DEC PDP-8 Family

MANAGEMENT SUMMARY

In May 1974, Digital Equipment Corporation added another chapter to the ongoing saga of its PDP-8 family by introducing the PDP-8/A to the 12-bit computer series. The 8/A is a one-board, medium-scale integration (MSI) version of the highly popular PDP-8/E, PDP-8/F, and OEM-oriented PDP-8/M. Originally offered on a per-board basis, the 8/A was reintroduced in November 1974 in three general configurations to both end users and OEM's with small memory needs (up to 16K). The 8/A-100 and the 8/A-200, aimed at OEM buyers, are basic packages—processor, 1K-word RAM memory, operator's panel, power supply, and chassis. Five variations on this theme are available at prices varying from $1,745 to $2,600 for single units. Prices drop about one-third on quantities of 50.

There is only one major difference between the 8/A-100 and 8/A-200 models: the -100 has 10-slot Omnibus and the -200 has a 12-slot Omnibus. Other than that, they are identical—as are the 8/A-400 and -500. None of the 8/A Omnibuses can be expanded. If your required hardware won't fit into 10 or 12 slots (including one for the processor), you'll have to get a bigger PDP-8 (an 8/E, 8/M, or 8/F, that is).

The 8/A-400 and 8/A-500 are new configurations. They are core memory machines aimed at a small system (up to 16K words) with a few peripherals (only 12 Omnibus slots), or a system that is not going to be expanded, such as a business minicomputer like the Datasystem 310. Prices for the OEM 8/A-400 range from $2,795 to $3,995 ▷

DEC has entered another important chapter in the continuing story of its PDP-8 family: the PDP-8/A. For those who missed earlier episodes, the PDP-8 family virtually founded the minicomputer industry in the mid-1960's. With more than 25,000 delivered to date, the PDP-8 is the world's most widely installed system.

CHARACTERISTICS

MANUFACTURER: Digital Equipment Corporation, 146 Main Street, Maynard, Massachusetts 01754. Telephone (617) 897-5111. DEC is a worldwide corporation.

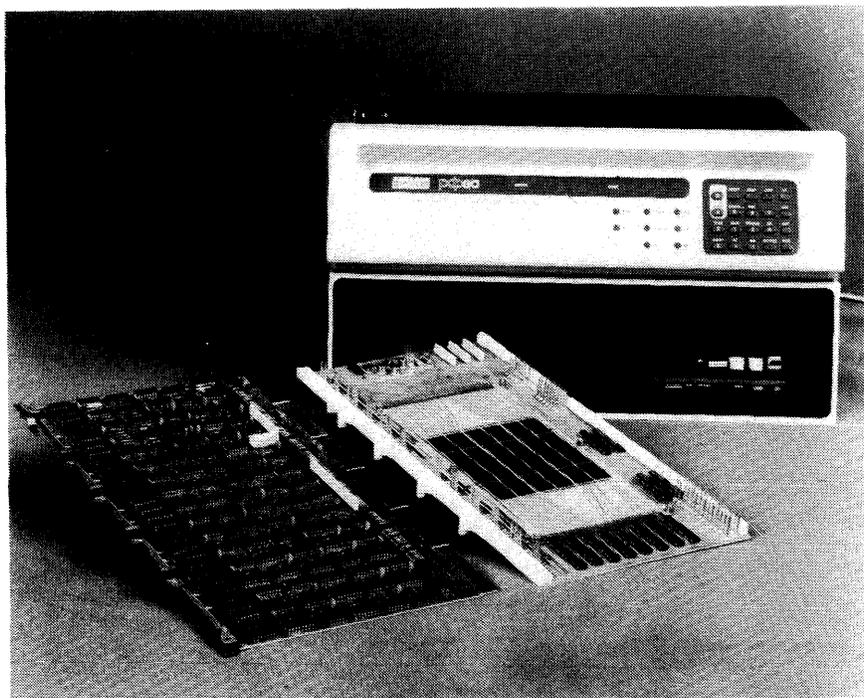MODELS: PDP-8/E, -8/M, -8/F, and -8/A.

DATA FORMATS

BASIC UNIT: 12-bit word.

FIXED-POINT OPERANDS: 12-bit words standard, with optional 24-bit double-precision operands. Half-word (6-bit) byte swaps can also be handled.

FLOATING-POINT OPERANDS: 36-bit single-precision operands with a 24-bit signed fraction and signed 12-bit exponent. Optional 72-bit operand with a 60-bit signed fraction and signed 12-bit exponent for double precision. Floating-point processor hardware is optional on all models; software subroutines are also available.

INSTRUCTIONS: One-word instructions. No decimal instructions are available for any PDP-8 model. Memory reference instructions use the first three bits to specify the instruction and the last nine bits to specify the operand address. In order for memory reference instructions to ▶

The DEC PDP-8/A-400, shown here with a processor board (left) and core memory board, was announced with the MOS-memory PDP-8/A-200 in November 1974. Initial 8/A-400 deliveries are scheduled for July 1975, while the look-alike 8/A-200 will be delivered initially in September 1975. Both models have a 1.5-microsecond processor cycle time. The 8/A-200 can use one 4K-word memory module, and can be equipped with a battery power supply for brownout protection. Its purchase price is $1,317 in quantities of 50, or $1,995 singly, for a 4K-word MOS-memory model, which includes power supply, operator's console, 12-slot Omnibus, and all standard PDP-8 features. The 8/A-400 offers the same features at quantity-50 purchase prices of $1,845 or $2,505 for units with an 8K or 16K single-board memory, respectively; corresponding single-unit prices are $2,795 or $3,795. Memory options for both models also include PROM, ROM, and fusable-link ROM in various sizes from 1K to 4K words.

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PDP-8 COMPARISON TABLE

PROCESSOR	PDP-8/A-100	PDP-8/A-200	PDP-8/A-400 & 500	PDP-8/E	PDP-8/M & 8/F
Cycle Time	1.5 microseconds	1.5 microseconds	1.5 microseconds	1.2 microseconds	1.2 microseconds
Omnibus	10-slot, nonexpandable	12-slot, nonexpandable	12-slot, nonexpandable	20-slot; chassis has room for 1 additional Omnibus; can be expanded with 1 BA-8 expander to max. of 76 slots	20-slot; can be expanded with 1 BA-8 expander to max. of 58 slots
Power supply	+5V@20A, −15V@¾A, , +15V@¾A	+15V@20A, −15V@¾A, +15V@¾A	+5V@25A, −15V@2A, +15V@2A	+5V@21A, −15V@8A, +15V@1½A	+5V@20A, −15V@5A, +15V@1A
Panel supplied	3-switch operator panel; optional Programmer panel with LED octal readout	Same	Same	20-switch Programmer console	3-switch Operator panel; optional Programmer console with LED indicators
MEMORY					
Max. capacity	16K words* (32K addressing)	16K words* (32K addressing)	16K words* (32K addressing)	32K words	32K words
Type/size/speed (microseconds)	RAM/1,2,4K/2.3 ROM/1,2,4K/1.5 PROM/1K/3.4	RAM/1,2,4K/2.3 PROM/1K/1.5	Core/8,16K/1.2 RAM/1,2,4K/2.3 ROM/1,2,4K/1.5 PROM/1K/3.4	Core/4,8K/1.2 PROM-RAM/1K-256/ 3.4	Core/4,8K/1.2 PROM-RAM/1K-256/ 3.4
Peripheral limitations	Cannot support: Floating-Point Processor, Real-Time Clock, Disk, or Line Printer; Cassette mag. tape only (TD8-E)	None	None	None	None
Price range	$1,745-$8,000	$1,995-$9,000	$2,795-$20,000	$4,490-$75,000	$2,750-$50,000
Intent	OEM, very small systems (up to 4K), little expansion	OEM, small systems (up to 8K), little expansion	End user (400) and OEM (500), small systems (up to 16K), little expansion	End user and OEM, large systems (up to 32K), much expansion	OEM (8M) and end (8F), large systems (up to 32K), moderate expansion

*Limitations and trade-offs are imposed by the power supply and peripheral slots used in these packages.

▷ for single units and from $1,845 to $2,505 in quantities of 50. Single-unit prices for the end-user 8/A-500 range from $3,795 to $5,195.

There are two factors limiting the ultimate configurations of the 8/A series processors—the 10- or 12-slot Omnibus, previously mentioned, and the power supplies in each package. The 8/A-100 and -200 have semiconductor memories which draw more current than core. Hence, less current is available for peripherals in these configurations than in the 8/A-400 or -500 with core memory (about a 5-Ampere difference for the +5V supply), permitting the 8/A-400 or -500 to support a wider variety of peripherals. The extra peripherals offered with the 8/A-400 and -500—disk, reel-to-reel magnetic tape, line printers, and card readers—are those more likely purchased by end users than by OEM's. Another restriction limiting 8/A configurations is that certain types of boards (memories especially) can occupy only certain Omnibus slots. For instance, the CPU board can go only into slot 1, and core ▷

▶ access memory directly, each 4K memory module is logically divided into 32 pages of 128 addresses each for page addressing. Seven of the nine bits are used to specify relative address within page; one bit is used to specify current page or page zero within the module, and one bit is used to specify whether direct or indirect addressing is used.

Through direct addressing, a memory reference instruction can reference any of 128 addresses on its own page or any of 128 addresses on page zero of its own 4K module; through indirect addressing, any location in memory can be referenced.

For manipulation and/or testing of data, a group of "Operate" instructions is available that specify shift, clear, complement, and test (and skip) operations on the accumulator and its associated link bit. The first three bits specify an Operate-type instruction, the fourth bit specifies one of two groups of commands, and bits 5 through 11 are predefined by position to indicate particular functions. These seven 1-bit indicators can be turned on in each Operate instruction, with each 1-bit flag referred to as a "microinstruction" (not to be confused with micro- ▶ programming).

