent one of the most widely discussed and written-about subjects in the EDP world today. Although relatively few companies have actually started using minicomputers, their steadily decreasing costs and increasing capabilities have caused nearly every wide-awake data processing executive to wonder whether this new breed of computer might represent the best solution to some or all of his EDP problems.

Approximately 10,000 minicomputers have been installed to date, largely in specialized real-time and control applications. The current minicomputer market volume is estimated at about $150 million a year. This is only a small slice of the $12 billion total market for EDP products and services—but it is now the fastest-growing segment, with estimates of the current annual growth rate ranging from 30 to 50 percent. By 1975, total mini-computer shipments are expected to reach $700 million a year.

Digital Equipment Corporation, the company that started the minicomputer boom with its highly successful PDP-8 line, is still the undisputed king of the minicomputer field. DEC has installed more than 7,000 computers to date, and estimates of its current share of the minicomputer market range from 60 to 80 percent. DEC's new PDP-11, already being produced at the rate of 20 a week, is an impressive 16-bit machine that effectively complements the aging 12-bit PDP-8 series.

Hewlett-Packard and Honeywell's Computer Control Division both claim second place in the minicomputer sales race, and Varian Data Machines is another major force in the field. Coming on fast are a number of aggressive young companies such as Data General and Interdata.

In all, some 60 U.S. companies are now building mini-computers. They range from such large, well-established companies as Lockheed, Motorola, Raytheon, and Texas Instruments to new, untried companies whose survival will depend upon their ability to back up their imaginative hardware ideas with effective marketing, production, software, and customer support. The current offerings of 40 of these manufacturers—including all of the really significant suppliers—are summarized in the accompanying minicomputer comparison charts.

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 if the many available models represents the best overall choice for you? This report is designed to answer these questions and bring you up to

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. Comparision charts summarize the capabilities of 77 computers from 40 different manufacturers.

date on the rapidly advancing state of the art in minicomputers.

## 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 $100,000 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 $100,000. Excluded from this survey are the general-purpose data processing systems which are (or soon will be) described in detailed reports in the Computer section of DATAPRO 70, as well as the electronic accounting machines designed strictly for business data processing. ▷
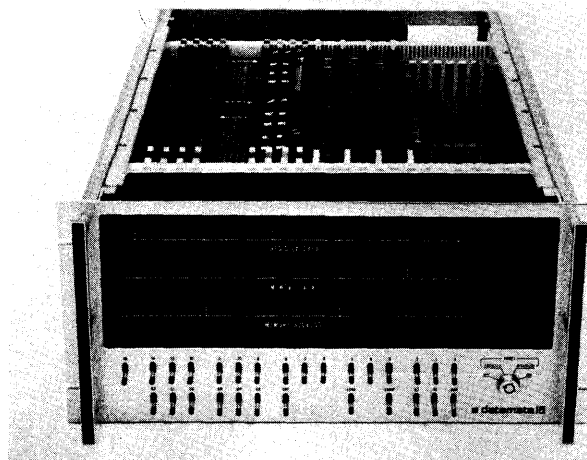
A view of the front panel and internal construction of the Datamate 16, a 16-bit minicomputer that is fairly typical of the current state of the art.

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▷ 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 machines are also appearing in ever-expanding numbers). 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 offers from 4,096 to 32,768 words of magnetic core storage with a cycle time of 1.0 to 1.5 microseconds. Parity checking and storage protection are available as extra-cost options.

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 2 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 600,000 words per second. The 2 external interrupt levels in the basic machine can be expanded to a maximum of 64 levels. 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 two-pass 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 purchase price of the basic system, including 4,096 words of core storage and a Teletype Model 33 ASR unit, is about $12,000. By all previous standards of value in the computer field, it's a truly impressive little package of computing power for the price.

## 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.

Among the largest current markets for minicomputers are industrial control, data communications, research, 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

● Computer-aided design

● Typesetting and photocomposition

● Computer-assisted instruction

● Engineering and scientific computations

● Time-sharing computational services ▷

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## ▷ 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.

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 programmer'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 being sold in quantity, on an O.E.M. (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 O.E.M. 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 recently introduced minicomputer systems designed primarily for business data processing applications. The Atron 501 Datamanager, the Clary Datacomp 404, and the Hetra S-1 system are all capable of performing decimal arithmetic on variable-length operands and feature business-oriented software. It is likely that many more of the minicomputer builders will recognize the great potential of the business data processing market and develop systems with a similar design orientation.
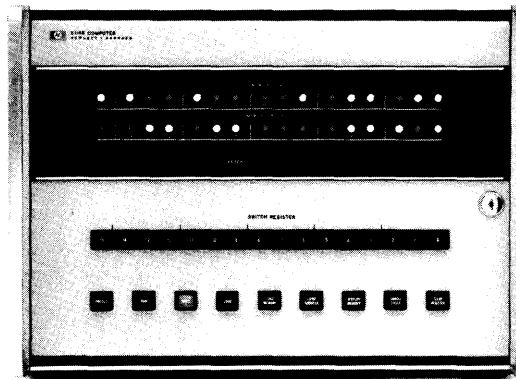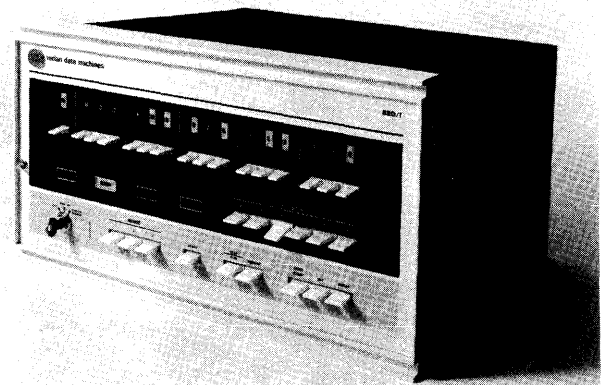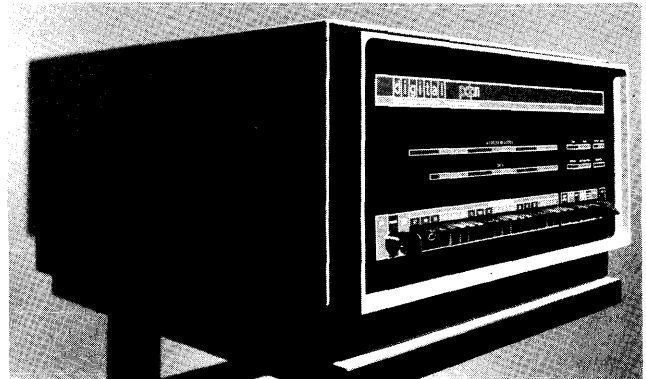


*These 16-bit machines from three of the biggest minicomputer suppliers illustrate the packaging that makes most of the current minicomputers suitable for either tabletop or rack-mounted use. From top to bottom are the Digital Equipment Corporation PDP-11, Varian Data Machines 620/f, and Hewlett-Packard 2114B.*

Second, two of the biggest minicomputer makers have recently introduced software designed to simplify the programming of business applications. Digital Equipment Corporation's DIBOL is a COBOL-like programming system for the widely-used PDP-8 series computers. DIBOL consists of three components: a language processor that enables users to state their problems in convenient terms; a data management system that handles input/output operations, sorting, and file maintenance; ▷

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▷ and a monitor that ties the components together and controls system operations. Varian's 620/RPG is a report program generator, usable on a 4K 620/i or 620/f computer, that permits many business applications to be expressed in a concise language consisting of straightforward data-defining and procedural statements. The 620/RPG system requires a card reader, card punch, and line printer, and magnetic tape or disk units can be utilized if available. If these two new software packages deliver what their impressive specifications promise, they will definitely open new doors for DEC and Varian in the world of business data processing.

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. An example is EDP Technology, Inc. (Washington, D.C.), which offers a minicomputer-based Computer Business System (CBS) to handle the bookkeeping and general ledger accounting requirements for accounting firms and small business users. 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 77 commercially available minicomputers from 40 manufacturers are presented in the accompanying comparison charts. All information in the charts was supplied and/or verified by the 40 manufacturers during May and June of 1970; 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 opera-

tions—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 12, 18, or 24 bits, and 8-bit machines are now proliferating rapidly. The 8-bit minicomputers are suitable for many functions where low cost is more important then 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 nearly all current minicomputers is magnetic cores. Though semiconductor and thin-film memories promise significant advantages for the future, most minicomputer designers are continuing to choose core storage because of its demonstrated ability to satisfy all reasonable requirements for performance, reliability, and economy.

In addition to, or in place of, their standard, alterable core 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. ▷

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▷ 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 0.5 to 8 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 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.
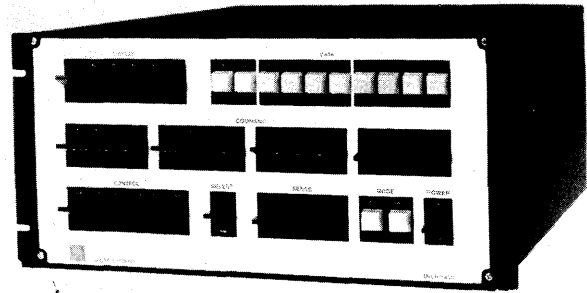


*The MicroSystem Micro 800 is a microprogrammable computer built around a file of 16 registers and a 220-nanosecond read-only memory. The user can define his own instruction repertoire or select one of two specific microprogrammed adaptations supplied by MicroSystems for general-purpose or communications processing.*

## 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.

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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▷ 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 shut-down 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.

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 ▷

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▷ 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.

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, ▷



*The Atron Datamanager 501 is one of the first of a new breed of minicomputers designed primarily for business data processing.*

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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 are just beginning to appear on the market, and it seems likely that they will find rapid acceptance among minicomputer builders and 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 applications 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:

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▷ ● Scheduling, loading, and supervising the execution of programs;

● Allocating storage and I/O devices;

● Initiating and controlling I/O operations;

● Analyzing interrupt signals and dealing with errors;

● Handling communications between the system and its human operator; and

● 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. A Teletype Model 33 Automatic Send/Receive unit, which serves as the basic I/O device for most minicomputers, is included wherever available. 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. 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.

