DEC PDP-15 and XVM Systems

MANAGEMENT SUMMARY

In April 1975, Digital Equipment Corporation announced the latest improvements to its mature line of PDP-15 minicomputers. Departing from the long-lived PDP designation, the new models are called the XVM series, and are available in two basic forms—XVM-100 and XVM-200—each having several configurations. These newest members of DEC's solidly established 18-bit computer line combine several new features with options of previous PDP-15 systems to provide increased performance at reduced cost.

The new improvements are incorporated in an internal memory processor which performs all the functions previously performed by the KA15 automatic priority interrupt, KM15 memory protect, and KT15 memory relocation hardware options, plus the added functions of memory interleaving, memory management, and automatic instruction lookahead. All existing PDP-15 installations above 32K words can be upgraded to XVM status by purchasing the XM15 memory processor for $9,000.

Along with the memory processor, DEC has also introduced a new core memory board, the MF15, which is compatible with the current ME15 980-nanosecond memory but not with the earlier MM15 800-nanosecond memory. This new memory has the desirable characteristic of being considerably cheaper than the ME15 while providing the same 980-nanosecond cycle time. At present, the MF15 memories are offered only with the XM15 memory processor; *but* 32K words of MF15 memory purchased with the XM15 costs $17,500, where- ▷

DEC's solid 18-bit PDP-15 line was enhanced and largely superseded on April 1, 1975 by the XVM Systems, which incorporate memory management and increased addressing capabilities for up to 256K words, memory interleaving, instruction lookahead, and a new memory processor, adding up to a 30 percent increase in processor speed. A PDP-15 hallmark is the use of a PDP-11 as a peripheral controller.

CHARACTERISTICS

MANUFACTURER: Digital Equipment Corporation (DEC), 146 Main Street, Maynard, Massachusetts 01754. Telephone (617) 897-5111. Digital is a worldwide corporation with sales and service offices in all major U.S. and Canadian cities and in major cities throughout the world.

MODELS: Current models are the XVM-100 and XVM-200. Previous models include the PDP-15/10, 15/20, 15/30, 15/35, 15/40, 15/50, 15/73, 15/75, 15/76, 15/76C, 15/78, and 15/79. The 15/76's and 15/78 are still available.

DATA FORMATS

BASIC UNIT: 18-bit word plus optional parity bit. (Parity is not available on the PDP-15/76C, 15/78, or XVM systems.)

FIXED-POINT OPERANDS: 18-bit words used as integers include 17 data bits plus one sign bit. 36-bit, 2-word integers include 35 data bits plus one sign bit.

FLOATING-POINT OPERANDS: "Short" 36-bit (2-word) floating-point operands include 27-bit fractions and 9-bit ▶

DEC's newest improvement to the long-standing PDP-15 line signals a farewell to the PDP-15 name. From now on, it's the DEC XVM series. Still based on the KP15 processor, the new systems feature a memory processor which incorporates many previous optional features augmented by memory interleaving and instruction lookahead, permitting speed increases of up to 30 percent and a fourfold increase in maximum memory size (now up to 256K). The system shown here is designed for computer-assisted design (CAD) applications and includes (left to right) a VT50 video terminal; a GT15 graphic system with a 17-inch CRT; an RK15 unichannel disk system with a PDP-11/10 peripheral processor, XM15 memory processor and 32K memory, and RK05 1.28-megaword cartridge disk drive; an XVM-100 processor and programmer console; a PC15 paper tape reader/punch; a dual DECtape system; a 9-track, 45ips magnetic tape system; and an LA36 DECwriter II terminal (foreground). This system sells for about $105,000.

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as the same 32K of ME15 memory *alone* costs $19,600. In many instances, DEC is not even quoting ME15 memory to users wishing to upgrade. For $2,100 less, a user upgrading an existing PDP-15 installation gets increased program length capabilties and increased performance through instruction lookahead plus memory protection, memory relocation, and automatic priority interrupt (assuming these features were not in the original configuration). To further sweeten the deal, DEC is currently offering purchase credit toward the upgrade price for these features if they are being replaced by the XM15.

The new XVM systems also provide interfacing capabilities that permit a PDP-11, used as a peripheral processor, direct access to the PDP-15 memory, essentially resulting in a small-scale processing network capability. This particular feature is not new, but was offered first with the PDP-15/70 series.

HISTORY

The PDP-15 family was first introduced in early 1969, making it the second oldest line in DEC's vast current repertoire of minicomputer systems. Older by three years is DEC's PDP-8 family of 12-bit minicomputers, first introduced in 1965 (see Report M11-384-101).

In the original offering, there were six PDP-15 models, the 15/10, 15/20, 15/30, 15/35, 15/40, and 15/50. All were based on the KP15 processor and used 800-nanosecond MM15 core memory. Configuration was the only difference between these systems, each having a specified memory size and peripheral complement. Users who upgraded these systems by adding memory or peripherals would often thereby extend their systems into higher model numbers.