DEC PDP-8 Family

PERIPHERALS/TERMINALS

DEVICE	DESCRIPTION	SPEED
MAGNETIC TAPE UNITS		
TU56-M DECtape	Single-drive, 350 bpi, 97 ips, bidirectional tape motion; requires 1 slot (TU56-MH is dual drive)	8250 words/sec
TU10-EA	Industry-compatible, 9-track, 800 bpi, 45 ips; requires 4 slots	36 KBS
TU10-FA	Industry-compatible, 7-track, 800/556/200 bpi, 45 ips; requires 4 slots	36 KBS
TU60-AA	Dual cassette drive, 93K bytes capacity; requires 1 slot	560 bytes/sec
TS03	Industry-compatible, 9-track, 800 bpi, 12½ ips, 7-in. reels	10 KBS
LINE PRINTERS		
LS01-EC	132-position, 64-character set; requires 1 slot	165 cps
LE8-VA	132-position, 64-character set, variable forms length; requires 1 slot	300 lpm
LE8-WA	132-position, 96-character set, variable forms length; requires 1 slot	300 lpm
PUNCHED CARD UNITS		
CM8-FA	Optical Mark Reader, 80-column; requires 1 slot	300 cpm
CR8-FA	Punched Card Reader, 80-column; requires 1 slot	300 cpm
PAPER TAPE EQUIPMENT		
PR8-E	Reader, 8-level; requires 1 slot	300 cps
PC8-E	Reader/Punch, 8-level; requires 1 slot	300/50 cps
TERMINALS		
LA36 DECwriter	Keyboard and Printer, 132 positions; requires 1 slot	30 cps
LT33	ASR-33 Teletypewriter (modified)	110 bps
VT50	CRT Terminal, 64 ASCII character set, switch-selectable speeds, current-loop interface	75-9600 bps
VT8	A/N Graphic Display, 20 lines x 32 or 64 characters, upper case	
RT01 DEClink	Data Entry Terminal, 16-character keyboard, 4 status indicators, current loop or RS-232C interface, 4- to 12-digit display	110 or 300 bps
RT02 DEClink	A/N Data Entry Terminal, 16-character-keyboard, 32-character display	110, 150, 300, or 1200 bps

▷ memory boards can be plugged only into slots 4 through 8.

In order to underscore the market targeting of each of the new packages, DEC has quoted on-site service contract prices only for the 8/A-400 and -500 systems. Prices for service for 8/A-100 and -200 systems must be obtained on request.

The PDP-8/E, -8/F, and -8/M are the older brothers of the newer 8/A's. The 8/E is for end users who wish to assemble larger systems (up to 32K) with many and varied peripherals. The 8/M (the OEM version of the 8/E) and the 8/F are nearly identical. All use the same processor, which consists of five boards (and hence requires five Omnibus slots). The major differences among the three models lie not in the processors, but in the chassis and power supplies of each. The 8/E comes with one 20-slot Omnibus and room for an extra one if desired. In addition, its power supply is large enough to supply the needed current to the extra cards. The 8/M and 8/F, on the other hand, have room for only one 20-slot Omnibus and hence a slightly smaller power supply. Both Omni-busses can be expanded, however, through the use of the BA-8 expander—the 8/E to 76 slots and the 8/M and 8/F to 58 slots. ▷

► For I/O instructions, the first three bits specify I/O, the next six bits select a device, and the last three bits specify the operation to be performed.

INTERNAL CODE: Binary.

MAIN STORAGE

TYPE: Core; and static MOS used for RAM, ROM, and PROM.

CYCLE TIME: Core—1.2 microseconds; RAM—2.3/2.8 microseconds (read/write); ROM—80 nanoseconds access, 1.5 microseconds cycle time; and PROM—3.4/3.6 microseconds (read/write).

CAPACITY: Core—4 to 32K words in 4, 8, or 16K increments. RAM—1 to 32K words in 1, 2, or 4 increments. ROM—1 to 32K words in 1, 2, or 4K increments. PROM—1 to 32K words in 1K increments. The capacity of each system is dependent on the power supply used. See Report M13-100-101, *Minicomputer Add-On Memory*, for non-DEC alternatives.

CHECKING: None.

STORAGE PROTECTION: None.

CENTRAL PROCESSORS

GENERAL: All of the PDP-8 Family processors are single-address, fixed-word length, parallel machines using two's-complement arithmetic on 12-bit binary numbers with an accumulator and multiplier-quotient architecture and direct accumulator-to-device and device-to-accumulator ►

DEC PDP-8 Family

▷ Prices for the PDP-8/E range from $4,190 for a very basic system with processor, 4K words of core memory, programmer console, teletypewriter console, power supply, and chassis to about $20,000 for a system with processor, 16K words of core memory, bootstrap loader, cassette tape, cartridge disk, DECwriter II, interfaces, cabinet, power supply, and OS/8 operating system.

Prices for the 8/M span a smaller range, owing to its OEM-centered marketing: $3,200 to $6,100 for a processor, various memory combinations, operator panel or programmer console, power supply, and chassis.

HISTORY

DEC's venerated PDP-8 family officially began life in 1965 with the first shipment of the original PDP-8. Actually, however, the architecture and basic concepts behind the PDP-8 really started with the PDP-5 in 1963.

The PDP-5 was based upon a 12-bit word length, and was intended for dedicated laboratory/process control applications, with typical system prices of about $28,500. The PDP-5 was manufactured with hand-wired production techniques, making it impractical to produce in large quantities. As it was, about 100 PDP-5's were produced (most of which continue in operation). The enthusiastic market demand for the PDP-5 delighted DEC, and plans were immediately made for a mass-producible version—the PDP-8. The PDP-8 was not originally called a minicomputer, but was certainly the first of the popular, low-cost, small-scale machines that would seen revolutionize the computer industry.

The PDP-8 was announced less than two years after the PDP-5, and was identical to the PDP-5 except that the internal register for a program counter was built into hardware instead of being implemented at memory location 0, as was the case for the PDP-5. The PDP-8 was widely recognized as 1) the first mass-produced computer, 2) the first popular minicomputer, and 3) the first computer selling for less than $20,000 (CPU only; typical system costs were somewhat higher).

The PDP-8 (and its "crowd pleaser" transparent chassis) was followed a year later by the PDP-8/S—the first OEM ▷

▶ I/O transfers. There are two distinct processor versions of the same fundamental architecture. Model KK8-E is used with the models 8/E, 8/F, and 8/M; and KK8-A, the newest processor model, is used in the PDP-8/A's.

The PDP-8/E, 8/F, and 8/M have provisions for an optional Extended Arithmetic Element (EAE) that permits double-precision fixed-point operations plus hardware fixed-point multiply/divide. The EAE contains extension hardware that can operate on 24-bit signed numbers rather than the conventional 12-bit operands. The EAE adds 26 extended instructions to the PDP-8/E, 8/F, and 8/M repertoires.

A Floating Point Processor (FPP) is available for use with all PDP-8's. This unit provides the capability of operating with 36-bit floating-point operands (24-bit mantissa and 12-bit exponent). It can also be expanded to handle 72-bit operands (60-bit mantissa and 12-bit exponent).

Three types of real-time clocks are offered for the PDP-8/E, 8/F, and 8/M. These units vary in the timing source, using internal line frequency, a selected crystal frequency, or programmable intervals. The line frequency version marks off 16-millisecond intervals; the crystal model measures fixed intervals determined by a crystal oscillator (user's choice); and the programmable internal model ticks off intervals specified by 12-bit constants loaded under program control. Only the latter model and 100 Hz are offered with the PDP-8/A's.

Power failure/auto restart, bootstrap loader, and memory extension control are offered as separate options on the PDP-8/E, 8/F, and 8/M. These three options are combined on a single board in PDP-8/A systems. In addition, the memory extension control, which permits addressing memory locations about 4K, also contains a time-share control which provides monitor and user modes for time-shared operations.

Another combination of options, available on the PDP-8/A's only, is the input/output options board. This board contains a 100-Hz real-time clock, a programmer console control, a 12-bit parallel I/O interface, and an asynchronous serial line interface with switch-selectable speeds to 9600 bits per second.

REGISTERS: All models of the PDP-8 Family have eight major registers. Six are 12-bit registers: one accumulator (AC); one general-purpose register (MQ) for use as temporary storage or as an extension of the accumulator if the Extended Arithmetic Element is employed; a program counter (PC); memory address (MA) register; a switch register (SR) to manually load memory or another register from a programmer's console; and a memory buffer (MB) register to transfer data between other registers and memory. A three-bit instruction register (IR) containing the op-code of the current instruction and a one-bit link (L) carry register for accumulator overflow are also provided.

Eight autoindexing registers are implemented in octal locations 10 through 17 of each 4K-word memory module. When any of these locations is addressed implicitly by a ▶
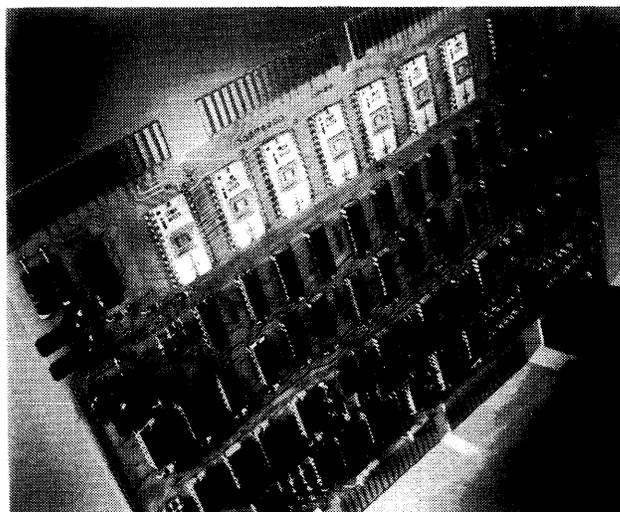
SUMMARY DATA FOR THE PDP-8 FAMILY

	PDP-5	PDP-8	PDP-8/S	LINC-8	PSP-8/I	PDP-8/L	PDP-12	PDP-8/E	PDP-8/M	PDP-8/F	PDP-8/A (100,200)	PDP-8/A (400,500)
Announced	1963	1965	1966	1966	1968	1968	1969	1970	1971	1972	1974	1974
First Delivered	9/63	5/65	9/66	9/66	3/68	7/68	6/70	3/71	12/71	11/72	9/74	—
CPU Price ($)	27,000	18,000	10,000	38,000	13,500	8,500	20,000	5,000	4,000	4,000	1,745	4,000
Avg. System ($)	28,500	22,500	12,500	40,000	17,000	11,500	32,000	13,500	8,000	9,500	—	7,000
Cycle Time (usec)	—	1.5	8.0	—	1.5	1.6	1.6	1.2	1.2	1.2	1.5	1
Number Installed*	90	9,950 (total)				17,150 (total)					—	—

*As of January 1, 1975.