*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 31, 1970. 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 40 manufacturers whose products are summarized in the comparison charts.

*Atron Corporation,* 1256 Trapp Road, St. Paul, Minnesota 55118.

*BIT, Inc.* (formerly Business Information Technology), 5 Strathmore Road, Natick, Massachusetts 91760.

*Clary Datacomp Systems, Inc.,* 404 Junipero Serra Drive, San Gabriel, California 91776.

*Compiler Systems Incorporated,* P.O. Box 366, Ridgefield, Connecticut 06877.

*Computer Automation Incorporated,* 895 West Sixteenth Street, Newport Beach, California 92660.

*Computer Development,* 3001 S. Daimler Street, Santa Ana, California 92705.

*Control Data Corporation,* 8100 34th Avenue South, Minneapolis, Minnesota 55440.

*Datacraft Corporation,* 1200 N.W. 70th Street, P.O. Box 23550, Fort Lauderdale, Florida 33307.

*Data General Corporation,* Southboro, Massachusetts 01772.

*Datamate Computer Systems, Inc.* (a subsidiary of Siboney Corporation), P.O. Box 310, Big Spring, Texas 79720.

*Digital Equipment Corporation,* Maynard, Massachusetts 01754.

*Electronic Associates, Inc.,* West Long Branch, New Jersey 07764.

*Electronic Products International Corporation* (U.S. distributors of the ELBIT-100 System), 649 North Milwaukee Avenue, Wheeling, Illinois 60090.

*EMR Computer* (EMR Division of Weston Instruments, Inc., a Schlumberger Company), 8001 Bloomington Freeway, Minneapolis, Minnesota 55420.

*General Automation, Inc.,* 1402 E. Chestnut Avenue, Santa Ana, California 92701.

*General Electric Company,* Process Computer Department, Phoenix, Arizona.

*Hetra Computer and Communications Industries, Inc.,* P.O. Box 970, 1151 S. Eddie Allen Road, Melbourne, Florida 32901. ▷

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▷ *Hewlett-Packard Company*, Cupertino Division, 11000 Wolfe Road, Cupertino, California 95014.

*Honeywell Inc.*, Computer Control Division, Old Connecticut Path, Framingham, Massachusetts 01710.

*Infotronics Corp.*, 8500 Cameron Road, Austin, Texas 78753.

*Interdata, Inc.*, 2 Crescent Place, Oceanport, New Jersey 07757.

*Lockheed Electronics Company* (a division of Lockheed Aircraft Corporation), Data Products Division, 6201 E. Randolph Street, Los Angeles, California 90022.

*MicroSystems Inc.* (a subsidiary of Microdata Corporation), 644 East Young Street, Santa Ana, California 92705.

*Monitor Data Corporation*, 17805 Sky Park Circle, Irvine, California 92664.

*Motorola Instrumentation and Control Inc.* (a subsidiary of Motorola Inc.), P.O. Box 5409, Phoenix, Arizona 85010.

*Raytheon Computer* (a division of Raytheon Company), 2700 South Fairview Street, Santa Ana, California 92704.

*Redcor Corporation*, 21200 Victory Boulevard, P. O. Box 1100, Woodland Hills, California 91364.

*Scientific Control Corporation*, P.O. Box 96, Carrollton, Texas 75006.

*Spiras Systems, Inc.* (an affiliate of USM Corporation), 332 Second Avenue, Waltham, Massachusetts 02154.

*SYSTEMS Engineering Laboratories, Inc.*, 6901 West Sunrise Boulevard, Fort Lauderdale, Florida 33313.

*Tempo Computers, Inc.*, 1550 South State College Boulevard, Anaheim, California 92806.

*Texas Instruments Inc.*, Digital Systems Division, P.O. Box 66027, Houston, Texas 77006.

*Unicom Inc.*, 1275 Bloomfield Avenue, Fairfield, New Jersey 07006.

*UniComp, Inc.*, 18219 Parthenia Street, Northridge, California 91324.

*Varian Data Machines* (a subsidiary of Varian Associates), 2722 Michelson Drive, Irvine, California 92664.

*Varisystems Corporation*, 207 Newtown Road, Plainview, New York 11803.

*Viatron Computer Systems Corporation*, Route 62, Bedford, Massachusetts 01730.

*Wang Laboratories, Inc.*, 836 North Street, Tewksbury, Massachusetts 01876.

*Weismantel Associates Inc.*, Box 1957, St. Paul, Minnesota 55111.

*Xerox Data Systems* (a subsidiary of Xerox Corporation), 701 South Aviation Boulevard, El Segundo, California 90245. □
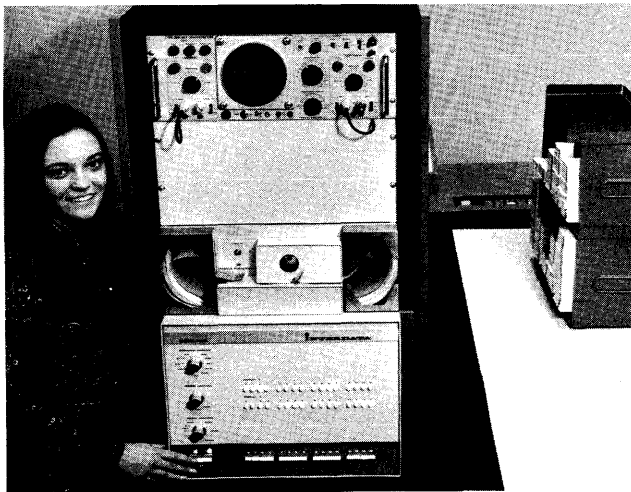


*This Interdata Model 4 is equipped with a Fast Fourier Transform (FFT) capability in read-only memory that enables it to perform more effectively in many medical, scientific, and industrial applications.*
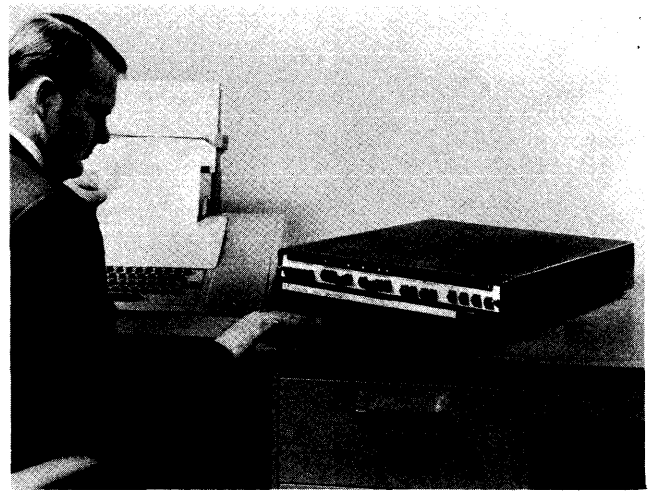


*One of the skinniest of the minis (and one of the least expensive as well) is the 8-bit MD708 from Monitor Data Corporation. It occupies just 3.5 inches of vertical rack space, weighs 25 pounds, and requires only 170 watts of power.*

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| MANUFACTURER & MODEL | Atron 501 Datamanager | BIT, Inc. BIT 483 | Clary Datacomp 404 | Compiler Systems Inc. CSI 16 | Compiler Systems Inc. CSI 24 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 8-bit byte | 8-bit byte | 16 | 16 | 24 |
| Fixed-point operand length, bits | 1-256 bytes | 1-64 bytes | 16/32/48/64 | 16 | 24 |
| Instruction length, bits | 1-5 bytes | 16/32 | 16/32 | 16 | 24 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 2.0 | 0.98 | 2.0 | 0.9 | 0.9 |
| Minimum capacity, words | 4,096 | 1,024 | 1,024 | 4,096 | 4,096 |
| Maximum capacity, words | 32,768 | 65,536 | 65,536 | 32,768 | 8,388,608 |
| Parity checking | Optional | Optional | No | No | No |
| Storage protection | Optional | Standard | Optional | Standard | Standard |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | Variable | 1 | 4 | 3 | 3 |
| No. of index registers | Variable | 0 | 2 | 1 | 1 |
| No. of directly addressable words | 32,768 | 512 | 1,024 | 2,048 | 524,288 |
| Indirect addressing | Multi-level | One-level | Multi-level | One-level | One-level |
| Add time, microseconds (full word) | Variable | 2.3 | 98 (15 digits) | 1.8 | 1.8 |
| Hardware multiply/divide | No | Optional | Standard | Standard | Standard |
| Hardware floating point | No | Optional | No | Standard | Standard |
| Hardware byte manipulation | Standard | Standard | No | No | No |
| Immediate (literal) instructions | Standard | No | Standard | No | No |
| Power failure protection | Optional | Standard | Optional | Optional | Optional |
| Real-time clock or timer | Optional | Optional | Optional | Optional | Optional |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 8 + parity | 8 | 16 | 16 | 24 |
| Direct memory access channel | Optional | Standard | Optional | Standard | Standard |
| Maximum I/O rate, words/sec | 250,000 | 1,020,000 | 250,000 | 1,100,000 | 1,100,000 |
| No. of external interrupt levels | Variable | 8-32 | Variable | 4-256 | 4-256 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | No | Yes | Yes | Yes | Yes |
| Non-interchangeable disk storage | Yes | No | Yes | Yes | Yes |
| Drum storage | No | Yes | No | Yes | Yes |
| Magnetic tape speed, cps | 37.5 in/sec | 20K-30K | — | 30,000 | 30,000 |
| Punched card input speed, cpm | 300-1000 | 225 | — | 300 | 300 |
| Punched card output speed, cpm | 100 | 150 | — | — | — |
| High-speed paper tape input, cps | — | 300 | 500 | 600 | 600 |
| High-speed paper tape output, cps | — | 60 | 75 | 120 | 120 |
| Other standard peripheral units | Line printer, Communications Interface | CRT display, Tape cassette, Line printer, Plotter | Tape cassette, Magnetic card Selectric typewriter | Tape cassette, Line printer, A/D converters | Tape cassette, Line printer, A/D converters |
| **SOFTWARE** | | | | | |
| Assembler | 2-pass | 2-pass | 1-pass | 1-pass | 1-pass |
| Macro assembler | Yes | Yes | No | Yes | Yes |
| FORTRAN compiler | No | Yes | No | Yes | Yes |
| Other compilers | RPG | No | COBOL, BASIC | ALGOL, BASIC | ALGOL, BASIC |
| Operating system | No | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $6,000 range in quantity | $9,010 | $9,950 | $12,850 | $17,200 |
| Price of basic system with 8K words / Teletype Model 33 ASR | $8,000 range in quantity | $10,950 | $13,950 | $16,800 | $24,150 |
| Date of first delivery | Sept. 1969 | Jan. 1970 | Oct. 1969 | July 1970 | July 1970 |
| Number installed to date | 40 | 55 | NA | 0 | 0 |
| **COMMENTS** | Designed for business data processing; macros handle variable-length operands. | Performs both decimal and binary arithmetic on variable-length operands. | Performs both decimal and binary arithmetic; can be used as an "intelligent terminal." | One-pass compilers for ALGOL, BASIC, and FORTRAN IV operate in 4K words of storage; all software is separately priced. | |