The smallest PDP-15 package, the 15/10, consisted of the KP15 processor, 4K 18-bit words of memory, and an ASR-33 terminal. Adding 4K words of memory, a paper tape reader/punch, DEC's extended arithmetic element, and a dual DECtape drive changed the system to a PDP-15/20. Ultimately, the largest of the original six, the 15/50, consisted of all the above equipment plus a floating-point processor, a disk drive, and industry-compatible magnetic tape drive instead of the DECtape. Prices for the six original systems, in their basic configurations, ranged from $17,820 to $114,900.

In 1972 DEC unveiled the PDP-15/70 series, consisting of the 15/73, 15/75, 15/77, and 15/79 systems. Again the KP15 processor formed the basis for the system, but 980-nanosecond ME15 core memories were used in place of the faster MM15. A giant step backward? Not really. Production costs of the 980-nanosecond memories were significantly lower, permitting a 20 percent drop in initial system costs and 50 percent lower memory expansion costs. In systems where the 180-nanosecond speed difference was tolerable, substantial savings were realized. For those in which the difference was not acceptable, the older 800-nanosecond memory was, and still is, available.

exponents. "Long" 54-bit (3-word) floating-point operands have 36-bit fractions and 18-bit exponents. Floating-point operands are supported both through software and an optional hardware floating-point processor (FP15).

INSTRUCTIONS: All instructions are one word in length. Sixty-five instructions are standard; with the optional extended arithmetic element, 26 additional instructions are available. Other optional instruction sets which can be added include: floating-point instructions (120), paper tape subsystem (nine instructions), memory protection (seven instructions), and automatic priority interrupts (four instructions).

The basic instruction set comprises five types; memory-to-memory, register-to-register, I/O control, immediate operation, and extended arithmetic element. The memory-to-memory instruction format consists of a six-bit operation code, a two-bit address type (E), and a 12-bit address. With the E field, either direct or indirect addressing as well as indexing can be specified.

Memory management hardware on the XM memory processor adds 10 more instructions.

INTERNAL CODE: ASCII.

MAIN STORAGE

STORAGE TYPE: Magnetic core.

CYCLE TIME: There are three types of core existent in PDP-15 or XVM systems: MM15, ME15, and MF15. MM15 is 800-nanosecond core in 4K or 8K-word blocks. It was used in the first PDP-15 series, models 15/10 through 15/50, and is still available from DEC for replacement purposes. ME15 is 980-nanosecond core which was less expensive than MM15 core. It is available from DEC in 8K or 16K-word blocks. MF15 is also 980-nanosecond core, made for the XVM systems, and is available in 16K or 32K-word blocks. Using the instruction lookahead feature of the XVM hardware, effective cycle times as low as 850 nanoseconds can be realized, depending on the instruction mix.

CAPACITY: MM15 core memory for the 15/10 through 15/50 ranges from 4,096 to 131,072 words in blocks of 4K, 8K, or 16K words. ME15 core for the 15/Series 70 ranges from 16,384 to 131,072 words in 8K or 16K blocks. In order to address MM15 core storage beyond 32K words, one MX15 Memory Multiplexor option must be added for each block of 32K additional words. Thus, the maximum core supported requires three such memory expansion units. ME15 core memory does not require the MX15 option for expansion.

MM15 and ME15 memory units can be combined on a PDP-15, but MM15 memory cannot be used on XVM systems. MF15 (XVM) memory can be expanded to 128K words in 32K increments. ME15 memory can also be attached to XVM systems in 8K increments. Special expansion to 256K words has been planned in XVM systems, but will not be supported by software.

CHECKING: Optional parity bit is added to each 18-bit word. If the MP15 option is selected, there must be one per memory module and it must be added to all such modules or none. Additonally, the parity option adds up to 0.2 microsecond to memory cycle time.

Parity checking is not available on XVM systems.

STORAGE PROTECTION: Optional memory protection is provided by a ten-bit register which specifies the boundary