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The PDP-8/E on the bottom is the most powerful model in the long and extremely popular line of 12-bit minicomputers from DEC The PDP-8/M perched above it is a lower-priced modular version for OEM customers.

This is an MR8-FB programmable read-only memory (PROM) board for the PDP-8/A. It plugs into the Omnibus and contains 256 read/write address locations; PROM and read/write memory can be mixed. The PROM cycle time is 3.4 to 3.6 microseconds. At the top of the card can be seen the seven ultraviolet erasable PROM chips. They are reprogrammable up to 100 times. Light energy in the ultraviolet wavelength, shining through the quartz windows on the MOS chips at an intensity of 6 watt-seconds per square centimeter, erases the PROM contents.

DEC's PDP-8 based FORTRAN Engine package was heralded by the company at its introduction as having five times the performance capability of systems costing twice as much. The configuration is based on DEC's EduSystem-25 and contains a PDP-8/E processor with at least 16K words of core memory, an RK8-E disk cartridge system, the OS/8 operating system, and the FORTRAN IV compiler at a purchase price of $25,000 and up. The system can support floating-point hardware.

The ubiquitous PDP-8. This photo was taken during trial runs at Watkins Glen and shows Ferrari team driver Sam Posey studying lap count and time data produced by a PDP-8/L (minus covers, on the ground at lower right). Mike Hawthorne and Hans Tanner used to have to do it with stopwatches.

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computer—and the Laboratory Instrumentation Computer (LINC-8). The LINC-8 grew out of a project to produce a PDP-8-like system that had both the PDP-8 and the original MIT Lincoln Lab instruction sets. The LINC-8 was a specialized system with a relatively narrow market appeal (about 100 were delivered). It was succeeded by the PDP-12, a laboratory system retaining many of the LINC-8's best features. PDP-12's are marketed today as part of DEC's LDP (Laboratory Data Processor) series.

The PDP-8/S (S for "Serial") took more than five times as long to execute a typical instruction as did the original PDP-8. The "S" used serial rather than parallel internal logic and was widely advertised as the first computer selling for less than $10,000.

The next developments in the PDP-8 family were an integrated-circuit version of the processor—8/I—for end-users, and then a low-cost 8/L ("Low") IC version for OEM's, built with a limited I/O configurability and a correspondingly less powerful power supply.

It was not until 1970 that the PDP-8 Series received its next major enhancement, with release of the PDP-8/E ("Expanded") OEM or end-user processor that employs the design used in each of the current PDP-8 Series systems: the PDP-8/E, 8/M (OEM-oriented), and 8/F (the end-user version of the 8/M). During the period between the release of the 8/I and the 8/E, work was under way on the more powerful DEC PDP-11 family, and it seemed to many in the computer industry that the PDP-8's lifespan would be terminated. But DEC did not share that view, and the latest addition—the PDP-8/A—keeps the PDP-8 family current with improvements that reflect the latest technological advances. (We have placed a Summary Data table at the bottom of the fourth page as a convenient way to recap the history of the many PDP-8 models.)

MARKETING

Prospective purchasers of DEC's products and services may notice that the company's marketing structure, for the most part, is divided into a number of application-oriented specialty groups. By working within this structure, DEC believes that it can best support the spectrum of applications in which the PDP-8 and certain other computer series are involved. The application groups are: Industrial Products Group, Business Products Group, Communications Group, Educational Systems Group, Laboratory Data Products Group, Engineering Computational Group, Typeset Group, and Components Group. All except the Components Group offer the PDP-8's as well as the PDP-11 processors as packaged systems. (The PDP-15 Group sells its product across all applications.) The Components Group offers equipment in components form (processors, memories, interfaces, etc.) to OEM buyers who wish to include this equipment in larger systems of mixed manufacturing origin.

Among the packaged PDP-8 systems available from DEC are the Industrial 8-11B system for industrial and process control ($19,000 to $30,000), the Typeset/8 for graphic arts and typesetting applications ($95,000 to $150,000),

memory reference instruction, the contents are automatically incremented by one and then used as an address. When referenced explicitly as memory, these locations function as any other.

INDIRECT ADDRESSING: One level.

INSTRUCTION REPERTOIRE: All processors have 6 memory reference instructions, 4 interrupt system control instructions, 3 flag processing instructions, and 41 Operate instructions for logic control, etc. Models 8/E, 8/F, and 8/M can support the optional Extended Arithmetic Element which provides six additional shift instructions, four arithmetic instructions (including multiply/divide, and six double-precision instructions.

INSTRUCTION TIMING: All times presented are for full-word, fixed-point operands in *microseconds*.

	PDP-8/E, 8/F, 8/M	PDP-8/A
Load/store	2.6	3.0
Add/subtract	2.6/5.0	3.0/6.0
Multiply/divide	256.5/342.4	–
Compare & branch	2.4	3.0

INTERRUPTS: A single-line interrupt structure is provided, with software polling of I/O devices required to determine the origin and priority of each interrupt.

Two operating modes, user and executive, are possible if the extended memory control is present. User mode is the only standard mode of operation, with executive mode being an option requiring a hardware modification on the processor board. In executive mode, full access is available to all programmable machine functions. In user mode, (invoked for time-sharing or foreground/background multiprogramming), direct I/O access is denied to unauthorized user programs.

Automatic push-down stacks are implemented in software to facilitate sharable (re-entrant) routines. The size of the push-down stacks is limited only by the size of available memory.

PHYSICAL SPECIFICATIONS: The PDP-8/E chassis is 10½ inches high, 19 inches wide, 24 inches deep, and weighs 100 pounds.

The PDP-8/M and 8/F chassis is 10½ inches high, 19 inches wide, 16¾ inches deep, and weights 90 pounds.

The PDP-8/A chassis is 10½ inches high, 19 inches wide, 10½ inches deep, and weighs 55 pounds.

A KK8-A processor board measures 8½ inches by 15¾ inches.

A standard cabinet is 72 inches high, 21 inches wide, 25 inches deep, and weighs 120 pounds. A short cabinet is 42 inches high, 21 inches wide, 25 inches deep, and weighs 90 pounds.

PDP-8 power requirements are as follows: The 8/E, 8/F, and 8/M require 90-135 VAC, single-phase, 60-Hz power at 5.6 Amperes for each model and for the BA8 Expander. The 8/A's also use 90-135 VAC, single-phase, 60-Hz power, but require no more than 3 Amperes fully loaded.

The operating environment tolerances of the 8/E, 8/F, and 8/M are the same: 32 to 100 degrees Fahrenheit at 10 to 90 percent noncondensing relative humidity. The 8/A's are different; they can operate at 41 to 132 degrees Fahrenheit at 8 to 90 percent noncondensing relative humidity.

The above operating environment figures are for the basic CPU, memory, and internal options only. Environmental requirements for system I/O devices vary considerably and generally impose stricter tolerances.

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▷ the Datasystem 310 and 340 small general business systems ($12,000 and up), the CLASSIC educational computer system ($7,900), and the LAB-8/E laboratory computer system ($9,900 to $35,000).

Some vendors that provide non-DEC packaged systems which use the PDP-8's (and the uses of the systems) are: Digital Communications, Atlanta Georgia (communication network components; Corning Glass Works, Medfield, Massachusetts (blood analysis); Reuters Ltd., New York, New York (communications); Unico, Frankeville, Wisconsin (stepping motor control); Electro Nucleonics, Fairfield, New Jersey (blood analysis); and Warner & Swasey, King of Prussia, Pennsylvania (industrial and numerical control systems).

Regarding performance, it is interesting to note that DEC has run PDP-8/E benchmarks against IBM's 360/30—a system with typical monthly rentals about five times that of a PDP-8/E configuration running under OS/8 software. The tests show that matrix inversions and other mathematical calculations take about half as long on the PDP-8.

Surprisingly, the trend toward 16-bit (and, more recently, 32-bit) minicomputers has not dampened the demand for PDP-8's. There are still certain applications involving relatively small memory requirements in which the PDP-8 family's price/performance characteristics make it the best choice. This choice is further enhanced by the vast quantity of fully developed software for these systems.

Another reason for the continuing success of the PDP-8, as well as other Digital lines, is DEC's field service force—over 2500 strong in more than 130 locations worldwide. In addition, DEC recently added five new training facilities in order to bring its training closer to the market. Training classes, previously held only in Maynard, Massachusetts, are now available in Blue Bell, Pennsylvania (near Philadelphia); Washington, D.C.; Princeton, New Jersey; Chicago, Illinois; and Tokyo, Japan.

Those who thought the advent of DEC's 16-bit PDP-11 family signaled the beginning of the end for the PDP-8 have had to concede that this enormously popular family of 12-bit minicomputers will continue to be with us for quite some time to come.