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# All About Minicomputers

| MANUFACTURER & MODEL | Computer Automation Model 208 | Computer Automation Model 808 | Computer Automation Model 216 | Computer Automation Model 816 | Computer Development cd 200 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 8 | 8 | 16 | 16 | 8 |
| Fixed-point operand length, bits | 8 | 8 | 16 | 16 | 8/16 |
| Instruction length, bits | 8/16 | 8/16 | 16 | 16 | 8/16/24 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | |
| Cycle time, microseconds/word | 2.67 | 8.0 | 2.67 | 8.0 | 1.0 |
| Minimum capacity, words | 4,096 | 4,096 | 4,096 | 4,096 | 256 |
| Maximum capacity, words | 16,384 | 16,384 | 32,768 | 16,384 | 61,440 |
| Parity checking | No | No | No | No | Optional |
| Storage protection | Optional | Optional | Optional | Optional | No |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 1 | 1 | 2 | 2 | 8 |
| No. of index registers | 0 | 0 | 1 | 1 | Up to 8 |
| No. of directly addressable words | 512 | 512 | 1,024 | 1,024 | 61,440 |
| Indirect addressing | Multi-level | Multi-level | Multi-level | Multi-level | Multi-level |
| Add time, microseconds (full word) | 8 | 24 | 5.33 | 16 | 3.9 |
| Hardware multiply/divide | No | No | No | No | Optional |
| Hardware floating point | No | No | No | No | No |
| Hardware byte manipulation | Standard | Standard | No | No | Standard |
| Immediate (literal) instructions | No | No | Standard | Standard | Standard |
| 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 | 8 | 16 | 16 | 8 |
| Direct memory access channel | No | No | Optional | Optional | Standard |
| Maximum I/O rate, words/sec | 67,000 | 16,000 | 250,000 | 125,000 | 2,000,000 |
| No. of external interrupt levels | 3-64 | 3-64 | 3-4,096 | 3-4,096 | 1-64 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | Yes | Yes | Yes | Yes | No |
| Non-interchangeable disk storage | Yes | Yes | Yes | Yes | Yes |
| Drum storage | Yes | Yes | Yes | Yes | No |
| Magnetic tape speed, cps | 10K-25K | 8K-10K | 10K-30K | 10K-30K | 20K |
| Punched card input speed, cpm | 300 | 300 | 300 | 300 | 400 |
| Punched card output speed, cpm | — | — | — | — | — |
| High-speed paper tape input, cps | 400 | 400 | 400 | 400 | 300 |
| High-speed paper tape output, cps | 60/120 | 60/120 | 60/120 | 60/120 | 60 |
| Other standard peripheral units | Line printer, Communications interfaces | Line printer, Communications interfaces | Line printer, Communications interfaces | Line printer, Communications interfaces | Tape cassette |
| **SOFTWARE** | | | | | |
| Assembler | 3-pass | 3-pass | 2-pass | 2-pass | 2-pass |
| Macro assembler | No | No | No | No | Yes |
| FORTRAN compiler | No | No | Yes | Yes | No |
| Other compilers | No | No | No | No | No |
| Operating system | No | No | No | No | No |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $8,000 | $6,500 | $14,900 | $11,990 | $5,690 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $10,950 | $9,200 | $19,750 | $17,440 | $7,490 |
| Date of first delivery | Aug. 1969 | April 1968 | July 1969 | Dec. 1968 | Aug. 1970 |
| Number installed to date | 26 | 111 | 82 | 38 | 0 |
| **COMMENTS** | Models 208 and 808 are program-compatible; designed for high reliability in hostile electrical environments. | | Models 216 and 816 are program-compatible; designed for high reliability in hostile electrical environments. | | Has a 400-nsec MOS read-only memory and eight 16-bit general registers. |

# All About Minicomputers

| MANUFACTURER & MODEL | Control Data 1700 | Control Data SC-1700 | Datacraft DC 6024/1 | Datacraft 6024/3 | Data General Nova |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 16 + 2 | 16 + 2 | 24 | 24 | 16 |
| Fixed-point operand length, bits | 16 | 16 | 24/48 | 24/48 | 16 |
| Instruction length, bits | 16/32 | 16/32 | 24 | 24 | 16 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.1 | 1.5 | 0.6 | 1.0 | 2.6 |
| Minimum capacity, words | 4,096 | 4,096 | 8,192 | 8,192 | 2,048 |
| Maximum capacity, words | 32,768 | 32,768 | 65,536 | 65,536 | 32,768 |
| Parity checking | Standard | Standard | Standard | Standard | No |
| Storage protection | Standard | Standard | Optional | Optional | No |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 2 | 2 | 5 or 6 | 5 or 6 | 4 |
| No. of index registers | 2 | 2 | 3 | 3 | 18 |
| No. of directly addressable words | 256 | 256 | 65,536 | 65,536 | 1,024 |
| Indirect addressing | Multi-level | Multi-level | Multi-level | Multi-level | Multi-level |
| Add time, microseconds (full word) | 2.2 | 3.0 | 1.2 | 2.0 | 5.9 |
| Hardware multiply/divide | Standard | Standard | Standard | Standard | Optional |
| Hardware floating point | No | No | Optional | Optional | Optional |
| Hardware byte manipulation | No | Optional | Standard | Standard | No |
| Immediate (literal) instructions | No | No | Standard | Standard | No |
| Power failure protection | Standard | Standard | Optional | Optional | Standard |
| Real-time clock or timer | Optional | Optional | Optional | Optional | Optional |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 16 | 16 | 24 | 24 | 16 |
| Direct memory access channel | Optional | Optional | Optional | Optional | Standard |
| Maximum I/O rate, words/sec | 900,000 | 650,000 | 1,667,000 | 1,000,000 | 312,000 |
| No. of external interrupt levels | 2-16 | 2-16 | 4-72 | 4-24 | 16-62 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | Yes | Yes | Yes | Yes | No |
| Non-interchangeable disk storage | No | No | No | No | Yes |
| Drum storage | Yes | Yes | No | No | Yes |
| Magnetic tape speed, cps | 30K max. | 30K max. | 120K | 120K | — |
| Punched card input speed, cpm | 330-1200 | 330-1200 | 1,000 | 1,000 | 225/400 |
| Punched card output speed, cpm | 100-460 | 100-460 | 205 | 205 | — |
| High-speed paper tape input, cps | 400 | 400 | 600 | 600 | 150/300 |
| High-speed paper tape output, cps | 120/150 | 120/150 | 110 | 110 | 63 |
| Other standard peripheral units | Line printer, CRT displays, OCR, A/D converters | Line printer, CRT displays, OCR, A/D converters | Tape cassette, Communications interfaces | Tape cassette, Communications interfaces | Line printer, A/D converters |
| **SOFTWARE** | | | | | |
| Assembler | 2-pass | 2-pass | 2-pass | 2-pass | 2-pass |
| Macro assembler | Yes | Yes | No | No | No |
| FORTRAN compiler | Yes | Yes | Yes | Yes | Yes |
| Other compilers | No | No | CAL | CAL | ALGOL, BASIC |
| Operating system | Yes | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $37,420 | $22,580 | Not avail. | Not avail. | $9,200 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $45,900 | $27,080 | $53,900 | $35,300 | $12,850 |
| Date of first delivery | April 1966 | July 1970 | May 1969 | Feb. 1970 | Feb. 1969 |
| Number installed to date | NA | NA | 7 | 10 | 500 |
| **COMMENTS** | 18-bit word includes parity and storage protection bits; prices include Model 35 (heavy duty) ASR. | | The two Datacraft models are program-compatible; quoted prices include a basic software package, with other software available at extra cost. | | Read-only memory is interchangeable with standard core storage. |