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PERIPHERALS/TERMINALS

| DEVICE	DESCRIPTION & SPEED	MANUFACTURER
MAGNETIC TAPE		
TU10-E	9-track, 45 ips, 800 bpi, industrycompatible, uses TC59 controller; 36 KB/sec	DEC
TU10-F	7-track, 45 ips, 200/556/800 bpi, industry-compatible, uses TC59 controller; 36KB/sec at 800 bpi	DEC
PUNCHED CARD		
CR15-D	Optical Reader and controller, tabletop mount, 1000 cpm	Documation
CR15-F	Optical Reader and controller, tabletop mount, 300 cpm	Documation
PAPER TAPE		
PC15	Paper Tape Reader/Punch, optical reader, 300 cps/50 cps	DEC reader, Tally punch
LINE PRINTERS		
LP15-V	132 column, 64-character, includes controller, 300 lpm	Dataproducts
LP15-W	132 column, 96-character, includes controller, 300 lpm	Dataproducts
LP15-R	132 column, 64-character, includes controller, 1200 lpm	Dataproducts
PLOTTERS		
XY15-A	Drum Plotter and Controller, 11-inch Y-axis, 120-foot X-axis, 0.01 or 0.005-inch steps, requires DW15 interface, 300 steps per second	Calcomp 565
XY15-B	Drum Plotter and Controller, 28.5-inch Y-axis, 120-foot X-axis, 0.01 or 0.005-inch steps, requires DW15 interface, 300 steps per second	Calcomp 563
XY11	Incremental Plotter Controller for use with UC15 or RK15 Unichannel peripheral processor to interface Complot DP-1 or Complot DP-10 plotter	DEC
XY311	Plotter and Controller for use with UC15 or RK15 Unichannel peripheral processor; 34.2-inch Y-axis, 120-foot X-axis, 0.002-inch steps, 1800 steps per second	Calcomp 936
TERMINALS		
LA36	DECwriter II Keyboard Printer, 132 columns, upper and lower case, dot-matrix impact printer, full ASCII character and control code set. Requires LT15, LT19, or DC01 interface if used for other than console device, 30 cps	DEC
VT05	Alphanumeric Display Terminal, CRT display with nonparity 64-character keyboard, 20 lines by 72 characters, addressable cursor, half- or full-duplex operation, 20 mA and EIA interfaces, switch selectable data rates of 110 to 2400 bps	DEC
VT50	Alphanumeric Display Terminal, CRT display with 64-character keyboard, 12 lines by 80 characters, teleprinter compatible, ASCII upper case alpha, numeric, and punctuation characters, half- or full-duplex operation, 20 mA interface with EIA also available, data rates to 9600 bps	DEC
GRAPHIC EQUIPMENT		
GT15-S	Graphic System with 17-inch CRT display; includes VT15 high-speed stroke vector graphics processor, ASCII character generator, 8-direction vector generation, VT04 display console, light pen, and arbitrary vector generator; keyboard, writing tablet, and slave display multiplexer are also available	DEC
GT15-L	Graphic System with 21-inch CRT display; same as GT15-S in all other respects	DEC
VT04	Graphic Display Console; 17-inch CRT, 9¼ by 9¼-inch major drawing area, 1¼ by 9¼ menu area, 6 lighted function buttons; does not include LK35 keyboard or VL04 light pen	DEC
VT07	Graphic Display Console; 21-inch CRT, 12 by 12-inch major drawing area, 2 by 12-inch menu area, 6 lighted pushbuttons; does not include LK37 Keyboard or VL07 light pen	DEC
VW01	Writing Tablet and Controller, 11 by 11-inch writing tablet, spark pen, 10-bit data word per direction (1 part in 1024 resolution)	Science Accessories Co.

▷ In 1973, another substantial improvement was announced: the PDP-15/76, which incorporated the Unichannel-15, a PDP-11 minicomputer used an an independent I/O processor connected to the PDP-15 memory bus through the MX15-B memory multiplexer. This enhancement resulted in improved batch throughput by providing spooled operation of slower devices such as card readers, line printers, plotters, and printer/plotters. The PDP-11 processor is run by the PIREX software package. Under PIREX, commands and parameters are expanded for execution by the PDP-11, relieving the ▷

▶ between user-accessible storage (upper memory) and executive or protected storage (lower memory).

Memory protection includes a boundary register for retaining the number of protected memory segments (256 words per segment), and instructions for setting and resetting the memory protect mode and for detecting memory protect errors. No user under memory protection can execute IOT or Halt instructions. Also, instructions referring to protected storage are trapped. Autoindexing and channel transfers temporarily suspend memory protection.

Storage protection for XVM systems includes dual relocation registers which divide the user's mapped address space ▶

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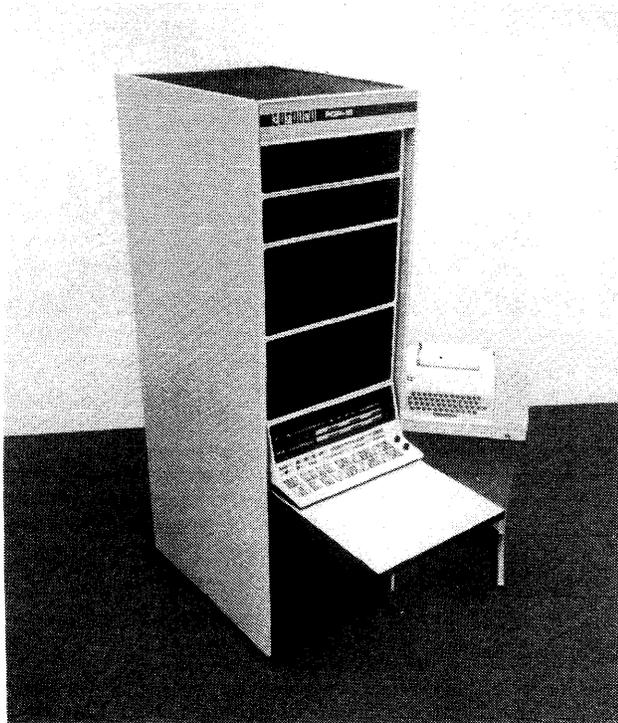
The smallest member of the PDP-15 line, the PDP-15/10, was introduced in 1969. This minimum system consisted of a KP15 processor, 4K words of 800-nanosecond core memory, an ASR 33 terminal, and programmer's console. It originally sold for $16,500 and is currently available for $17,820, an increase of only 8 percent over 7 years. Other members of the line included the 15/20, 15/30, 15/35, 15/40, 15/50, all based on the same KP15 processor and 800-nanosecond core memory. Later versions used 980-nanosecond core and were priced 20 percent lower. These early models can still be purchased from DEC as replacements, but PDP-15 systems announced later offer more attractive cost-performance characteristics.