USER REACTION

Datapro conducted a general survey of minicomputer users' experience in September 1974. In that survey, 27 users of 80 DEC PDP-8's rated these minicomputers in 8 categories as follows:

	Excellent	Good	Fair	Poor	WA*
Overall performance	11	14	1	0	3.4
Ease of programming	6	4	9	5	2.5
Ease of operation	12	13	2	0	3.3
Hardware reliability	11	15	1	0	3.4
Maintenance service	10	7	6	1	3.1 ▷

▶ INPUT/OUTPUT CONTROL

OMNIBUS: A synchronous bus is provided with each processor. (One is standard in the PDP-8/E, with a second Omnibus as an option.) The Omnibus permits plugging memory/processor options or I/O devices into any available slot location, eliminating the need for special back-panel wiring. The maximum programmed data transfer rate is 134,000 words/second.

DIRECT MEMORY ACCESS: A standard 12-channel DMA (data break) feature is provided for high-speed block data transfers between memory and higher-speed peripheral/terminal devices on a cycle-stealing basis, and is an integral part of the Omnibus. Any peripheral/terminal controller with a DMA interface can operate directly to memory. In conjunction with the DMA feature, multiple external devices can directly increment multiple memory locations, and external data can be combined (add/subtract) directly to memory locations without processor intervention. The maximum DMA data transfer rate is 833,000 words/second.

CONFIGURATION RULES: The key to configuring the PDP-8/E, 8/F and 8/M is the Omnibus, which consists of prewired slots that permit physical attachment of I/O devices and/or memory/processor options. Each Omnibus has 20 slots in it, and when an additional Omnibus is added, one slot position in each is occupied by the interconnection cables. In a basic 4K-word 8/E, two Omnibuses are included with 10 slots used for the processor, console interface, and basic 4K words of core memory (11 slots if 8K words are present); this leaves 28 slots (27 with 8K words) for attachment of additional devices or optional features.

The 8/E can be further expanded in 18-slot increments to a total capacity of 46 or 64 slots (45 or 63 with 8K words). The 8/F and 8/M come with one Omnibus for a capacity of 10 (or 9) available slots that can be increased to 28 or 46 (27 or 45) total slots with the addition of one or two Omnibusses, respectively. The first memory board (4K or 8K) occupies four slots, with each expansion board (4K or 8K) occupying three slots. Each 256-word bootstrap ROM, the programmable clock, floating-point hardware, and the extended arithmetic option, require two slots. Power failure/automatic restart, the fixed interval real-time clock, and the bootstrap loaders each use one slot. The asynchronous line interfaces, I/O interfaces, and general-purpose interfaces use one slot, whereas the synchronous line interface uses two slots.

For the PDP-8/A series, the story is slightly different. Not only must the constraints of the standard Omnibus be observed, but the limitations of the power supply also need to be taken into account. The 8/A-100 package has a 10-slot Omnibus, and the 8/A-200 a 12-slot Omnibus. Neither can be expanded. In addition, the 8K and 16K-word core memory modules cannot be used due to their power requirements. The 8/A-400 and 8/A-500 also have a 12-slot, nonexpandable Omnibus, but these models have been endowed with a larger power supply. However, these configurations will not support any MOS RAM memory modules.

In all 8/A systems, certain modules must be placed in specified Omnibus slots. Slot 1 is reserved for the CPU board. No other module can occupy that slot. The I/O option board or the extended options board must be placed in slots 2 or 3. On the 8/A-200, 4K-word RAM memory modules must be placed in slots 4 through 8. For the 8/A-400 and -500, the number of core memory modules is limited to three (which can provide up to 32K words), and these must also use slots 4 through 8.

Please refer to the Peripherals/Terminals table on the third page of this report and the Equipment Prices section that concludes this report for specific device/slot requirements.

MASS STORAGE

For PDP-8 Family mass storage, DEC offers users the choice of DECtape, "floppy" disk (diskette), cartridge disk, or fixed-head disk. DECtape is bidirectionally searchable. ▶

DEC PDP-8 Family

	Excellent	Good	Fair	Poor	WA*
Technical support	6	6	5	5	2.6
Operating systems	4	9	2	4	2.7
Compilers & assemblers	4	9	5	1	2.8
Applications programs	5	2	5	5	2.4
TOTALS	69	79	36	21	3.0
PERCENTAGES	34%	39%	17%	10%	–

*Weighted average on a scale of 4.0 for Excellent.

With 73 percent of all the users' responses in either the "excellent" or "good" classification, there seems little need to be wary of selecting the PDP-8. Further, DEC feels that the Maintenance Service and, especially, the Technical Support ratings would have been higher if Datapro had separated the "on-call" service users from the "contract" service users in this grouping. We regret not having known in advance that it would be wise to do so, but we feel that the ratings thus compiled are admirable, all things considered. Also, we note that the five users who rated Ease of Programming as "poor" gave generally "good" ratings to DEC's compilers and assemblers. Could it be that they simply wished that they had not been forced by the PDP-8's 12-bit word size to write compact programs? □

▶ The diskette storage will be announced about the time this report is published. The fixed-head (head-per-track) disks are popular as "swapping" disks for re-entrant tasks.

DECTAPE: The TD8-E DECtape system serves as auxiliary magnetic tape storage. It utilizes 10-track read/write. Redundant recording of each character bit on nonadiacent tracks materially reduce bit drop-out errors and results in a highly reliable system. A reel of DECtape holds 2.7 million bits; this is 0.75-inch wide, 1-mil thick, 250-foot Mylar reel. Data is transferred at the rate of 33,300 3-bit units (half characters) per second; tape speed is 93 inches per second in both directions.

RX8E FLOPPY DISK: Available in late summer 1975 in 1- and 2-drive models, with 12K 12-bit words or 256K 6-bit DECbytes per diskette, this unit can be configured with one or two drives per controller. Average access time is 483 milliseconds, counting the 83-millisecond rotational delay due to the 360-rpm rotational speed. A track-to-track seek takes 10 milliseconds. The 77 tracks are divided into 26 sectors each. DEC has not disclosed the data transfer rate of this diskette nor its maintenance price as yet. It is believed to be manufactured by CalComp.

RS08 FIXED-HEAD DISK FILE: Provides fixed-head storage of 262,144 13-bit words (12 bits plus parity) of storage per spindle with an average access time of 16.9 milliseconds and a data transfer rate of 62.5K words/second. Data is stored on a single disk surface which is serviced by 128 read/write heads (2K words per track). Eight read/write protect switches on each RS08 can block access to blocks of 16K words in locations 0-13K. Up to four RS08 drives can be attached to an RS08 controller. The RS08/RF08 subsystem is housed in a separate cabinet(s) and does not use any chassis slots.

RK8 REMOVABLE DISK CARTRIDGE AND CONTROLLER: Provides storage for 1.6 million 12-bit words with an average access time (including head movement) of 50 milliseconds, and a data transfer rate of 120K words/second. Each disk cartridge records on both surfaces of a single disk, on 200 cylinders, with 2 tracks per cylinder, 16 sectors per track, and 256 words per sector. Up to three RK05 Disk Cartridge Drives can be added to the basic RK8 system for total of 6.6 million words of storage. The RK8

subsystem uses RK03 disk cartridges, is housed in a separate cabinet(s), and plugs into three Omnibus slots.

In addition to the disk products offered by DEC, more than 15 manufacturers currently supply DEC-compatible disk drives. These units are either DEC-equivalent units or IBM 2315, 5440, or 3470 equivalents. A detailed summary of these products is presented in Report M13-100-201, *Minicomputer Disk and Drum Storage.*

INPUT/OUTPUT UNITS

See Peripherals/Terminals table on the third page of this report. Also, more than 10 independent manufacturers offer direct replacement magnetic tape drives for the PDP-8 series computers; these units are summarized in Report M13-100-301, *Minicomputer Magnetic Tape Units.* Similarly, 17 vendors manufacture direct replacement line printers for the PDP-8 series, as outlined in Report M13-100-401, *Minicomputer Printers.* Finally, non-DEC punched card and punched tape units can be located in Reports M13-100-501 and M13-100-601, *Minicomputer Punched Card Units* and *Minicomputer Punched Tape Units.*

The KA8-E External Interface for non-Omnibus-compatible I/O devices is required to connect the FPP12 Floating Point Processor, the RF08 Fixed-Head Disk, or the DC08-H Automatic Call Unit and Multiplexer to the Omnibus. Since this device merely converts certain control signals, only one is required per system. It occupies one slot.

KD8-E Data Break Interface implements one of 12 possible data break channels in the PDP-8 and requires one slot. No more than 12 of these units may be incorporated in a system.

DR8-EA Twelve-Channel Buffered Digital I/O Interface is used to provide control and interfacing between the PDP-8 and up to 12 external circuits or devices. This unit is especially useful in the design of specialized systems with nonstandard I/O devices, since it provides data interfacing and buffering, control signal decoding, and interrupt capabilities to these devices. It requires one slot and is limited to eight per system.

The DB8-EA Interprocessor Buffer permits multiple PDP-8's to transfer words through programmed I/O (maximum of eight per system). It occupies one slot.

The DW08-A I/O Conversion Panel converts the positive bus to a negative bus (for use with KA8-E or KD8-E above).

COMMUNICATIONS CONTROL

The following units are provided to control various communication interfaces.

The KL8-JA Asynchronous Serial Line Interface provides full- or half-duplex control of one local RS-232C or 20mA current-loop line. Data rates range from 110 to 9600 bits per second and are switch-selectable. This unit is required to connect such peripherals as the VT50 Video Terminal, the LT33 teletypewriter terminal, the LA36 DECwriter terminal, and the RT01 and RT02 DEClink data entry terminals to the Omnibus. Modem control disciplines can be added to the KL8-JA through addition of the KL8-M Modem Control Interface. This add-on unit allows the system to interface one Bell 103 or 202 or equivalent modem. Each unit requires one slot.