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# All About Minicomputers

| MANUFACTURER & MODEL | Data General Supernova | Datamate-16 | Datamate-70 | Digital Equipment PDP-8/I | Digital Equipment PDP-8/L |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 16 | 16 | 16 | 12 | 12 |
| Fixed-point operand length, bits | 16 | 16/32 | 16 | 12 | 12 |
| Instruction length, bits | 16 | 16 | 16 | 12/24 | 12/24 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 0.8 | 1.0 | 1.0 | 1.5 | 1.6 |
| Minimum capacity, words | 2,048 | 4,096 | 4,096 | 4,096 | 4,096 |
| Maximum capacity, words | 32,768 | 32,768 | 32,768 | 32,768 | 8,192 |
| Parity checking | No | No | No | Optional | Optional |
| Storage protection | Optional | No | No | No | Standard |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 4 | 1 | 4 | 1 | 1 |
| No. of index registers | 18 | 1 | 2 | 8 | 8 |
| No. of directly addressable words | 1,024 | 512 | 512 | 256 | 256 |
| Indirect addressing | Multi-level | Multi-level | Multi-level | One-level | One-level |
| Add time, microseconds (full word) | 0.8 | 2.0 | 1.0 | 3.0 | 3.2 |
| Hardware multiply/divide | Optional | Standard | Optional | Optional | No |
| Hardware floating point | Optional | No | No | No | No |
| Hardware byte manipulation | No | Standard | Standard | No | No |
| Immediate (literal) instructions | No | Standard | Standard | No | No |
| 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 | 16 | 12 | 12 |
| Direct memory access channel | Standard | Standard | Standard | Standard | Optional |
| Maximum I/O rate, words/sec | 1,250,000 | 1,000,000 | 1,000,000 | 666,000 | 625,000 |
| No. of external interrupt levels | 16-62 | 0-64 | 0-62 | 1-64 | 1-64 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | No | Yes | Yes | Yes | Yes |
| Non-interchangeable disk storage | Yes | Yes | Yes | Yes | Yes |
| Drum storage | Yes | Yes | Yes | Special order | Special order |
| Magnetic tape speed, cps | — | 96K max. | 96K max. | 36K | 36K |
| Punched card input speed, cpm | 225/400 | — | — | 200 | 200 |
| Punched card output speed, cpm | — | — | — | — | — |
| High-speed paper tape input, cps | 150/300 | 500 | 500 | 300 | 300 |
| High-speed paper tape output, cps | 63 | 75 | 75 | 50 | 50 |
| Other standard peripheral units | Line printer, A/D converters | Line printer, etc. | Line printer, etc. | DECtape, Plotter, CRT displays, etc. | DECtape, Plotter, CRT displays, etc. |
| **SOFTWARE** | | | | | |
| Assembler | 2-pass | 2-pass | 2-pass | 1 & 2-pass | 1 & 2-pass |
| Macro assembler | No | Yes | No | Yes | Yes |
| FORTRAN compiler | Yes | Yes | No | Yes | Yes |
| Other compilers | BASIC, ALGOL | No | No | ALGOL, BASIC DIBOL, FOCAL | ALGOL, BASIC DIBOL, FOCAL |
| Operating system | Yes | No | No | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $12,950 | $16,600 | $9,600 | $12,800 | $8,500 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $17,450 | $19,600 | $12,300 | $16,800 | $12,500 |
| Date of first delivery | April 1970 | Nov. 1969 | Aug. 1970 | March 1968 | Oct. 1968 |
| Number installed to date | 8 | 7 | 0 | NA | NA |
| **COMMENTS** | Read-only memory with 300-nsec cycle time is interchangeable with standard core storage. | Basic FORTRAN compiler needs only 4K words; FORTRAN IV requires 8K words. | Measures only 1-3/4 by 19 by 20 inches; fast semiconductor memory is an option. | Extensive software is available, as well as integrated, computer-based systems for specific applications. The PDP-8/I is designed to allow plug-in expansion, while the 8/L is not. | |

# All About Minicomputers

| MANUFACTURER & MODEL | Digital Equipment PDP-11 | Digital Equipment PDP-12 | Digital Equipment PDP-15 | Electronic Associates EAI 640 | Electronic Products ELBIT-100 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 16 | 12 | 18 | 16 | 12 |
| Fixed-point operand length, bits | 16 | 12 | 18 | 16 | 12 |
| Instruction length, bits | 16/32/48 | 12/24 | 18 | 16 | 12 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.2 | 1.6 | 0.8 | 1.65 | 2.0 |
| Minimum capacity, words | 4,096 | 4,096 | 4,096 | 8,192 | 1,024 |
| Maximum capacity, words | 32,726 | 32,768 | 131,072 | 32,768 | 4,096 |
| Parity checking | No | Optional | Optional | No | No |
| Storage protection | No | Optional | Optional | Standard | No |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 8 | 1 | 1 | 2 | 1 |
| No. of index registers | Up to 8 | 16 | 1 | 1 | 1 |
| No. of directly addressable words | 32,726 | 1,024 | 4,096 | 512 | 256 |
| Indirect addressing | Two-level | One-level | One-level | Multi-level | One-level |
| Add time, microseconds (full word) | 2.3 | 3.2 | 1.6 | 3.3 | 7.2 |
| Hardware multiply/divide | Optional | Optional | Optional | Standard | No |
| Hardware floating point | No | No | No | Optional | No |
| Hardware byte manipulation | Standard | No | No | No | No |
| Immediate (literal) instructions | Standard | No | No | Standard | Standard |
| Power failure protection | Standard | Optional | Optional | Standard | Standard |
| Real-time clock or timer | Optional | Optional | Optional | Optional | Standard |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 16 | 12 | 18 | 16 | 12 |
| Direct memory access channel | Standard | Standard | Standard | Standard | Optional |
| Maximum I/O rate, words/sec | 883,000 | 625,000 | 1,000,000 | 600,000 | 250,000 |
| No. of external interrupt levels | Variable | 1-64 | 28-64 | 7-64 | 4 min. |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | Under dev'ment | Yes | Yes | No | Yes |
| Non-interchangeable disk storage | Yes | Yes | Yes | Yes | Yes |
| Drum storage | No | Special order | Yes | No | Yes |
| Magnetic tape speed, cps | Under dev'ment | 36K | 60K max. | 36K | |
| Punched card input speed, cpm | Under dev'ment | 200 | 200 | 400 | 300 |
| Punched card output speed, cpm | — | — | — | — | 100 |
| High-speed paper tape input, cps | 300 | 300 | 300 | 300 | 125/300 |
| High-speed paper tape output, cps | 50 | 50 | 50 | 120 | 60/120 |
| Other standard peripheral units | Line printer, DECtape, Communications interfaces | DECtape | DECtape, A/D converters, Real-time interfaces | Tape cassette, Line printer, Communications interfaces | |
| **SOFTWARE** | | | | | |
| Assembler | 2-pass | 2-pass | 2-pass | 2-pass | 2-pass |
| Macro assembler | Runs on PDP-10 | No | Yes | No | Yes |
| FORTRAN compiler | Under dev'ment | Yes | Yes | Yes | |
| Other compilers | BASIC | BASIC | FOCAL | Operations Interpreter | |
| Operating system | Under dev'ment | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $10,800 | $14,900 | $16,500 | Not avail. | $5,400 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $14,300 | $18,900 | $22,500 | $24,500 | Not avail. |
| Date of first delivery | April 1970 | April 1969 | Fall 1969 | Feb. 1967 | Nov. 1966 |
| Number installed to date | NA | NA | NA | 115 | 485 |
| **COMMENTS** | "Unibus" permits great flexibility in I/O and memory units; 500-nsec read-only core memory is available. | Designed for laboratory applications; can execute PDP-8 programs; built-in CRT display. | Program compatible with the PDP-9, and has 17 new instructions. | Can serve as the digital portion of a hybrid computer system. | Factory microprogrammable; has 256 words of 400-nsec read-only memory. |

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# All About Minicomputers

| MANUFACTURER & MODEL | EMR Computer EMR 6120 | General Automation SPC-12 | General Automation SPC-16 | General Automation System 18/30 |
|---|---|---|---|---|
| **DATA FORMATS** | | | | |
| Word length, bits | 16 | 8 | 16 | 16 |
| Fixed-point operand length, bits | 16 (32 opt.) | 8 | 16 | 16/32 |
| Instruction length, bits | 16/32 | 8/16 | 16 | 16/32 |
| **MAIN STORAGE** | | | | |
| Storage type | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.9 | 2.16 | 0.96 | 0.96 |
| Minimum capacity, words | 4,096 | 4,096 | 4,096 | 4,096 |
| Maximum capacity, words | 32,768 | 16,384 | 32,768 | 32,768 |
| Parity checking | Optional | Optional | No | Standard |
| Storage protection | No | No | No | Standard |
| **CENTRAL PROCESSOR** | | | | |
| No. of accumulators | 2 | 4 | 16 | 2 |
| No of index registers | 2 | 3 | 6 | 3 |
| No. of directly addressable words | 32,768 | 4,096 | 32,768 | 32,768 |
| Indirect addressing | One-level | One-level | One-level | One-level |
| Add time, microseconds (full word) | 4.4 | 6.48 | 0.96 | 2.4 |
| Hardware multiply/divide | Standard | No | Optional | Standard |
| Hardware floating point | No | No | No | No |
| Hardware byte manipulation | No | Standard | Standard | No |
| Immediate (literal) instructions | Standard | Standard | Standard | Standard |
| Power failure protection | Optional | Optional | Standard | Standard |
| Real-time clock or timer | Optional | Standard | Standard | Standard |
| **INPUT/OUTPUT CONTROL** | | | | |
| I/O word size, bits | 16 | 8/12 | 16 | 16 |
| Direct memory access channel | Optional | Optional | Standard | 5 standard |
| Maximum I/O rate, words/sec | 500,000 | 460,000 | 1,040,000 | 960,000 |
| No. of external interrupt levels | 8-28 | 2-256 | 8-unlimited | |
| **PERIPHERAL EQUIPMENT** | | | | |
| Disk pack storage | No | No | Yes | Yes |
| Non-interchangeable disk storage | Yes | No | No | No |
| Drum storage | No | No | Yes | Yes |
| Magnetic tape speed, cps | 20K | — | 60K max. | 60K max. |
| Punched card input speed, cpm | — | — | 300/500 | 300/500 |
| Punched card output speed, cpm | — | — | 300 | 300 |
| High-speed paper tape input, cps | 400 | 300 | 300 | 300 |
| High-speed paper tape output, cps | 63 | 60 | 60 | 60 |
| Other standard peripheral units | Line printer | A/D converters, Communications interfaces | A/D converters, Communications interfaces | A/D converters, Communications interfaces |
| **SOFTWARE** | | | | |
| Assembler | 2-pass | 1-pass | 2-pass | 1-pass |
| Macro assembler | Yes | No | Yes | No |
| FORTRAN compiler | Yes | No | Yes | Yes |
| Other compilers | No | No | No | No |
| Operating system | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $12,800 | $6,500 | $11,800 | $19,500 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $16,700 | $8,900 | $16,200 | $25,500 |
| Date of first delivery | July 1970 | Jan. 1968 | May 1970 | July 1969 |
| Number installed to date | 0 | NA | NA | NA |
| **COMMENTS** | Read-only memory of 1024 12-bit words holds 256 basic micro-instructions. | | 480-nsec read-only memory modules are interchangeable with standard core modules | Instruction set is fully compatible with the IBM 1130 and 1800. |