PDP-15 hardware of nearly all peripheral overhead. Any previous PDP-15 could be field-upgraded to 15/76 status by addition of the Unichannel-15 peripheral processor. The Unichannel may have been developed and introduced to prevent inroads upon the PDP-15 customer/prospect base by enhanced PDP-11's. It is worth noting that PDP-15's are marketed as a product entity, rather than by specific applications groups, as are the PDP-8 and PDP-11.

In 1974, DEC added the "compact" series, the PDP-15/78 and PDP-15/76C, to the PDP-15 line. Still using the KP15 processor and 11/05 peripheral processor, these new systems passed reductions in material costs on to their users. The cost reductions were the result of new modular power supplies and cabinets plus another cost reduction on the 980-nanosecond ME15 memories.

APPLICATIONS AND COMPETITION

The PDP-15 finds widespread usage in laboratory systems, industrial control, statistics, and, more generally, in nearly any application in which 16-bit words provide neither sufficient precision nor addressing range. A PDP-15 user and member of DECUS, DEC's user group, states that 600 to 700 PDP-15's are currently installed.

into a task-specific (local) section and a common or global section.

The XVM hardware also offers memory protection in the form of three operating modes: EXEC, USER, and USER I/O. EXEC is fully unprotected; all memory writes and I/O instructions are permitted. USER is fully protected; only the operating system may write to all memory areas and initiate I/O instructions; user programs may write only in their own memory (local) areas. USER I/O mode retains memory protection but permits user programs to initiate physical I/O operations.

Under operating system control, common areas may be designated as read/write or read-only.

CENTRAL PROCESSOR

GENERAL: Both PDP-11 series, the newer 15/70's and the original 15's, are built on a single processor, the KP15. The Series 70 systems offer slower core and more peripherals per package. The KP15 comprises three components: a set of ten registers, a control console, and an arithmetic logic unit.

XVM systems are based on a modified version of the KP15 processor, the KP15C.

REGISTERS: PDP-15 Series systems have 10 user-accessible registers, eight of which are 18 bits long. One other is six bits, and the last is one bit long. The registers are an accumulator, index register, program counter, loop limit register, operand address register, memory input and output registers, immediate instruction register (6 bits), data switch, and link register (one bit). An 18-bit multiply/divide register and a step counter register are included.

Memory management provides two 10-bit base registers, a 10-bit boundary register, a 2-bit segment length register, an 18-bit accounting clock register, and a 6-bit memory management function register.

INDIRECT ADDRESSING: One-level indirect addressing on PDP-15's uses a 15-bit address (32K). Indirect addressing on XVM's allows up to 18-bit indirect addresses (256K), although current software supports only 15-bit or 17-bit indirect addressing.

INSTRUCTION REPERTOIRE: The basic KP15 processor has only 65 instructions: memory reference (13), operate (11), register-to-register (28), and I/O control (13). The extended arithmetic element adds 26 arithmetic instructions, and the XVM hardware adds 10 memory management instructions.

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

	800 nanosec.	980 nanosec.
Load/Store	1.6	1.96
Add/Subtract	1.6	1.78
Multiply/Divide*	2.915**	2.915**
Compare, Branch	3.2	3.92

* Option only.

** Plus 0.26 times L or M. (L = number of 1's in multiplier; M = number of division steps).

Instruction timings for the XVM processors will fall between the values for 800- and 980-nanosecond core because of instruction lookahead. Generally, XVM timing is sensitive to instruction sequencing.

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▷. Laboratory and industrial control applications often demand both increased precision and faster operation than the popular 16-bit minis can deliver. A three-word floating-point number, common in such applications, consists of a 17-bit exponent and a 35-bit fraction in the PDP-15. The same precision with 16-bit words would require one more word and, typically, over 30 percent more processing time.

Memory addressing is another strong point of an 18-bit machine. Single-word instructions can have more range than those of the more common 16-bit systems.

Competition for the PDP-15 is generally academic. If an 18-bit processor is mandatory, it's easy; there is really no competition. However, if a 16-bit machine can fill the need, two strong contenders for applications similar to DEC's target market for the PDP-15 are the Varian V75 system (Report M11-890-201) and DEC's own PDP-11/40 and PDP-11/45 systems (Report M11-384-301). The Harris (formerly Datacraft) Slash 4 and Slash 5 systems (Report M11-310-101) are 24-bit machines that also offer performance and characteristics in line with those of the PDP-15.