The DP8-EA Synchronous Modem Interface controls Bell 201 or equivalent modems. Its strap-selectable interfacing includes RS-232C/CCITT, 20mA current loop, or logic levels. Character length is strap-selectable for six-, seven-, or eight-bit characters. The interface operates in full- or half-duplex modes on data break (DMA) channels. Data rates are strap-selectable to 50K bits per second. Sync codes can be specified by straps on the board. The DP8-EB is similar and provides an interface for a Bell 300 or equivalent modem. Either unit requires two slots. ▶

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▶ The KG8-E Redundancy Check Unit provides hardware-generated LRC, VRC, and industry-compatible CRC characters to multiple output data streams. It also checks the same data on multiple input streams. The unit occupies one slot.

The DC08-H Automatic Calling Unit and 10-Channel Multiplexer controls Bell 801A and 801C or equivalent automatic call units. Dialing interface to individual lines is made through a DC08-J adapter. This unit does not connect to the Omnibus, but rather is used with the KA8-E external interface (see Input/Output Units). It is not available for the PDP-8/A-100 or 8/A-200.

SOFTWARE

OPERATING SYSTEMS: There are five operating systems available to PDP-8 users: OS/8, CAPS-8, TS8/E, RTS-8, and COS-500. The first four are directed toward OEM and end-user applications; the fifth, the COS-300 Data Management System, is available only as a bundled package with the PDP-8/E-based Datasystem 340 and the PDP-8/A-based Datasystem 310 (which uses a version called COS-310). These two business systems are marketed by DEC's Business Products Group and are covered in detail in Reports M11-385-101 and M11-385-201.

OS/8 is a comprehensive magnetic tape or disk executive system for batch and interactive operation on an 8K-word (or larger) PDP-8 system with one or more tape drives or a minimum of 64K words of disk storage. OS/8 provides standard dynamic I/O handling for a maximum of 15 I/O devices, as well as modular program development support for FORTRAN II and IV, BASIC, FOCAL, BATCH, six different levels of assembly language, and PIP (Peripheral Interchange Program). Modules in more than one language can be combined to form a composite programming system. Also supported under OS/8 are a symbolic editor, dynamic debug programs, and absolute and relocatable program loaders.

OS/8 is the software basis for nearly every specialized package PDP-8 system offered by DEC except the Datasystems. Examples of these numerous offerings are briefly summarized below.

The CLASSIC (CLASSroom Interactive Computer) system (see Report M11-385-301), a classroom education system designed to introduce and accustom students to computers, is marketed by the Educational Products Group.

The CMS/1 (Computional Minicomputer System), for engineers, (see Report M11-385-301) provides FORTRAN IV capabilities along with all the other aspects of OS/8. This system is marketed by the Business Products Group.

The Industrial-800 and Industrial-811 systems, which provide on-line control of industrial processes, are designed, produced, and marketed by the Industrial Products Group.

The Typeset/8 Storage and Edit Systems, for the graphic arts and typesetting industries, are marketed by (naturally) the Typeset Group.

The LAB/8-E Laboratory Control System contains application software which performs peak signal analysis, signal averaging, and other highly specialized laboratory computational and control functions. This system is offered by DEC's Laboratory Data Products Group. The application software is offered on several media and runs either in stand-alone fashion or under OS/8. Laboratory peripherals, analog/digital (A/D) input/output, a programmable clock, and point-plot or storage displays are supported by OS/8 BASIC and FORTRAN IV.

The *CAPS-8* operating system is an elementary or entry-level PDP-8 software product. As such, CAPS-8 runs on PDP-8's with a TA8 cassette subsystem, an 8K-word CPU, a console terminal device (such as the LA36 DECwriter II), and an optional line printer. CAPS-8 provides a monitor-level executive with file handling capabilities, facilities for fault detection, and program development support for a subset of BASIC, the PAL-C Symbolic Assembler, and the EDIT Symbolic Editor.

RTS-8 (Real-Time System for PDP-8 family) allows concurrent running of up to 63 fixed-priority tasks. The RTS monitor controls scheduling, startup and suspension of tasks, and intertask communications. It can also support foreground/background operation. RTS-8 is oriented toward I/O and data collection involving real-time operationsl As such, it supports time-driven operations (clocks), power-fail features, VDC functions, and most standard I/O and process interfaces. RTS-8 exists as a small run-time module, whose tasks are created by a development-type operating system such as OS/8. RTS-8 does not support an assembler.

The monitor occupies less than 700 words in main memory, and tasks require an additional 10 words each. The RTS-8 system modules support most standard DEC peripherals. Minimum system requirements are simply any PDP-8 series CPU, 4K words of main memory, a console terminal, and an input medium. Input to RTS-8 is in the form of assembly language statements.

Expanding the RTS-8 system to 12K words of main memory will, however, permit the OS/8 Version III Monitor to run in background mode. Expansion to 16K permits OS/8 BATCH to be run in the background. RTS-8 tasks do not support any high-level programming languages. DEC anticipates that future implementations of RTS-8 will involve a DECnet implementation. DECnet, announced as this report goes to press, is described in the May 1975 issue of *MiniNews*.

A monitor console routine (MCR) in the RTS-8 system permits the user to exercise on-line control, inspect, and debug the system. Functions that can be performed through the MCR include: request task execution, suspend task execution, execute task at a specified time, examine memory, enter value into memory, enter date, enter time, print task status, and return to OS/8. Single functions or strings of functions can be entered are performed.

TS8/E provides general-purpose time-sharing for up to 17 concurrent users on a 24K-word system with a disk for swapping and storage of user programs. The minimum system requirements are 16K, supporting up to 8 users. With on-line editing and debugging programs, TS8/E supports interactive program development in a time-shared environment. (The system is also known as TSS/8 or EduSystem 50).

Languages supported under TS8/E include BASIC, FORTRAN, ALGOL, Assembly Language, FOCAL, and QUICK-POINT. All languages are available simultaneously to users of the system.

LANGUAGES: The following are PDP-8-supported languages.

PAL III (Program Assembly Language, version III) is a two-pass assembler (with an optional third pass) designed for the PDP-8 series minicomputers. During the first pass of the assembly, all user symbols are defined and placed in the symbol table. In the second pass, the binary equivalents of the input source language are generated and punched. The third pass (optional) produces an assembly listing. The binary output tape is then loaded by the Binary Loader for execution.

PAL III requires a PDP-8 with 4K words of memory and a teletypewriter console. The assembler can also use either the high-speed paper tape reader, the high-speed paper tape punch, or both. The symbol table can be changed by the programmer to reflect the specific machine configuration.

MACRO-8 is also a 4K two-pass paper tape assembler that is similar to PAL III but contains several additional features. These features include link generation, literals, Boolean operations, double-precision integer output, floating-point input, a text input facility, and user-defined macros.

The *4K PAL-D Assembler* operates under the PDP-8/I Disk Monitor System and the PDP-8 Time-Sharing System. PAL-D is compatible with PAL III, except for memory reference instructions, and is also compatible with MACRO-8 in respect to Boolean operators, linkage genera- ▶

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▶ tion, literals, and its text facility. It does not have the user-defined macros, floating-point constants, nor double-precision numbers of MACRO-8.

PAL8 is an 8K two-pass assembler designed to run under the OS/8 operating system. The first pass reads the input file and sets up the symbol table. The second pass reads the input file and uses the symbol table to generate the object file in binary. The binary file is an absolute binary tape that can be loaded into core via either the Absolute Loader or the Binary Loader. An optional third pass produces octal and symbolic listings and a listing of the symbol table. PAL8 can handle I/O from any OS/8 device supporting ASCII text, and has pseudo-operations and options not available in the other PDP-8 assemblers. It is loaded and saved via the OS/8 Monitor and Absolute Loader. It will accept input generated by the Editor and generates output acceptable to the Absolute Loader and CREF.

SABR (Symbolic Assembler for Binary Relocatable programs) is an 8K one-pass assembler that produces relocatable binary code with automatically generated page and field linkages. It supports an extensive list of pseudo-operations, which provide several facilities including external subroutine calling with argument passing and conditional assembly.

SABR differs from DEC's other 8K assembler, PAL8, in the following ways:

● SABR produces relocatable binary code; PAL8 produces absolute or location-dependent binary code.

● SABR is page- and field-independent; PAL8 is page-dependent.

● SABR programs are loaded with the 8K Linking Loader and use run-time linkage routines provided by the Loader; PAL8 does not require any run-time routines.

SABR requires a PDP-8 with 8K words of memory and a teletypewriter. A high-speed paper tape reader/punch is recommended.

OS/8 SABR is a modified version of the 8K SABR assembler. It can be used as the automatic second pass of the FORTRAN compiler, called separately to do assemblies of FORTRAN-compiled files, or used as an independent assembler with its own assembly language. In addition, SABR statements can be used in an OS/8 FORTRAN program to expand the capabilities of the FORTRAN language.

FLAP and *RALF* are assemblers that translate PDP-8 processor and Floating-Point Processor (FPP) operation codes in a source program into binary codes in two or three passes. The first pass assigns numeric values to the symbols and places them in the symbol table. The second pass generates the binary coding. The third pass generates the program listing. FLAP or RALF is used to assemble programs using the RPP instructions and capabilities.

FLAP is designed to run on an OS/8 system with a Floating Point Processor (FPP) without any supporting programs. It generates absolute binary output, which is valid input to the OS/8 Absolute Loader. RALF, an extension of FLAP, is part of the OS/8 FORTRAN IV system. It accepts assembly-language files or FORTRAN compiler output and generates relocatable binary modules that can be loaded by the relocatable loader.

BASIC is a language designed for use in scientific and business environments to solve both simple and complex mathematical problems. DEC provides four versions of BASIC for the PDP-8.