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## All About Minicomputers

| MANUFACTURER & MODEL | General Electric GE-PAC 30-1 | General Electric GE-PAC 30-2 | Hetra S-1 Commercial DP System | Hetra T-1 Remote Batch Terminal |
|---|---|---|---|---|
| **DATA FORMATS** | | | | |
| Word length, bits | 16 | 16 | 8 | 8 |
| Fixed-point operand length, bits | 16 | 16 | Variable | Variable |
| Instruction length, bits | 16/32 | 16/32 | 16 | 16 |
| **MAIN STORAGE** | | | | |
| Storage type | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.5 | 1.0 | 1.0 | 1.0 |
| Minimum capacity, words | 2,048 | 4,096 | 4,096 | 4,096 |
| Maximum capacity, words | 32,768 | 32,768 | 65,536 | 65,536 |
| Parity checking | Optional | Optional | Optional | Optional |
| Storage protection | Optional | Optional | No | No |
| **CENTRAL PROCESSOR** | | | | |
| No. of accumulators | 16 | 16 | 4 | 4 |
| No. of index registers | 15 | 15 | 3 | 3 |
| No. of directly addressable words | 32,768 | 32,768 | 64 | 64 |
| Indirect addressing | No | No | No | No |
| Add time, microseconds (full word) | 38 | 5.6 | Variable | Variable |
| Hardware multiply/divide | Standard | Optional | No | No |
| Hardware floating point | No | Optional | No | No |
| Hardware byte manipulation | Standard | Standard | Standard | Standard |
| Immediate (literal) instructions | Standard | Standard | Standard | Standard |
| Power failure protection | Optional | Optional | Optional | Optional |
| Real-time clock or timer | Optional | Optional | Optional | Optional |
| **INPUT/OUTPUT CONTROL** | | | | |
| I/O word size, bits | 8 | 8 | 8 | 8 |
| Direct memory access channel | Optional | Optional | Optional | Optional |
| Maximum I/O rate, words/sec | 250,000 | 250,000 | | |
| No. of external interrupt levels | 256 | 256 | 8 | 8 |
| **PERIPHERAL EQUIPMENT** | | | | |
| Disk pack storage | No | No | Yes | Yes |
| Non-interchangeable disk storage | No | No | Yes | Yes |
| Drum storage | Yes | Yes | No | No |
| Magnetic tape speed, cps | 20K | 20K | 20K | 20K |
| Punched card input speed, cpm | 200 | 200 | 400 | 400 |
| Punched card output speed, cpm | — | — | 100 | 100 |
| High-speed paper tape input, cps | 300 | 300 | — | — |
| High-speed paper tape output, cps | 60 | 60 | — | — |
| Other standard peripheral units | TermiNet 300, Real-time interfaces | TermiNet 300, Real-time interfaces | Line printer, CRT display, Communications interfaces | Line printer, CRT display, Communications interfaces |
| **SOFTWARE** | | | | |
| Assembler | 1 & 2-pass | 1 & 2-pass | 2-pass | 2-pass |
| Macro assembler | No | No | Yes | Yes |
| FORTRAN compiler | No | See Comment | Yes | Yes |
| Other compilers | No | No | COBOL | COBOL |
| Operating system | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $11,075 | $13,230 | $13,800 | $12,300 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $16,135 | $18,290 | $15,800 | $14,300 |
| Date of first delivery | May 1969 | June 1969 | July 1970 | July 1970 |
| Number installed to date | 17 | 30 | 0 | 0 |
| **COMMENTS** | Read-only memory (an array of pulse transformers) holds prewired microprogram. | Model 30-2E has built-in floating-point and multiply/ divide, and can use a FORTRAN compiler. | Read-only control memory holds "firmware" microprogram; performs both decimal and binary arithmetic. | Read-only control memory holds "firmware" microprogram; performs both decimal and binary arithmetic. |

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# All About Minicomputers

| MANUFACTURER & MODEL | Hewlett-Packard 2114B | Hewlett-Packard 2115A | Hewlett-Packard 2116B | Honeywell DDP-416 | Honeywell DDP-516 |
|---|---|---|---|---|---|
| **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 | 16/32 | 16/32 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 2.0 | 2.0 | 1.6 | 0.96 | 0.96 |
| Minimum capacity, words | 4,096 | 4,096 | 8,192 | 4,096 | 4,096 |
| Maximum capacity, words | 8,192 | 8,192 | 32,768 | 16,384 | 32,768 |
| Parity checking | Optional | Optional | Optional | Optional | Optional |
| Storage protection | No | Optional | Optional | Optional | Optional |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 2 | 2 | 2 | 1 | 2 |
| No. of index registers | 0 | 0 | 0 | 0 | 1 |
| No. of directly addressable words | 2,048 | 2,048 | 2,048 | 1,024 | 1,024 |
| Indirect addressing | Multi-level | Multi-level | Multi-level | Multi-level | Multi-level |
| Add time, microseconds (full word) | 4.0 | 4.0 | 3.2 | 1.92 | 1.92 |
| Hardware multiply/divide | No | Optional | Optional | No | Optional |
| Hardware floating point | No | No | No | No | Optional |
| Hardware byte manipulation | No | No | No | No | Standard |
| Immediate (literal) instructions | No | No | No | No | No |
| 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 | Optional | 2 optional | 2 optional | Optional | Optional |
| Maximum I/O rate, words/sec | 500,000 | 210,000 | 263,000 | 1,040,000 | 1,040,000 |
| No. of external interrupt levels | 7-24 | 8-40 | 16-48 | 2-48 | 2-48 |
| **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 | 2,500 | 7,500 | 7,500 | 64K | 64K |
| Punched card input speed, cpm | 200/1,000 | 200/1,000 | 200/1,000 | 200-800 | 200-800 |
| Punched card output speed, cpm | — | — | — | 100-400 | 100-400 |
| High-speed paper tape input, cps | 500 | 500 | 500 | 300 | 300 |
| High-speed paper tape output, cps | 120 | 120 | 120 | 110 | 110 |
| Other standard peripheral units | Line printers, Plotters, Data-Phone interface | Line printers, Plotters, Data-Phone interface | Line printers, Plotters, Data-Phone interface | Line printer, CRT display, Real-time interface | Line printer, CRT display, Real-time interface |
| **SOFTWARE** | | | | | |
| Assembler | 2-pass | 2-pass | 2-pass | 1 & 2-pass | 1 & 2-pass |
| Macro assembler | No | No | No | No | No |
| FORTRAN compiler | Yes | Yes | Yes | No | Yes |
| Other compilers | ALGOL BASIC | ALGOL BASIC | ALGOL BASIC | No | No |
| Operating system | Yes | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $10,500 | $16,500 | Not avail. | $16,900 | $25,000 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $15,000 | $21,500 | $26,000 | $24,900 | $33,000 |
| Date of first delivery | Oct. 1968 | Nov. 1967 | Sept. 1967 | April 1967 | Oct. 1966 |
| Number installed to date | 600 | 300 | 700 | NA | NA |
| **COMMENTS** | FORTRAN operates in 4K; ALGOL and BASIC require 8K. | FORTRAN operates in 4K; ALGOL and BASIC require 8K. | Software allows multi-programming and time-shared access by up to 16 users in 16K disk systems. | | Software allows multi-programming of real-time programs; available in a "ruggedized" version. |