Recently, several manufacturers have introduced 32-bit systems that will offer strong competition in those instances where users require more than 16 bits. Examples of, these newer products are Interdata's 8/32 Megamini (Report M11-530-401), Modcomp's 32-bit series (Report M11-641-100), and Systems Engineering Laboratories' 32/50 and 32/55 (*MiniNews*, M17-501-011).

Generally, there is no directly comparable competition for current PDP-15 configurations (PDP-15/70 and above) because of the Unichannel-15 peripheral processor included as standard equipment. Early configurations used a PDP-11/05 processor, but later systems use the PDP-11/10. Other PDP-11 models can be substituted for the PDP-11/10. The peripheral processor runs its own program (PIREX) with 8K or 12K words of dedicated memory, and also has access to the PDP-15 main memory. The PDP-15 communicates with the PDP-11 peripheral processor with software task control blocks maintained in the common (dual-access) memory area. Once instructed by the PDP-15, the PDP-11 will carry on the assigned functions without intervention by the main processor. This results in nearly zero-overhead I/O operations. Peripherals for the PDP-15 are connected to the PDP-11 Unibus, which is an 18-bit bus and provides both programmed and DMA transfers to the PDP-15 memory.

XVM SYSTEMS

New features incorporated in the XM15 memory processor are improved addressing range, automatic instruction lookahead, memory interleaving, memory management hardware, and dual memory busses.

The increased addressing range is accomplished through expansion of the indirect addressing function. In previous ▷

▶ INTERRUPTS: An automatic priority interrupt is standard on XVM processors and optional on all other PDP-15's. This interrupt provides four hardware levels and four software levels. Interrupts are vectored directly to the appropriate service routine. Any number of devices can be attached on the I/O bus, and one device may control more than one interrupt vector or data channel.

INPUT/OUTPUT CONTROL

Peripherals are connected to the PDP-15 or XVM processor through either the KP15 internal I/O processor or through the UC15 Unichannel peripheral processor (PDP-11/05 or 11/10).

The UC15 Unichannel peripheral processor is a front-end for the PDP-15 or XVM based on a DEC PDP-11/05 or 11/10 processor running under the PIREX software. The PDP-11 Unibus provides a second high-speed I/O bus for the PDP-15. The Unibus is also 18 bits wide and can support data transfer rates up to 1 million words per second. The UC15 Unichannel is supported by the DOS-15, XVM/DOS, BOSS-15, RSX Plus III, and XVM/RSX software systems. Currently, the RK11/RK05 cartridge disk, the LP11 LS11, and LV11 line printers, the CR11 card reader, the XY11 and XY311 plotters, the DL11 asynchronous serial interface, and the KG11 check-character generator are supported by PIREX.

I/O CHANNELS: The PDP-15 I/O processor administers all data transfers between I/O devices and the CPU. Maximum data rate is one million words per second over the eight channels constituting the I/O processor.

CONFIGURATION RULES: On the common bus available with both PDP-15 series, up to eight devices can operate on a single mass storage or magnetic tape controller. Generally, all devices connected to this I/O processor impose a single "bus load" such that 20 bus loads can be supported.

The PDP-15 I/O bus cannot be expanded, but approximately 105 feet of bus can be used, permitting very large configurations without the need for bus repeaters.

SIMULTANEOUS OPERATIONS: PDP-15's overlap their operations between instruction execution and memory accesses. The I/O processor operates independently of the CPU. On XVM systems, four-way memory interleaving is used on each of two separate memory busses. Both these memory busses can operate simultaneously, permitting separate independent memory accesses from the CPU and I/O or from the CPU and the Unichannel CPU.

MASS STORAGE

DECDISK SYSTEM: Includes an RF15 controller for up to eight disk units and one fixed-head RS09 DECdisk. The RS09 has a capacity of 262,144 18-bit words. Its main attribute is that each word is directly addressable. Three data transfer rates (15.625K, 31.23K, or 62.5K words per second) are switch-selectable. Capacity of a full DECdisk subsystem (eight drives) is over 2M words.

RP152 DISK PACK SYSTEM: Includes an RP15 controller for up to eight drives and one RP02 disk drive with a storage capacity of 10.24 million 18-bit words per disk drive. Data is recorded in sectors of 256 words on 200 tracks per surface (20 surfaces per pack). Average access time is 41.5 milliseconds, with a transfer rate of 145K words per second. Capacity of a full subsystem (eight disk drives) is 81.9 million words.

RP153 DISK PACK SYSTEM: Includes an RP15 controller and one RP03 20-million-word disk drive. Average access time is 41.5 milliseconds, and data transfer rate is 135K ▶

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PDP-15 models, indirect addresses were fixed at 15 bits, but in the new XVM hardware, the user has the choice of 15, 16, 17, or 18-bit indirect addresses. This additional range permits program lengths of 128K, a fourfold increase over the previous limitations in the earlier PDP-15's. Datapro notes, however, that the 32K program-length limitation was imposed largely by DEC's programming software, for efficiency reasons, and not by the PDP-15 hardware. The ability to use 18-bit addresses has always been present in the PDP-15's through the indexed addressing modes, which use 18-bit index registers, but this method is very inefficient and not widely used. In addition, the new XVM software utilizes only two of the four possible indirect address lengths, 15 and 17 bits. Users requiring 16 or 18-bit indirect addressing will have to develop their own software or modify DEC's.