4K BASIC for EduSystem 10 is the most elementary BASIC. It is directed primarily toward use in an educational environment and requires a minimum of 4K words of memory.

8K BASIC is an extended version of 4K BASIC that has additional facilities including one- and two-dimensional

subscripting, faster execution time, user-coded functions, use of the LP08 high-speed line printer and high-speed reader/punch, and specification of input and output devices from any part of a program. Minimum requirements to support 8K BASIC include a PDP-8 with 8K words of memory. The high-speed reader/punch and the LP08 line printer are supported.

OS/8 BASIC, which runs under OS/8, has greater capabilities than 8K BASIC, with such features as chaining, string manipulation, and file-oriented input/output. LAB8/E functions are also supported, enabling the user to solve a range of real-time and pseudo real-time problems using BASIC.

Industrial BASIC combines the mathematical and decision-making ability of Dartmouth BASIC with a real-time executive to perform industrial control applications such as analog and digital input and output, time-based scheduling, and servicing of external interrupts. File handling and editing capabilities have also been implemented. Minimum system requirements for Industrial BASIC are 8K words of main memory, an industrial control subsystem, a real-time clock, and either a dual DECtape or a cartridge disk. Industrial BASIC is available to both OEM's and end users who purchase Industrial 801-B or 811-B systems from DEC's Industrial Products Group.

FOCAL-8 is a high-level programming language designed for students, managers, and technicians who do not have the time to learn complex languages and yet need problem-solving capabilities. It consists of 12 commands, which are all the programmer (user) needs. These commands are: TYPE, ASK, SET, GO or GOTO, IF, DO, RETURN, QUIT, FOR, COMMENT or CONTINUE, ERASE, ERASE ALL, and MODIFY.

The minimum system requirement for running FOCAL-8 is a 4K PDP-8 with an ASR 33 teletypewriter.

FORTRAN is available in three versions for the PDP-8. The 8K paper tape *FORTRAN II* system consists of a one-pass compiler, the SABR Assembler, the Linking Loader, and a library of subprograms. The language itself enables the programmer to express his problem using common English words and mathematical statements. The FORTRAN source program may be initially prepared off-line or by using the appropriate Editor program. The computer translates the programmer's source program into symbolic language (SABR). The symbolic version of the program is then assembled into relocatable binary code. Minimum requirements for running FORTRAN II include a PDP-8 series computer with 8K words of memory, a teletypewriter, and a high-speed reader and punch.

OS/8 8K FORTRAN is an expanded version of 8K paper tape FORTRAN II that runs under the OS/8 operating system. Its additional features include Hollerith constants, implied DO loops, chaining, mixing of SABR and FORTRAN statements, and device-independent I/O.

OS/8 FORTRAN IV provides full standard ANSI FORTRAN IV under the OS/8 operating system. The compiler accepts a single FORTRAN source-language program or subroutine as input, examines each FORTRAN statement for validity, and produces a list of error diagnostics plus a RALF assembly-language version of the source program, along with an optional annotated source listing. A job of one or more subroutines is executed by compiling and assembling the main program and each subroutine separately, then combining them with the loader.

OS/8 FORTRAN IV requires a minimum hardware configuration of a PDP-8 with 8K words of mainframe memory, a console terminal, and at least 96K of mass storage. Additional equipment that can be utilized when present includes an Extended Arithmetic Element, a Floating Point Processor, up to 32K words of mainframe memory, LAB/8-E peripherals, and any I/O device supported by the PDP-8 series.

UTILITIES: The following are PDP-8 utility programs. ▶

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►*BITMAP* is an OS/8 utility program that constructs a table (map) showing the memory locations used by specified binary files. BITMAP runs on the standard OS/8 configuration and requires the OS/8 software package. It uses 8K words of core to map programs that use up to 16K of core, but requires 12K words to map programs using more than 16K of core.

BOOT is an OS/8 program used to bootstrap from one PDP-8 system to another and to bootstrap from one device to another, which is accomplished by typing commands on the keyboard. BOOT can run from OS/8, COS-300, or any other PDP-8 operating system (e.g., CAPS-8).

BUILD is the OS/8 system generation program; it allows the user to: 1) create an OS/8 monitor system from elements on cassettes or paper tape; 2) maintain and update device handlers in an existing OS/8 system; 3) add DEC-supplied device handlers to a new or existing system; and 4) add user-written device handlers to a new or existing system. Simple keyboard commands are used to manipulate the device handlers which make up the OS/8 peripheral configuration, and BUILD allows the user to easily insert devices that are not standard on the system.

CAMP (Cassette and Magnetic Tape Positioner) is used to position cassettes, magnetic tapes, and other devices. CAMP can position these devices to the beginning of a storage medium or another selected position on a given tape.

CREF (Cross Reference Program) assists the programmer in writing, debugging, and maintaining assembly-language programs by providing the ability to pinpoint all references to a given symbol. CREF operates on output from the PAL8, SABR, and RALF assemblers.

PIP (Peripherals Interchange Program) is the OS/8 system program that is used to transfer files between devices, to merge and delete files, and to list, zero, and compress directories. PIP accepts up to nine input files and performs output to a single file. Since PIP performs file transfers for all types of files (ASCII, Image or SAVE format, or binary) there are no assumed extensions. All extensions for either input or output files must be explicitly specified in the commands to PIP.

MCPIP, a variant of PIP, is an OS/8 program used to transfer files between standard cassettes or magnetic tapes and other OS/8 system devices, delete such files, and transfer file directories. MCPIP can read or write any standard cassette file on a DEC cassette or magnetic tape. Specifically, it can read or write any file created by or to be used by the CAPS-8 system or by the OS/8 system (using any OS/8 device handler). MCPIP can also read or write any magnetic tape file that is in standard cassette file format (i.e., a file created by MCPIP or by CAPS-8). MCPIP can be run on any OS/8 system equipped with at least 8K words of memory and TA8E cassette drives or TM8E magnetic tape drives. MCPIP supports any OS/8 system device.

PIP10 is an OS/8 utility program that provides file compatibility with the DECsystem-10 computers. PIP10 can transfer files to and from DECsystem-10 formatted DECtapes. It provides the facilities for transferring ASCII, Image (PAL10 binary output), and sequenced ASCII files. PIP10 can automatically determine which of two or more specified DECtapes is a DECsystem-10 tape; work interchangeably on TC08 and TD8E DECtape controllers; and read and write to DECsystem-10 tapes in both forward and reverse directions on TC08 tapes, or forward only on TD8E tapes.

RESORC (Systems Resources) is an OS/8 program that is used to determine what device handlers are present on a given OS/8 system. Other information about the device handlers is also available through the use of the RESORC options.

SRCCOM (Source Compare) is an OS/8 utility program that compares two source files line by line and prints all of the differences. Usually, the two files being compared are different versions of a single program. In that case, SRCCOM prints all of the editing changes that have occurred. Used in this manner, SRCCOM can be a valuable debugging tool.

DDT (Dynamic Debugging Tool) and *ODT* (Octal Debugging Tool) are a pair of debugging routines included in the system software package for the PDP-8. These routines allow the programmer to run his binary program on the computer and use the teletypewriter keyboard to control program execution, examine registers, change their contents, and make other alterations to his program.

RTAPE and *WTAPE* are two DECtape read and write subprograms available for the 8K FORTRAN and 8K SABR systems. These subprograms are furnished on one relocatable, binary-coded paper tape, which is loaded into field 0 by the Linking Loader. RTAPE or WTAPE allow the user to read and write any amount of core-image data onto DECtape in absolute, non-file-structure data blocks. They can be called from any 8K FORTRAN or SABR program. The arguments are the same for both subprograms and are formatted in the same manner. They specify the following: DECtape unit number (from 0 to 7); number of the DECtape block at which transfer is to start; number of words to be transferred; and core address at which the transfer is to start.

DIRECT is an OS/8 program that produces listings of OS/8 device directories. These directories can be of several types, depending upon the options specified in the DIRECT command line. The standard directory listing consists of file name, file name extension, length (decimal) in blocks written, and creation date.

EPIC is the Edit, Punch, and Compare utility program for OS/8. It assists users in reading and punching paper tape files and patches, editing arbitrary files, and comparing files in any format. After EPIC is loaded, a command entered from the console selects the function desired.

FOTP is an OS/8 program used to transfer files from one device to another, delete files from a device, and rename files. It is faster than PIP and performs some functions not available in PIP, such as transferring files longer than 256 blocks and performing multiple-file transfers and deletions without requiring multiple accesses to the directory.

FOTP copies files in image mode, word for word and character for character, without making any changes in the file. Thus, it can be used to copy core image and binary files as well as ASCII files, without specifying options to identify the types of files.

LIBSET is the FORTRAN Library Setup Program. It creates a library of subroutines from the relocatable binary output of SABR. These library files can then be scanned by the Linking Loader.

The *Linking Loader* is the PDP-8 system program used to load and link a user's program and subprograms into any field of memory. It can be called automatically to load or load and start a FORTRAN or SABR program, or independently to load or load and start a relocatable binary file stored on a device. It can load programs over itself, and has options to obtain storage map listings of core availability.

The Linking Loader can load any number of user and library programs into any field of memory. Typically, several programs are loaded into each field. Any common storage reserved by the programs being loaded is allocated in a specified field, and the space reserve for common storage is subtracted from the available loading area in field 1. The program reserving the largest amount of common storage must be loaded first.

The Run-Time Linkage Routines necessary to execute SABR programs are automatically loaded into the required areas of every field by the Linking Loader as part of its initialization. The user needs to know nothing more about these routines than the particular areas of core they occupy.