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| MANUFACTURER & MODEL | Honeywell H-316 | Infotronics mini/max | Interdata Model 1 | Interdata Model 2 | Interdata Model 3 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 16 | 16 | 8 | 16 | 16 |
| Fixed-point operand length, bits | 16 | 16 | 8 | 16 | 16 |
| Instruction length, bits | 16/32 | 16 | 8/16 | 16/32 | 16/32 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.6 | 1.0 | 1.0 | 3.0 | 1.5 |
| Minimum capacity, words | 4,096 | 2,048 | 2,048 | 512 | 2,048 |
| Maximum capacity, words | 32,768 | 65,536 | 16,384 | 2,048 | 32,768 |
| Parity checking | No | Optional | Optional | Optional | Optional |
| Storage protection | No | Optional | No | Optional | Optional |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 2 | 2 | 1 | 16 | 16 |
| No. of index registers | 1 | 12 | 8,192 | 15 | 15 |
| No. of directly addressable words | 1,024 | 65,536 | 512 | 2,048 | 32,768 |
| Indirect addressing | Multi-level | One-level | One-level | No | No |
| Add time, microseconds (full word) | 3.2 | 2.0 | 2.0 | 45 | 34 |
| Hardware multiply/divide | Optional | Optional | No | No | Optional |
| Hardware floating point | No | No | No | No | No |
| Hardware byte manipulation | Standard | Standard | Standard | Standard | Standard |
| Immediate (literal) instructions | No | No | Standard | Standard | Standard |
| Power failure protection | Optional | Optional | Optional | No | Optional |
| Real-time clock or timer | Optional | Optional | Standard | Optional | Optional |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 16 | 16 | 8 | 8 | 8 |
| Direct memory access channel | Optional | 16 optional | 4 optional | No | Optional |
| Maximum I/O rate, words/sec | 312,000 | 1,000,000 | 500,000 | 5,000 | 750,000 |
| No. of external interrupt levels | 2-48 | 0-256 | 4-8 | 2-256 | 2-256 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | Yes | No | Yes | No | No |
| Non-interchangeable disk storage | Yes | Yes | Yes | No | Yes |
| Drum storage | Yes | No | Yes | No | No |
| Magnetic tape speed, cps | 64K | — | 20K | — | 20K max. |
| Punched card input speed, cpm | 200-800 | 200 | 200 | 200 | 200 |
| Punched card output speed, cpm | 100-400 | — | 100 | 100 | 100 |
| High-speed paper tape input, cps | 300 | 125 | 300 | 300 | 300 |
| High-speed paper tape output, cps | 110 | 90 | 60 | 60 | 60 |
| Other standard peripheral units | Line printer, CRT display, Real-time interface | Line printer | Tape cassette | Plotter, A/D converters | Plotter, A/D converters |
| **SOFTWARE** | | | | | |
| Assembler | 1 & 2-pass | 2-pass | 1 & 2-pass | No | 1 & 2-pass |
| Macro assembler | No | Yes | No | No | No |
| FORTRAN compiler | Yes | No | No | No | Yes |
| Other compilers | No | No | No | No | No |
| Operating system | Yes | Yes | Yes | No | No |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $11,400 | $16,500 | $7,050 | Not avail. | $10,600 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $16,900 | $21,100 | $9,450 | Not avail. | $15,400 |
| Date of first delivery | June 1969 | NA | Sept. 1970 | July 1968 | May 1967 |
| Number installed to date | NA | NA | 0 | NA | NA |
| **COMMENTS** | Logically identical with the DDP-516; software allows multi-programming of real-time programs. | 82 instruction types allow over 3,000 discrete operations. | 2,048-byte read-only memory modules can be intermixed with standard core modules | Read-only memory (an array of pulse transformers) holds prewired microprogram. | Read-only memory (an array of pulse transformers) holds prewired microprogram. |

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| MANUFACTURER & MODEL | Interdata Model 4 | Interdata Model 5 | Lockheed Electronics MAC 16 | Lockheed Electronics MAC Jr. | Monitor Data Corp. MD708 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 16 | 16 | 16 | 16 | 8 |
| Fixed-point operand length, bits | 16 (32 opt.) | 16 | 16 | 16 | 8 |
| Instruction length, bits | 16/32 | 16/32 | 16 | 16 | 8/16 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.0 | 1.0 | 1.0 | 1.0 | 1.6 |
| Minimum capacity, words | 2,048 | 4,096 | 4,096 | 4,096 | 1,024 |
| Maximum capacity, words | 32,768 | 32,768 | 65,536 | 8,192 | 65,536 |
| Parity checking | Optional | Optional | Optional | No | No |
| Storage protection | Optional | Optional | Optional | No | Optional |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 16 | 16 | 1 | 1 | 2 |
| No. of index registers | 15 | 15 | 8-64 | 4-16 | 2 (optional) |
| No. of directly addressable words | 32,768 | 32,768 | 1,024 | 1,024 | 4,096 |
| Indirect addressing | No | No | Multi-level | Multi-level | No |
| Add time, microseconds (full word) | 3.2 | 3.2 | 2.0 | 2.0 | 1.6 |
| Hardware multiply/divide | Optional | Standard | Optional | Optional | Optional |
| Hardware floating point | Optional | Standard | No | No | No |
| Hardware byte manipulation | Standard | Standard | Standard | Standard | Standard |
| Immediate (literal) instructions | Standard | Standard | Standard | Standard | No |
| Power failure protection | Optional | Optional | Standard | Optional | Optional |
| Real-time clock or timer | Optional | Optional | Standard | Optional | Optional |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 8 | 8/16 | 16 | 16 | 8 |
| Direct memory access channel | Optional | Optional | Standard | Optional | Optional |
| Maximum I/O rate, words/sec | 900,000 | 900,000 | 1,000,000 | 1,000,000 | 625,000 |
| No. of external interrupt levels | 2-256 | 2-256 | 8-64 | 4-16 | 1-8 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | No | Yes | No | No | Yes |
| Non-interchangeable disk storage | Yes | Yes | No | No | Yes |
| Drum storage | No | Yes | Yes | Yes | No |
| Magnetic tape speed, cps | 20K max. | 20K max. | 20K max. | 20K max. | 60K max. |
| Punched card input speed, cpm | 200 | 200 | 300 | 300 | 1000 |
| Punched card output speed, cpm | 100 | 100 | — | — | 100 |
| High-speed paper tape input, cps | 300 | 300 | 300 | 300 | 600 |
| High-speed paper tape output, cps | 60 | 60 | 60 | 60 | 60 |
| Other standard peripheral units | Plotter, A/D converters | Line printer, Tape cassette, A/D converters | Line printer, Communications interfaces, CRT displays | Line printer, Communications interfaces, CRT displays | Communications interfaces, Tape cassette |
| **SOFTWARE** | | | | | |
| Assembler | 1 & 2-pass | 1 & 2-pass | 2-pass | 2-pass | 1 & 2-pass |
| Macro assembler | No | No | Yes | Yes | Yes |
| FORTRAN compiler | Yes | Yes | Yes | Yes | No |
| Other compilers | No | No | No | No | No |
| Operating system | No | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $12,600 | $15,600 | $12,800 | $9,500 | $5,150 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $17,400 | $21,400 | $16,750 | $12,600 | $6,600 |
| Date of first delivery | Aug. 1968 | July 1970 | Feb. 1969 | Late 1970 | June 1970 |
| Number installed to date | NA | 0 | 150 | 0 | 0 |
| **COMMENTS** | 16 hardware general registers; read-only memory holds prewired microprogram. | Software is designed to coordinate multi-task operations. | Optional Multiplex Data Channel handles up to 16 concurrent I/O operations. | Program-compatible with MAC 16. | Macro-assembler can be run on either an 8K MD 708 or an IBM System/360 |

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| MANUFACTURER & MODEL | MicroSystems Micro 800 | MicroSystems Micro 810 | MicroSystems Micro 812 | Motorola MDP-1000 | Redcor RC 70 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 8 or 9 | 8 | 8 | 8 | 16 |
| Fixed-point operand length, bits | Variable | 8/16/24/32 | 8/16/24/32 | 8 | 16 |
| Instruction length, bits | 16 | 8/16/24/32 | 8/16/24/32 | 8/12 | 16/32 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.1 | 1.1 | 1.1 | 2.16 | 0.86 |
| Minimum capacity, words | 0 | 4,096 | 4,096 | 4,096 | 4,096 |
| Maximum capacity, words | 32,768 | 32,768 | 32,768 | 16,384 | 32,768 |
| Parity checking | Optional | Optional | Optional | No | Standard |
| Storage protection | No | No | No | No | Standard |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 15 | 1 | 2 | 4 | 2 |
| No. of index registers | 0 | 1 | 1 | 3 | 1 |
| No. of directly addressable words | 32,768 | 32,768 | 32,768 | 4,096 | 32,768 |
| Indirect addressing | — | One-level | One-level | One-level | One-level |
| Add time, microseconds (full word) | 0.22 | 11 | 11 | 4.32 | 1.9 |
| Hardware multiply/divide | No | No | No | No | Standard |
| Hardware floating point | No | No | No | No | No |
| Hardware byte manipulation | Standard | Standard | Standard | Standard | No |
| Immediate (literal) instructions) | Standard | Standard | Standard | Standard | No |
| Power failure protection | Optional | Optional | Standard | Optional | Standard |
| Real-time clock or timer | Optional | Optional | Standard | Standard | Standard |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 8 | 8 | 8 | 8/12 | 16 |
| Direct memory access channel | Optional | Optional | Optional | No | Standard |
| Maximum I/O rate, words/sec | 100,000 | 50,000 | 50,000 | 46,000 | 1,100,000 |
| No. of external interrupt levels | 1-64 | 1-64 | 1-64 | 1-128 | 0-32 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | No | No | No | No | Yes |
| Non-interchangeable disk storage | Yes | Yes | Yes | No | Yes |
| Drum storage | Yes | Yes | Yes | Yes | No |
| Magnetic tape speed, cps | 20K | 20K | 20K | 2,400 | 20/60/120K |
| Punched card input speed, cpm | 400 | 400 | 400 | 60 | 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 | 120 | 60 |
| Other standard peripheral units | None | None | None | High-speed teleprinter, Communications interfaces | Line printers, CRT displays, Communications controllers |
| **SOFTWARE** | | | | | |
| Assembler | 2-pass | 2-pass | 2-pass | 2-pass | 1-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 & Teletype Model 33 ASR | $5,850 | $7,630 | $12,090 | $8,300 | $17,600 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $7,950 | $9,730 | $14,190 | $11,300 | $22,500 |
| Date of first delivery | Jan. 1969 | Jan. 1969 | Dec. 1969 | June 1968 | April 1969 |
| Number installed to date | 100 | 100 | 10 | NA | 120 |
| **COMMENTS** | A micro-programmable computer built around a file of 16 registers and a 220-nsec read-only memory. | A micro-programmed adaptation of the Micro 800. | Programmable communications processor; handles up to 32 low-speed lines. | "Shared byte" instructions can conserve memory space. | Single-pass FORTRAN IV compiler requires 8K words. |