Automatic instruction lookahead is the XVM's alternative to the PDP-11/70's cache memory (Report M11-334-301). In the 11/70, a memory reference results in extracting the contents of not only the desired location, but also the next three sequential locations. These four words are stored in the cache, a 300-nanosecond bipolar memory. Generally, if the contents of one memory location are required, statistics show that the contents of the next locations will also be required. Hence, the contents of the next three memory locations are prestored in the cache and require much less time for access, providing faster processing. The XVM uses a four-word stack, with an 80-nanosecond access time, and extracts *instructions only* rather than all referenced memory contents. The instructions are then pre-analyzed, and the processor is readied for them. This approach, according to DEC, provides nearly the same increase in performance at far less incremental cost, since a four-word stack requires less hardware than a cache memory. DEC's statistics show that over 60 percent of all memory fetches are for instruction access. Thus, the XVM lookahead facility, when combined with the time savings due to pre-analysis, will permit the XVM processor to perform comparably to computers with cache memory at a lower incremental cost.

The memory management hardware provides address relocation (two registers); three processor operating modes (EXEC, USER I/O, and USER); and memory protection through a lower boundary register and a one-bit read/write storage protection key. EXEC mode permits tasks to freely access memory and initiate I/O. USER mode prevents alteration of memory outside the task area and initiation of I/O operations without operating system supervision. USER I/O mode allows user tasks to *directly* initiate I/O operations without operating system monitoring, but prevents alteration of memory outside the task area.

Memory interleaving is provided by the memory processor in conjunction with the ME15 or MF15 memories, which operate as independent 8K or 16K blocks. Up to four-way interleaving can be implemented on each memory bus if enough units are used.

words per second. The controller can support up to eight disk drives, providing a maximum disk subsystem capacity of greater than 160 million words.

RK15 CARTRIDGE DISK SYSTEM: This is the Unichannel system which may be used to upgrade an existing PDP-15 system to XVM-200 status. Included in the system is a UC15 Unichannel peripheral processor (PDP-11/10) with 8K words of core memory, one RK11 disk controller, and one RK05 1.28-megaword cartridge disk drive (IBM System/3, 5440-type). The RK11 controller can support up to eight disk drives. This system is also available with 12K words of core memory.

DUAL DECTAPE SYSTEM: Includes a TC15 DECtape controller and one TU56 dual DECtape transport. The nominal data transfer rate is 5K words per second at 375 bpi, and each reel can store up to 150K words. The system features random-access read and write in either direction and 100 percent redundant recording on separate tracks. The controller can support up to four dual transports and operates on a multicycle direct memory access channel.

INPUT/OUTPUT UNITS

DEC offers an exceptionally complete and diverse complement of peripherals for both the PDP-15 and the PDP-11, used as the Unichannel peripheral processor. PDP-15 and XVM peripherals are outlined in the Peripherals/Terminals table on the third page of this report. Peripherals for the PDP-11 are outlined in Report M11-384-301.

COMMUNICATIONS CONTROL

DC01-ED SERIAL LINE SYSTEM: This system is a multistation teletype controller which includes eight serial channels. With a separate transmit clock for each channel, the DC01-ED is designed for use in MUMPS configurations.

DP09-A DATA COMMUNICATIONS SYSTEM: Interfaces any PDP-15 to a Bell System 201 or 301 data set. Fully compatible with EIA RS-232B, the industry standard, this system is a bit-synchronous interface which operates in full-duplex mode at 2400 baud.

LT19-D DATA COMMUNICATIONS CONTROL: Interfaces up to five Teletype line units to any PDP-15. Up to three such interface controls can be attached to a PDP-15 processor. Total throughput rate is 30,000 bits/second. The control includes a cabinet.

For additional communications adapters, see the Communications portion of the Equipment Prices section.

A full and extensive line of communications and specialized interfaces for the PDP-11 Unichannel processor is also available. See Report M11-384-301 for a list of these.

SOFTWARE

OPERATING SYSTEMS: Five major operating systems are available for the PDP-15 and XVM systems. DEC tailors these operating systems to the various configurations. Each system includes appropriate language processors, e.g., FORTRAN, FOCAL, MACRO, and BASIC, and utility routines; three include ALGOL compilers. These five prime systems are described below. Each is modular in structure with three monitor functions (I/O supervisor, file management, interrupt management), data transfer routines; device handlers, and utility packages.