SS BIN (Self-Starting Binary Loader) reads binary-format paper tapes from either the high-speed or low-speed reader and, if a starting address has been specified, automatically starts the program at the completion of loading. SS BIN itself is a read-in mode (RIM) format program and is loaded ►

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▶ with the RIM Loader or the hardware bootstrap, generally as the first part of a two-part tape. (The second part of this tape is the object program or data to be loaded, which is physically separated from SS BIN by leader/trailer codes.) SS BIN occupies 156 locations of the memory field into which it has been loaded.

The *Symbolic Editor* (EDIT) allows users to create and modify symbolic source program tapes from the teletypewriter keyboard. As the program is typed on the keyboard, it is entered into core, where it can be checked, corrected, and modified. When modification is complete, the Editor will produce a source program tape suitable for assembling or compiling into an object binary tape.

EDIT occupies about 1,000 core locations, leaving all but the last page for the source program. On a 4K machine, this allows about 60 lines of heavily commented text, or about 340 lines of text without comments. The source program is stored in the text buffer area of core. When the text buffer is full, the teletypewriter bell rings. At that time, the buffer may be enlarged or the contents of the buffer may be punched onto paper tape. If punched, the buffer can then be cleared, and the user can continue placing the rest of the source program into core and punching it out until the entire source program is on one tape ready for compilation or assembly. Text can also be entered into core via the high-speed paper tape reader.

OS/8 TECO (Text Editor and Corrector) is a useful text editing and correction program that runs under the OS/8 operating system. OS/8 TECO can be used to edit such ASCII text as program listings, manuscripts, correspondence, and the like. Because TECO is a character-oriented editor rather than a line editor, text edited with TECO does not have line numbers associated with it. Further, it is not necessary to replace an entire line of text in order to change one character.

APPLICATIONS SOFTWARE: DEC's numerous application programs are generally sold as an integral part of the many specialized end-user systems available from each of six market groups: Typeset Group, Industrial Products Group, Laboratory Data Products, Educational Systems Group, Engineering Computational Group, and Business Products Group. In addition, more than 1600 application and utility programs are maintained by the Digital Equipment Computer Users Society (DECUS).

PRICING

POLICY: PDP-8 systems, purchased as end-user equipment on a package basis, include installation and set-up charges in the package prices. In addition, these systems are generally covered by a 90-day warranty. Maintenance contracts are negotiated separately. Any modifications to the system (additional I/O, memory, etc.) are subject to DEC's OEM policies.

Systems purchased for OEM purposes can be discounted through a three-level scheme in DEC's OEM Discount Agreement. Under this agreement, the system buyer *must*

also purchase installation and a 30-day on-site warranty, priced at 3 percent of the system list price or a minimum of $250. Components purchased for OEM usage are covered by a 30-day return-to-factory warranty.

Prices for field installation of options are the sum of all the individual field installation charges (FIC's), or $75 minimum, plus a one-time travel charge from the nearest DEC Service Center if the straight-line distance exceeds 100 miles. Installation prices for areas considered remote (not normally serviced by DEC or its subsidiaries) must be quoted individually.

Return-to-factory warranties and services can be obtained from seven locations in the United States and Canada. These locations are: Chicago, Illinois; Sunnyvale, California; Kanata, Ontario; Maynard, Massachusetts; Houston, Texas; Santa Ana, California; and Princeton, New Jersey.

On-site warranty prices are quoted only for the PDP-8/A-400. Prices for similar coverage for 8/A-100 and 8/A-200 systems can be arranged.

Software prices usually include a one-time licensing fee.

EQUIPMENT: The following examples illustrate typical package offerings from DEC and their pricing. Also see Reports M11-385-101, M11-385-201, and M11-385-301 for other packaged systems based upon the PDP-8 Family.

16K STANDARD CORE MEMORY SYSTEM: Includes a PDP-8/E, 16K words of core memory, bootstrap loader, cassette magnetic tape system, 2315-type disk system, LA36 console typewriter, and OS/8 software. Purchase price is $20,000, and the monthly maintenance charge is $275.

BASIC LAB8/E-05 SYSTEM: DEC's lowest-cost, modular, PDP-8/E-based lab computer system, consisting of a PDP-8/E with 4K words of core memory, a Laboratory Data Panel (CPU and panel mount on a tabletop), ASR-33 teletypewriter, 10-bit A/D converter with ±5VDC input, 10-bit point-plot display controller, real-time programmable clock with 3 Schmitt triggers, and the LAB8/E software kit. Purchase price is $9,900, and the monthly maintenance charge is $117.

PDP-8/A-BASED EXPANDABLE LAB SYSTEM: Consists of a PDP-8/A with 8K words of core memory, serial line unit, real-time clock, parallel I/O, bootstraps, and power-fail/auto restart; programmer's console; dual diskette drives; DECwriter II; 16-channel multiplexer for 10-bit A/D I/O; signal distribution panel; programmable clock; cabinets; cables; and OS/8 and BASIC. This system could handle an oscilloscope and FORTRAN IV when expanded. Purchase price is $13,347. The monthly maintenance charge is not available at present, due to the diskette situation. ■

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EQUIPMENT PRICES

		Purchase Price	Monthly Maintenance
PROCESSORS			
PDP-8/A-100	CPU plus 1K RAM memory, operator panel, power supply, chassis with 10 slots	$1,745	—
PDP-8/A-100	CPU plus 2K RAM memory, operator panel, power supply, chassis with 10 slots	2,100	—
PDP-8/A-100	CPU plus 4K RAM memory, operator panel, power supply, chassis with 10 slots	2,600	—
PDP-8/A-100	CPU plus 1K PROM memory, operator panel, power supply, chassis with 10 slots	2,375	—
PDP-8/A-200	CPU plus 4K RAM memory, operator panel, power supply, chassis with 12 slots	1,995	—
PDP-8/A-400-EM	CPU plus 8K core memory, operator panel, memory extension control, power supply, chassis with 12 slots	2,795	60
PDP-8/A-400-EP	CPU plus 16K core memory, operator panel, memory extension control, power supply, chassis with 12 slots	3,795	70
PDP-8/A-400-BM	CPU plus 8K core memory, operator panel, extended option board, power supply, chassis with 12 slots	2,995	65
PDP-8/A-400-BP	CPU plus 16K core memory, operator panel, extended option board, power supply, chassis with 12 slots	3,995	75
PDP-8/A-500-CM	CPU plus 8K core memory, serial line unit, real-time clock, parallel I/O, bootstraps, power-fail/auto restart, 3 slots available for expansion	3,795	NA
PDP-8/E-DC	CPU plus 4K core memory, programmer console, teletype controller, power supply, chassis with 20 slots	4,490	53
PDP-8/E-DE	CPU plus 8K core memory and control, programmer console, teletype control, power supply, chassis with 20 slots	5,300	74
PDP-8/E-DS	CPU plus 16K core memory and control, programmer console, teletype control, power supply, chassis with 20 slots	6,900	117
PDP-8/E-EC	CPU plus 4K memory and control, programmer console, teletype control, power supply, chassis with 20 slots; tabletop mounted	4,490	74
PDP-8/E-ES	CPU plus 16K core memory and control, programmer console, teletype control, power supply, chassis with 20 slots; tabletop mounted	6,900	117
PDP-8/M-MH	CPU plus 4K core memory, operator panel power supply, chassis with 20 slots	3,200	NA
PDP-8/M-MK	CPU plus 8K core memory and control, operator panel, power supply, chassis with 20 slots	4,000	NA
PDP-8/M-MS	CPU plus 16K core memory and control, operator panel, power supply, chassis with 20 slots	5,600	NA
PDP-8/M-DH	CPU plus 4K core memory, programmer console, teletype control, power supply, chassis with 20 slots	3,800	53
PDP-8/M-DK	CPU plus 8K core memory and control, programmer console, teletype control, power supply, chassis with 20 slots	4,500	74
PDP-8/M-DS	CPU plus 8K core memory and control, programmer console, teletype control, power supply, chassis with 20 slots	6,100	117
PDP-8/M-MM	CPU plus 1K PROM with 256-word RAM, operator panel, power supply, chassis with 20 slots	2,750	NA
PDP-8/M-MP	CPU plus 2K PROM with 256-word RAM, operator panel, power supply, chassis with 20 slots	3,500	NA
PDP-8/F-AH	Rack-mount CPU with 4K core memory	3,990	53
PDP-8/F-A	Rack-mount CPU with 8K core memory	5,150	74
PDP-8/F-AS	Rack-mount CPU with 16K core memory	6,870	117
PROCESSOR OPTIONS			
DKC8 AA	Input/Output Option Board; includes RTC, console control, I/O interface, and 12-bit asynchronous serial line unit; for 8/A systems only	500	—
KM8-AA	Extended Option Board; includes memory extension and time-share control, power fail/auto restart, bootstrap loader; for 8/A only	500	—
MR8-SL	PROM Loader (FIC $80)	2,625	21
MR8-EC	256-Word OS/8 ROM for TD8-E systems; requires 2 slots (FIC $60)	900	5
MI8-E	Bootstrap Loader; 32-word programmable diode ROM (FIC $60)	570	5
KE8-E	Extended Arithmetic Element; not offered for 8/A systems (FIC $60)	1,300	5
KP8-E	Power Fail Detector and Auto Restart; for 8/E, 8/F, and 8/M systems only (FIC $60)	300	2
FPP12-AB	Floating Point Processor (24 + 12 bits); requires minimum OS/8 configuration; requires 2 slots (FIC $400)	9,000	51
FPP12-AE	Double Precision Option for FPP12-AB; provides 60 + 12 bits capability (FIC $50)	3,000	16
DK8-EA	Real-Time Clock, fixed interval, line frequency; not for 8/A series (FIC $60)	270	2
DK8-EC	Real-Time Clock, fixed interval, crystal frequency; not for 8/A series (FIC $60)	320	2
DK8-EP	Real-Time Clock, programmable; for all series (FIC $100)	700	3
KC8-AA	Programmer Console for 8/A	400	8
KC8-AB	Remote Programmer Console for 8/A	550	8
KC8-EA	Programmer Console for 8/E	630	—
KC8-ML	Programmer Console for 8/M	630	—
KC8-FL	Programmer Console for 8/F	630	—

NA—Not Applicable.
FIC—Field Installation Charge.