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| MANUFACTURER & MODEL | Raytheon 703 | Raytheon 704 | Raytheon 706 | Scientific Control SCC 4700 | Spiras Systems SPIRAS-65 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 16 | 16 | 16 | 16 | 16 |
| Fixed-point operand length, bits | 16 | 16 | 16 | 16 | 16/32 |
| Instruction length, bits | 16 | 16 | 16 | 16/32 | 16/32 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.75 | 1.0 | 0.9 | 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 | 65,536 | 65,536 |
| Parity checking | No | Optional | Optional | Optional | No |
| Storage protection | No | No | Optional | Optional | Optional |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 1 | 1 | 1 | 1 | 1 |
| No. of index registers | 1 | 1 | 1 | 1 | 1 |
| No. of directly addressable words | 2,048 | 2,048 | 2,048 | 32,768 | 65,536 |
| Indirect addressing | No | No | No | One-level | Multi-level |
| Add time, microseconds (full word) | 3.5 | 2.0 | 1.8 | 1.9 | 3.6 |
| Hardware multiply/divide | Optional | Optional | Optional | Optional | Standard |
| Hardware floating point | No | No | No | Optional | Standard |
| Hardware byte manipulation | Standard | Standard | Standard | Standard | No |
| Immediate (literal) instructions | Standard | Standard | Standard | Standard | Standard |
| Power failure protection | Optional | Optional | Optional | Optional | Optional |
| Real-time clock or timer | Optional | Optional | Optional | Standard | Optional |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 16 | 16 | 16 | 8/16 | 16 |
| Direct memory access channel | Optional | Optional | Optional | Optional | Standard |
| Maximum I/O rate, words/sec | 571,000 | 1,000,000 | 1,100,000 | 1,000,000 | 500,000 |
| No. of external interrupt levels | 1-16 | 1-16 | 1-16 | 0-16 | 1-64 |
| **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 | 60K | 60K | 60K | 60K | 19/60K |
| Punched card input speed, cpm | 1100 | 1100 | 1100 | 300 | 300 |
| Punched card output speed, cpm | 100-400 | 100-400 | 100-400 | — | — |
| High-speed paper tape input, cps | 300 | 300 | 300 | 400 | 300 |
| High-speed paper tape output, cps | 110 | 110 | 110 | 120 | 120 |
| Other standard peripheral units | Line printer, Tape cassette, Plotter, A/D converters | Line printer, Tape cassette, Plotter, A/D converters | Line printer, Tape Cassette, Plotter, A/D converters | — | Line printer, Plotter, Communications interfaces |
| **SOFTWARE** | | | | | |
| Assembler | 1 & 2-pass | 1 & 2-pass | 1 & 2-pass | 2-pass | 2-pass |
| Macro assembler | Yes | Yes | Yes | Yes | Yes |
| FORTRAN compiler | Yes | Yes | Yes | Yes | Yes |
| Other compilers | Conversational FORTRAN | Conversational FORTRAN | Conversational FORTRAN | No | No |
| Operating system | Yes | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $12,750 | $10,950 | $19,000 | $24,500 | $14,100 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $17,500 | $14,950 | $24,600 | $32,000 | $17,699 |
| Date of first delivery | Oct. 1967 | March 1970 | May 1969 | March 1969 | Aug. 1969 |
| Number installed to date | 250 | 15 | 100 | 15 | NA |
| **COMMENTS** | All three Raytheon computers are program-compatible; a software library of over 400 routines includes a Real-Time Operating System capable of controlling foreground/background multiprogramming in 8K disk systems. | | | | One-pass ASA FORTRAN IV compiler operates in 8K; programs can be assembled or simulated on an IBM 360. |

# All About Minicomputers

| MANUFACTURER & MODEL | SYSTEMS 810A | SYSTEMS 810B | SYSTEMS 840MP | Texas Instruments Model 960 | Texas Instruments Model 980 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 16 + 2 | 16 + 2 | 24 + 2 | 16 + 1 | 16 + 1 |
| Fixed-point operand length, bits | 16 | 16 | 24 (48 opt.) | 16 | 16 |
| Instruction length, bits | 16 | 16 | 16 | 32 | 16/32 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.75 | 0.75 | 1.75 | 1.0 | 1.0 |
| Minimum capacity, words | 4,096 | 8,192 | 8,192 | 4,096 | 4,096 |
| Maximum capacity, words | 32,768 | 32,768 | 98,304 | 65,536 | 65,536 |
| Parity checking | Optional | Standard | Standard | Standard | Standard |
| Storage protection | Optional | Optional | Optional | Standard | No |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 2 | 2 | 2 | 16 | 2 |
| No. of index registers | 1 | 1 or 2 | 3 | 16 | 1 |
| No of directly addressable words | 1,024 | 1,024 | 32,768 | 65,536 | 65,536 |
| Indirect addressing | Multi-level | Multi-level | Multi-level | One-level | One-level |
| Add time, microseconds (full word) | 3.5 | 1.5 | 3.5 | 6.0 | 2.0 |
| Hardware multiply/divide | Standard | Standard | Standard | Optional | Standard |
| Hardware floating point | No | No | Optional | No | No |
| Hardware byte manipulation | No | No | No | Standard | No |
| Immediate (literal) instructions | Standard | Standard | Standard | Standard | Standard |
| Power failure protection | Optional | Optional | Optional | Standard | Standard |
| Real-time clock or timer | Optional | Optional | Optional | Optional | No |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 16 + 1 | 16 + 1 | 24 + 1 | 1 to 16 | 16 |
| Direct memory access channel | Optional | Optional | Optional | Standard | Standard |
| Maximum I/O rate, words/sec | 572,000 | 1,333,000 | 572,000 | 1,000,000 | 1,000,000 |
| No. of external interrupt levels | 96 | 98 | 64/processor | 2 | 3-4,097 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | Yes | Yes | Yes | No | No |
| Non-interchangeable disk storage | Yes | Yes | Yes | Yes | Yes |
| Drum storage | Yes | Yes | Yes | Yes | Yes |
| Magnetic tape speed, cps | 120K | 120K | 120K | 60K | 60K |
| Punched card input speed, cpm | 600 | 600 | 600 | 300 | 300 |
| Punched card output speed, cpm | 100 | 100 | 100 | 100 | 100 |
| High-speed paper tape input, cps | 300 | 300 | 300 | 300 | 300 |
| High-speed paper tape output, cps | 110 | 110 | 110 | 60 | 60 |
| Other standard peripheral units | Line printers, Computer graphics, A/D converters | Line printers, Computer graphics, A/D converters | Line printers, Computer graphics, A/D converters | Line printer, Communications processor | Line printer, Communications processor |
| **SOFTWARE** | | | | | |
| Assembler | 2-pass | 2-pass | 2-pass | 2-pass | 2-pass |
| Macro assembler | Yes | Yes | Yes | Yes | No |
| FORTRAN compiler | Yes | Yes | Yes | No | Yes |
| Other compilers | No | No | No | No | No |
| Operating system | Yes | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $18,000 | Not avail. | Not avail. | $16,700 | $18,600 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $23,000 | $33,500 | $49,000 | $21,200 | $23,100 |
| Date of first delivery | Sept. 1965 | Aug. 1968 | Nov. 1965 | June 1970 | May 1968 |
| Number installed to date | 237 | 103 | 73 | 0 | 100+ |
| **COMMENTS** | Features COIL, an integrated software system for data acquisition and control. | Real-Time Executive can handle foreground/ background multiprogramming. | Up to four processors can access a shared memory of 8K to 65K words. | Designed for efficient manipulation of individual bits and bit fields; has 16 general registers. | Real-Time Monitor can handle foreground/ background multiprogramming. |

# All About Minicomputers

| MANUFACTURER & MODEL | Tempo Computers TEMPO I | Unicom CP-8 | UniComp COMP-16 | UniComp COMP-18 | Varisystems PAC-16 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 16 | 8 | 16 | 18 | 16 |
| Fixed-point operand length, bits | 16 | 8 | 16 | 18 | 8/16 |
| Instruction length, bits | 16/32 | 8/16 | 16 | 18 | 16 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core or ROM | Core | Core | Core |
| Cycle time, microseconds/word | 0.9 | 1.75 | 0.9 | 0.9 | 1.5/8 bits |
| Minimum capacity, words | 4,096 | 512 | 4,096 | 4,096 | 512 |
| Maximum capacity, words | 65,536 | 32,768 | 65,536 | 262,144 | 2,048 |
| Parity checking | Optional | Standard | Optional | No | Optional |
| Storage protection | Optional | Optional | Optional | Optional | Optional |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 8 (16 opt.) | 1 | 1 | 1 | 1 |
| No. of index registers | 8 (16 opt.) | 1 | 6 | 6 | 1 |
| No. of directly addressable words | 65,536 | 4,096 | 256 | 1,024 | 2,048 |
| Indirect addressing | One-level | 32,768 | One-level | One-level | Multi-level |
| Add time, microseconds (full word) | 1.8 | 3.5 | 2.25 | 2.25 | 4.5 |
| Hardware multiply/divide | Optional | Optional | Optional | Optional | No |
| Hardware floating point | No | No | Optional | Optional | No |
| Hardware byte manipulation | No | No | Optional | Optional | Standard |
| Immediate (literal) instructions | Standard | Yes | Standard | Standard | Standard |
| Power failure protection | Optional | Optional | Standard | Standard | Optional |
| Real-time clock or timer | Optional | Optional | Optional | Optional | No |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 16/8 | 8 | 16 | 18 | 8/16 |
| Direct memory access channel | Optional | Optional | Standard | Standard | Optional |
| Maximum I/O rate, words/sec | 700,000 | 45,000 | 1,100,000 | 1,100,000 | |
| No. of external interrupt levels | 4-256 | 4 | 1-128+ | 1-128+ | 0-2 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | Yes | No | Yes | Yes | Yes |
| Non-interchangeable disk storage | No | No | Yes | Yes | Yes |
| Drum storage | Yes | No | Yes | Yes | Yes |
| Magnetic tape speed, cps | 30/60K | 2 ips | 20K | 20K | 800 |
| Punched card input speed, cpm | 400 | — | 200 | 200 | — |
| Punched card output speed, cpm | 60 | — | 120 | 120 | — |
| High-speed paper tape input, cps | 400 | — | 625 | 625 | 500 |
| High-speed paper tape output, cps | 60/120 | — | 120 | 120 | 100 |
| Other standard peripheral units | Line printer, Communications multiplexer, 360 interface | CRT display, Page printer, Tape cassette | Line printer, A/D converters, Communications interfaces | Line printer, A/D converters, Communications interfaces | — |
| **SOFTWARE** | | | | | |
| Assembler | 1 & 2-pass | 2-pass | 1 & 2-pass | 1 & 2-pass | 2-pass |
| Macro assembler | Yes | Yes | Yes | Yes | No |
| FORTRAN compiler | Yes | No | Yes | Yes | No |
| Other compilers | No | No | BASIC | BASIC | No |
| Operating system | Under dev'ment | Yes | Yes | Yes | No |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $15,600 | $6,350 | $11,550 | $12,250 | Not avail. |
| Price of basic system with 8K words & Teletype Model 33 ASR | $21,500 | $8,750 | $13,600 | $14,300 | Not avail. |
| Date of first delivery | Sept. 1969 | March 1970 | 1970 | 1970 | Aug. 1969 |
| Number installed to date | NA | 27 | NA | NA | 14 |
| **COMMENTS** | Usable as a dual-processor system or as communications "front end" for a larger computer. | Available with either read-only or read/write memory; prices are for Model CP-8C with read/write core memory. | 48-word read-only memory holds bootstrap loader. | 48-word read-only memory holds bootstrap loader. | Programmable controller; price of 2K model without ASR is $3,850. |