Basic Monitor Software: This is the most elemental operating system, and it runs on all PDP-15 systems. It

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▷ **APPLICATIONS SUPPORT**

Applications are the strong point for the PDP-15 family. Not only has DEC designed and implemented strong applications packages, but the firm has also adapted specific hardware configurations to particular applications. Through this approach, DEC can go to specific control environments and offer fully checked-out, integrated systems. Examples of such specialized systems are the XVM-Graphics system for interactive computer-aided design (CAD) applications; ARK-2, a computer-based architectural package marketed by DEC in conjunction with its developers and owners, the Decision Graphics Corp. of Boston; and REDAC, a set of CAD programs for electronics layout and design marketed by DEC in conjunction with the REDAC company of Littleton, Mass., a subsidiary of REDAC Software, Ltd. in the United Kingdom.

DEC also has a specialized group, CSS Services, with offices in California, England, and Germany, to provide special services and products for XVM and PDP-15 systems customers.

DEC offers a number of strong operating systems for the PDP-15, and most of these are currently being upgraded to take advantage of the new hardware innovations in the XVM systems. These packages include the DOS-15 single-task disk operating system, the BOSS-15 batch processing system, the MUMPS-15 multi-user multiprogramming system, and the XVM/RSX real-time, multiprogramming, resource-sharing system which concurrently runs both batch and real-time programs. DEC expects to release the XVM versions with the first systems in the Fall of 1975. Two other PDP-15 packages—ADSS-15, a single-task, DECtape-based system, and B/F-15, a two-job, DECtape-based system—will not be upgraded for the increased ▷

▶ requires a paper tape reader/punch for program and data I/O, a console terminal for printed output and command input, and 8K words of memory. Languages supported are FOCAL, MACRO assembler, a text editor, and a debugger.

This software will not be supported on XVM systems, but can be run on XVM equipment as a PDP-15 system.

Advanced Monitor Software: Includes all the facilities of Basic Monitor with the additional facility to call, store, load, and execute system/user programs and to interpret and execute console commands to change I/O device assignments dynamically. AMS includes FORTRAN IV, MACRO assembler, an on-line debugger, a symbolic editor, the Peripheral Interchange Program (PIP), a linking loader, and an I/O monitor. When mass storage is selected, AMS is device-independent. Minimum configuration required to support AMS is the PDP-15/20 or equivalent.

This software will not be supported on XVM systems, but can be run on XVM equipment as a PDP-15 system.

XVM/DOS-BOSS: A single-task disk-based system for interactive operations. It requires 24K words of memory, one or more available disk subsystems with a minimum of 500K words, and a high-speed magnetic tape subsystem. Language support is offered for FORTRAN IV, FOCAL, MACRO Assembler, and a text editor, and the system also includes debugging routines, a linking loader, librarian facility, a file utility, and PIP.

BOSS was originally offered as a separate operating system, but it has now been combined with XVM/DOS. It provides only batch processing. BOSS is a card-oriented, disk-resident operating system with normal output to a line printer. The minimum configuration required for XVM/DOS-BOSS systems is an XVM-100 or greater with disk drive, card reader, and line printer. Early versions of DOS-BOSS are available for non-XVM systems.

XVM/RSX: A multiprogramming, real-time operating system based on the use of a disk subsystem. It is the latest version of a family of RSX monitors which have been in use for three years. As such, it offers both interactive and batch ▶
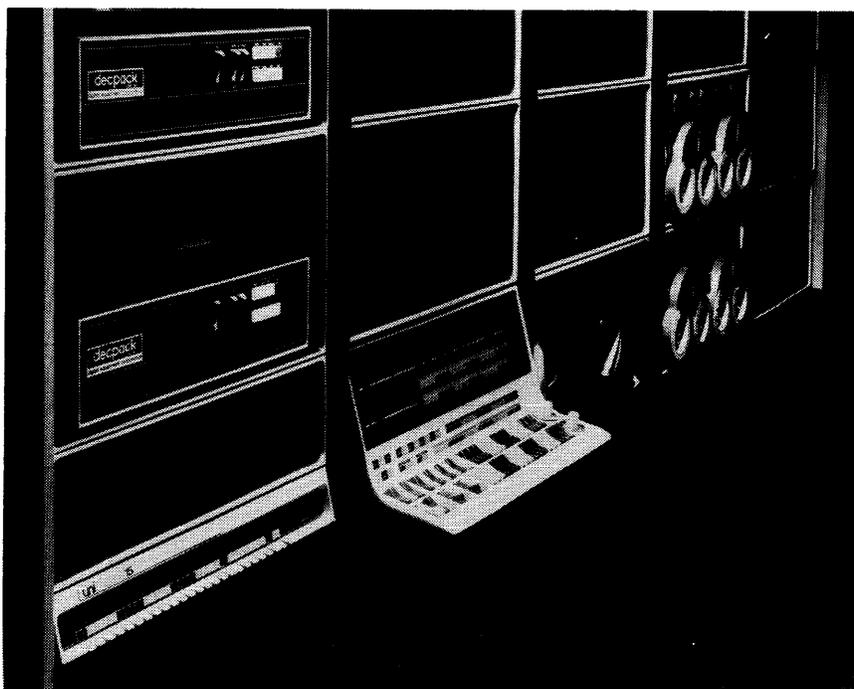
Typical of DEC's PDP-15/70 series, the BATCH-76 computational system is based on the PDP-15/76 and the PDP-11/05 peripheral processor. It was one of many configurations announced in 1973 designed for engineering, scientific, and commercial applications. This system includes (from left to right) two RK15 1.28-megaword cartridge disk drives, the UC15 (PDP-11/05) unichannel peripheral processor (below the RK15's), the PDP-15/76 processor with 32K memory and programmer's console, a PC15 paper tape reader/punch, and two dual DECtape transports. The system also includes an LP11 line printer and CR11 card reader driven through the PDP-11/05 Unibus, and can be purchased with DOS-15 software, a 90-day warranty, one-year system software subscription service, and six weeks' training credits.