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EQUIPMENT PRICES

		Purchase Price	Monthly Maintenance
MEMORY			
MC8-E	4K core memory with memory extension control and time-share option; for 8/E and 8/M systems; requires 4 slots (FIC $150)	$ 2,890	21
MM8-E	4K core memory expansion; for 8/E and 8/M systems; requires 3 slots (FIC $150)	2,500	21
MC8-EJ	8K core memory with memory extension control and time-share option; for 8/E and 8/M systems; requires 4 slots (FIC $175)	4,360	42
MM8-EJ	8K core memory expansion; for 8/E and 8/M systems; requires 3 slots (FIC $175)	3,900	42
MM8-AA	16K core memory for 8/A systems; requires 2 slots	1,500	15
MM8-AB	16K core memory for 8/A systems; requires 2 slots	2,500	25
MR8-FB	1K UV-erasable PROM with 256-word RAM; requires 1 slot	1,045	NA
MS8-AA	1K RAM memory; requires 1 slot	480	—
MS8-AB	2K RAM memory; requires 1 slot	835	—
MS8-AD	4K RAM memory; requires 1 slot	1,335	—
MR8-AA	1K fusible-link ROM; requires 1 slot	480	—
MR8-AB	2K fuxible-link ROM; requires 1 slot	760	—
MR8-AD	4K fusible-link ROM; requires 1 slot	1,300	—
MASS STORAGE			
RK8-EA	Disk cartridge drive and controller; capacity 1.6M words. Not offered with 8/A-100 or 8/A-200 (FIC $260)	7,900	350
RK05-AA	Disk cartridge drive; add-on unit for RK8-EA above, capacity 1.6M words	5,100	260
RK05K-8	Disk cattridge	99	—
RF08-A	Fixed-head disk file and control; capacity 262K words; not offered with 8/A-100 or	17,500	85
RS08	Disk file, 262K words (FIC $260)	11,000	48
RX8-A	Single diskette drive & controller (not field-upgradable)	2,900	NA
RX8-B	Dual diskette drives & controller	3,900	NA
MAGNETIC TAPE EQUIPMENT			
TD8-EH	DECtape drive and control; not offered with 8/A-100 and 8/A-200 (FIC $240)	4,200	240
FD8-EM	Dual DECtape drive and control; not offered with 8/A-100 and 8/A-200 (FIC $240)	5,800	240
TM8-EA	Industry-standard drive and controller; 9-track, 800 bpi, 45 ips; not offered with 8/A-100 and 8/A-200 (FIC $640)	11,500	640
TU10-EE	Industry-standard add-on drive for TM8-EA, above; 9-track, 800 bpi, 45 ips (FIC $400)	8,000	74
TM8-FA	Industry-stanard drive and controller; 7-track, 800/556/200 bpi, 45 ips; not offered with 8/A-100 and 8/A-200 (FIC $640)	13,125	101
TU10-FE	Industry-standard drive; 7-track, 800/556/200 bpi, 45 ips; not offered with 8/A-100 and 8/A-200 (FIC $400)	9,725	74
TS03	Industry-compatible, 9-track, 12½-ips, 800 bpi NRZI 7-inch reel drives, max. 2 per controller	3,500	NA
TS08	TS03 with controller	6,450	NA
TA8-AA	Dual cassette drive and controller; capacity 93K bytes per drive (FIC $220)	3,300	40
TU60-K	Cassette for TA8-AA above	8	—
PUNCHED CARD EQUIPMENT			
CM8-FA	Optical mark reader and control, 300 cpm (FIC $250)	5,700	53
CR8-FA	Punched card reader and control, 300 cpm (FIC $240)	5,100	53
PAPER TAPE EQUIPMENT			
PR8-E	Paper tape reader and control, 300 cps (FIC $160)	2,600	21
PC8-E	Paper tape reader/punch and control, 300/50 cps (FIC $320)	4,200	37
LINE PRINTERS/PLOTTERS			
LS8-FA	Printer and controller, 132 columns, 64-character set, 165 cps; not offered with 8/A-100 and 8/A-200 (FIC $120)	5,900	50
LS01-EC	Printer only; 132 columns, 64-character set, 165 cps; not offered with 8/A-100 and 8/A-200; for use with VT8-EA CRT terminal (FIC $100)	5,500	53
LE8-VA	Printer and controller; 132 columns, 64-character set, 300 lpm; not offered with 8/A-100 and 8/A-200 (FIC $200)	10,500	72
LE8-WA	Printer and controller; 132 columns, 96-character set, 300 lpm; not offered with 8/A-100 and 8/A-200 (FIC $220)	12,500	72
XY8-E	Plotter control module (FIC $50)	570	8
TERMINALS			
VT8-EA	CRT display and controller, 20 lines x 64 characters (FIC $80)	2,150	32
VC8-E	Point plot display control (FIC $100)	1,185	11
VT50-AA	Video terminal (FIC $40/unit + $120)	1,250	22

NA—Not Applicable.
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EQUIPMENT PRICES

TERMINALS (Continued)

		Purchase Price	Monthly Maintenance
LT33-DC	ASR-33 teletypewriter (modified) (FIC $120)	$ 2,000	37
LT33-MB	Modification kit for ASR-33 teletypewriter (FIC $175)	130	—
LT33-MD	Modification kit for KSR-33 teletypewriter (FIC $100)	105	—
LA36-CA	Keyboard and printer, 132 columns (FIC $50/unit + $115)	1,850	25
RT01	DEClink data entry terminal, 110 or 300 bps (FIC $60/unit + $120)	600	11
RT01-NA	4-digit Nixie Display option for RT01 (FIC $75)	100	11
RT01-NB	8-digit Nixie Display option for RT01 (FIC $75)	200	11
RT01-NC	12-digit Nixie Display option for RT01 (FIC $75)	300	11
RT02	DEClink data entry terminal, 110-1200 bps (FIC $75)	1,300	11

DATA COMMUNICATIONS

		Purchase Price	Monthly Maintenance
KL8-JA	Asynchronous serial line interface; 110 to 9600 bps (FIC $60)	470	11
KL8-M	Modem control interface for Bell 103 or 202 modems (FIC $60)	420	5
H312-A	Null modem adapter (FIC $50)	85	2 .
H313-A	Teletype-dataset adapter (FIC $25)	270	5
DP8-EA	Synchronous modem interface for Bell 201 series modems (FIC $100)	2,000	11
DP8-EB	Synchronous modem interface for Bell 300 series modems (FIC $100)	2,500	11
KG8-E	Redundancy Check Option (FIC $60)	600	5
DC08-H	Automatic calling unit control and 10-channel multiplexer for Bell 801 series modems (FIC $60)	2,100	6
DC08-J	One channel for DC08-H above (FIC $10)	300	2

I/O INTERFACES

		Purchase Price	Monthly Maintenance
KA8-E	External interface for positive I/O devices (FIC $60)	300	3
KD8-E	Data break interface (FIC $60)	580	3
DB8-EA	Interprocessor buffer (FIC $100)	580	5
DR8-EA	12-channel buffered digital I/O interface (FIC $100)	540	5
DW08-A	I/O conversion panel for positive to negative bus (FIC $160)	1,850	7
AD8-A	10-bit A/D converter, 16-channel multiplexer with sample and hold	1,000	25

EXPANSION SUBASSEMBLIES

		Purchase Price	Monthly Maintenance
BA8-AA	System expander box with power supply and 20-slot bus (FIC $60)	1,850	5
BE8-A	Omnibus expander, 20 slots (FIC $60)	650	—
H721-C	Expansion power supply, 5V, 20A (FIC $60)	1,000	5
861-C	Cabinet power control	350	—

CABINETS

		Purchase Price	Monthly Maintenance
H960-BC	Cabinet with power control, fans, and panels; 72 inches high	850	—
H961-AA	Option cabinet with power control and fans; 72 inches high	600	—
H967-BA	Cabinet with power control, fans, end panels; 50 inches high	850	—
H967-AB	Option with power control and fans; 50 inches high	600	—

SOFTWARE PRICES

		Purchase Price
QFO15-AB	OS/8 Operating System, including license	$ 300
QFO15-EC	OS/8 Sources and Listings (requires QFO15-AB)	950
QF006-AB	OS/8 BATCH, BASIC, and TECO (requires QFO15)	200
QF006-EC	OS/8 BATCH, BASIC, and TECO Sources and Listings (requires QF0006-AB)	150
QF008-AB	OS/8 FORTRAN IV (requires QF015)	700
QF008-MC	OS/8 FORTRAN IV Sources and Listings (requires QF008-AB)	
QF014-AB	OS/8 FORTRAN IV Plotter Package, including license	300
QF014-EC	OS/8 FORTRAN IV Plotter Package Sources and Listings (requires QF014-AB)	50
QF040-AB	8K BASIC, including license	50
QF050-AB	8K FORTRAN, including license	32
QF007-AN	CAPS-8 including license	250
QF007-EC	CAPS-8 Sources and Listings (requires QF007-AB)	250
QF001-AB	DEC/X8 including license	300
QF090-AC	OS/8 Industrial BASIC, including license (with OS/8)	1,500
QF095-AC	OS/8 Industrial BASIC, including license	1,200
QF095-EC	OS/8 Industrial BASIC Sources and Listings (requires QF090-AC or QF095-AC)	300
QF020-XB	RTS-8, including license and sources	500
QF060-AB	LAB8E Application Software Kit	120
QF009-AC	OS/8 LAB8E binaries on DECtape (requires QF015)	500

NA—Not Applicable.
FIC—Field Installation Charge.