# All About Minicomputers

| MANUFACTURER & MODEL | Varian 520/i | Varian 620/i | Varian 620/f | Viatron 2140 | Viatron 2150 |
|---|---|---|---|---|---|
| **DATA FORMATS** | | | | | |
| Word length, bits | 8 | 16 (18 opt.) | 16 | 16 | 16 |
| Fixed-point operand length, bits | 8/16/24/32 | 16 (18 opt.) | 16 | 8/16/32/48 | 8/16/32/48 |
| Instruction length, bits | 8/16/24 | 16/32 | 16/32 | 16/32 | 16/32 |
| **MAIN STORAGE** | | | | | |
| Storage type | Core | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.5 | 1.8 | 0.75 | 1.0 | 1.0 |
| Minimum capacity, words | 4,096 | 4,096 | 4,096 | 4,096 | 8,192 |
| Maximum capacity, words | 32,768 | 32,768 | 32,768 | 4,096 | 8,192 |
| Parity checking | Optional | Optional | Optional | No | No |
| Storage protection | No | Optional | Optional | No | No |
| **CENTRAL PROCESSOR** | | | | | |
| No. of accumulators | 2 | 2 | 2 | 3 | 3 |
| No. of index registers | 2 | 2 | 2 | 3 | 3 |
| No. of directly addressable words | 4,096 | 2,048 | 2,048 | 4,096 | 8,192 |
| Indirect addressing | Multi-level | Multi-level | Multi-level | One-level | One-level |
| Add time, microseconds (full word) | 4.5 | 3.6 | 1.5 | 5 | 5 |
| Hardware multiply/divide | No | Optional | Optional | Standard | Standard |
| Hardware floating point | No | No | No | No | No |
| Hardware byte manipulation | Standard | No | No | Standard | Standard |
| Immediate (literal) instructions | No | Standard | Standard | Standard | Standard |
| Power failure protection | Optional | Optional | Optional | Standard | Standard |
| Real-time clock or timer | Optional | Optional | Optional | Optional | Optional |
| **INPUT/OUTPUT CONTROL** | | | | | |
| I/O word size, bits | 8 | 16 (18 opt.) | 16 | 16 | 16 |
| Direct memory access channel | Optional | Standard | Standard | Standard | Standard |
| Maximum I/O rate, words/sec | 660,000 | 200,000 | 1,330,000 | 330,000 | 330,000 |
| No. of external interrupt levels | 4 | 0-64 | 0-64 | 2 | 4 |
| **PERIPHERAL EQUIPMENT** | | | | | |
| Disk pack storage | Yes | Yes | Yes | No | No |
| Non-interchangeable disk storage | Yes | Yes | Yes | No | No |
| Drum storage | No | Yes | Yes | No | No |
| Magnetic tape speed, cps | 20K | 20K | 20K | 2,200 | 2,200 |
| Punched card input speed, cpm | 300 | 300/400/1000 | 300/400/1000 | 13.3 | 13.3 |
| Punched card output speed, cpm | 200 | 200/300 | 200/300 | 13.3 | 13.3 |
| High-speed paper tape input, cps | 300 | 300 | 300 | — | — |
| High-speed paper tape output, cps | 60 | 60/120 | 60/120 | — | — |
| Other standard peripheral units | Line printer, Plotter, Data set coupler | Line printer, CRT display, A/D converters, Plotters, etc. | Line printer, CRT display, A/D converters, Plotters, etc. | System 21 Terminals and their peripherals | System 21 Terminals and their peripherals |
| **SOFTWARE** | | | | | |
| Assembler | 2-pass | 2-pass | 2-pass | 2-pass | 2-pass |
| Macro assembler | No | No | No | No | No |
| FORTRAN compiler | No | Yes | Yes | Yes | Yes |
| Other compilers | No | BASIC RPG | BASIC RPG | No | DDL-1 |
| Operating system | No | Yes | Yes | No | No |
| **PRICING & AVAILABILITY** | | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $7,400 | $11,750 | $12,300 | $4,752 (without ASR) | Not avail. |
| Price of basic system with 8K words & Teletype Model 33 ASR | $9,400 | $16,500 | $14,800 | Not avail. | $9,552 (without ASR) |
| Date of first delivery | Sept. 1968 | Sept. 1967 | June 1970 | June 1970 | June 1970 |
| Number installed to date | 50 | 1300 | 0 | 0 | 0 |
| **COMMENTS** | Two full sets of registers facilitate inter-program switching. | A ruggedized version, Model R-620/i, costs $18,700 with 4K words & ASR. | Upward compatible with 620/i; optional 300-nsec read-only memory uses braided cores. | Controls up to 8 Viatron System 21 terminals; uses MOS/LSI circuitry. | Controls up to 24 Viatron System 21 terminals; uses MOS/LSI circuitry. |

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| MANUFACTURER & MODEL | Wang Laboratories WANG 3300 | Weismantel Associates WAICOM-16 | Xerox Data Systems XDS CE16 | Xerox Data Systems XDS CF16 |
|---|---|---|---|---|
| **DATA FORMATS** | | | | |
| Word length, bits | 8 | 16 | 16 | 16 |
| Fixed-point operand length, bits | 8/16 | 16/32/64 | 16 | 16 |
| Instruction length, bits | 16 | 16 | 16 | 16 |
| **MAIN STORAGE** | | | | |
| Storage type | Core | Core | Core | Core |
| Cycle time, microseconds/word | 1.6 | 0.5 | 8.0 | 2.67 |
| Minimum capacity, words | 4,096 | 8,192 | 4,096 | 4,096 |
| Maximum capacity, words | 65,536 | 65,536 | 16,384 | 32,768 |
| Parity checking | No | Standard | No | No |
| Storage protection | No | Optional | No | Optional |
| **CENTRAL PROCESSOR** | | | | |
| No. of accumulators | 2 | 10 | 1 | 1 |
| No. of index registers | 0 | 6 | 1 | 1 |
| No. of directly addressable words | 768 | 65,536 | 768 | 768 |
| Indirect addressing | One-level | One-level | Multi-level | Multi-level |
| Add time, microseconds (full word) | 4.8 | 0.5 | 16.0 | 5.33 |
| Hardware multiply/divide | No | Standard | No | No |
| Hardware floating point | No | Optional | No | No |
| Hardware byte manipulation | Standard | Standard | No | No |
| Immediate (literal) instructions | Standard | Standard | Standard | Standard |
| Power failure protection | Optional | Standard | Optional | Optional |
| Real-time clock or timer | Optional | Standard | Optional | Optional |
| **INPUT/OUTPUT CONTROL** | | | | |
| I/O word size, bits | 8 | 16 + 2 | 16/8 | 16/8 |
| Direct memory access channel | Standard | Optional | Standard | Standard |
| Maximum I/O rate, words/sec | 500,000 | 2,000,000 | 125,000 | 250,000 |
| No. of external interrupt levels | 128 | | 3-64 | 3-64 |
| **PERIPHERAL EQUIPMENT** | | | | |
| Disk pack storage | Yes | Yes | No | No |
| Non-interchangeable disk storage | No | No | No | Yes |
| Drum storage | No | No | No | No |
| Magnetic tape speed, cps | 240 | 30K | 10K | 20K |
| Punched card input speed, cpm | — | 300 | 300 | 300 |
| Punched card output speed, cpm | — | — | — | — |
| High-speed paper tape input, cps | 30 | 300 | 300 | 300 |
| High-speed paper tape output, cps | — | 60 | 60 | 60 |
| Other standard peripheral units | Selectric I/O Writers | Line printer, Communications multiplexers, A/D converters | A/D converters, Communications interfaces | A/D converters, Communications interfaces |
| **SOFTWARE** | | | | |
| Assembler | 2-pass | 1 & 2-pass | 1 & 2-pass | 1 & 2-pass |
| Macro assembler | No | Yes | No | No |
| FORTRAN compiler | No | Yes | Yes | Yes |
| Other compilers | BASIC | No | No | No |
| Operating system | Yes | Yes | Yes | Yes |
| **PRICING & AVAILABILITY** | | | | |
| Price of basic system with 4K words & Teletype Model 33 ASR | $7,200 | Not avail. | $11,990 | $10,000 |
| Price of basic system with 8K words & Teletype Model 33 ASR | $9,700 | $90,000 | $17,515 | $14,850 |
| Date of first delivery | June 1970 | Nov. 1970 | May 1969 | Dec. 1969 |
| Number installed to date | 0 | 0 | 11 | 25 |
| **COMMENTS** | Time-sharing system; can handle up to 16 BASIC users simultaneously; software is separately priced. | 4 to 16 I/O channels; two processors can share core memory. | Basic FORTRAN compiler operates in 4K memory. | Basic FORTRAN compiler operates in 4K memory; fully compatible with CE16. |