DEC PDP-15 and XVM Systems

performance characteristics of the XVM hardware, but can still operate on XVM hardware.

DEC has introduced no major new software packages specifically for the XVM systems, and is not expected to do so for at least a year; but the XVM versions of the existing software systems represent substantial enhancements.

USER REACTION

Datapro interviewed six PDP-15 users, each of whom owned one system. The population included an aerospace research laboratory, two chemical research laboratories, two medical research facilities, and one transportation company, all of which points up the general application market for the PDP-15. The size and price range of PDP-15 systems is such that they are not frequently encountered in great numbers, as are smaller minicomputers such as the DEC PDP-8, the Data General Nova, and the Varian 620. Rather, the PDP-15 usually forms the nucleus of a comparatively large-scle processing system.

The six systems had all been installed and running for relatively long times, the oldest being over 5 years old and the newest 15 months old. The average age was slightly above 2½ years.

PDP-15 systems tend to be larger than most conventional minicomputer systems. Each of the six systems surveyed had at least two cartridge-type disks (IBM System/3 5440-type), and the average memory size was over 72K, ranging from a minimum of 32K to a maximum of 128K. Also, four of the six systems used 1200-lpm line printers, and the remaining two had 300-lpm units. Other equipment not regularly encountered included X-Y plotters (CalComp) on four of the systems, and extensive data acquisition interfaces, numbering over 200 channels in one system. Of note is the equipment replaced by three of the PDP-15's: an IBM 1800, an XDS 930, and an IBM System/360 Model 30.

User reactions to the PDP-15 were consistently divided; the hardware is excellent, but the software is cumbersome and needs more support, in the opinions of those interviewed. First the good news: the PDP-15 mainframe and peripherals were rated as exceptionally reliable, and the five users with maintenance contracts rated DEC's maintenance excellent.

The operating systems were also well thought of, with few complaints. RSX Plus III was considered good by the few users running it, and they felt that more users would make the switch if DEC could lessen the cost of changeover. The extra costs are entailed mainly by the greater external storage requirements of RSX Plus III. A spokesman for DEC notes that XVM upgrades can accomplish this more easily because the cost of this modification represents a reduction of nearly 50 percent over previous memory and memory management hardware. One user, also a member of DECUS, estimates that only five or six percent of the ▷

operation and comes in four versions or "kits," two of which support graphics and plotting. Major features of this operating system include: completely queued I/O processing; support for up to 100 simultaneous tasks and 128K words of memory; on-line program editing, compilation, and testing; plus an advanced file structure. Programs run under XVM/RSX can read DOS-created files, and conversely. Program development is supported via FORTRAN IV, MACRO, Text Editor, and BATCH processing. The minimum configuration required is the PDP-15/77 or equivalent. XVM/RSX requires 32K words of memory and 500K words of disk. It supports user programs of up to 128K words with all XVM features.

MUMPS (Massachusetts General Hospital Utility Multi-Programming System) is a multi-user system that provides time-shared use of a common data base management information system. MUMPS includes a multi-user monitor that allows up to 64 simultaneously active user partitions. A high-level, interactive programming language provides the interface between users and the system. Random-access storage and retrieval facilities and utility routines that perform system housekeeping functions are also provided.

The MUMPS language itself operates in a way similar to FOCAL and BASIC. The system interacts with users, enabling them to write programs, see the results, make modifications, and rerun their programs in a single session. User programs are always stored and used in their source form.

The minimum system requirement to run MUMPS includes a standard XVM-100 system, a DECdisk control with 2 DECdisk drives, a DCO1ED line scanner, and user terminals.

This minimum configuration, under the MUMPS software, provides a 500,000-word common data base information system. It can be expanded to include additional random-access secondary storage facilities, such as the dom-access secondary storage facilities, such as the RP15/RP02 Disk Pack System, and magnetic tape storage, plus up to 128K words of core storage. Equipment expansion requires only the reassembly of the existing software system. XVM/ MUMPS supports up to 128K words as user partitions or as buffer space for the active elements of the system data base. The minimum configuration for XVM/MUMPS is 32K words of main memory and 500K words of disk.

PIREX is a peripheral executive that resides in the local memory of the PDP-11 peripheral processor. The executive receives requests for I/O from the PDP-15 and initiates data transfers to and from shared memory and peripherals interfaced to the Unibus. The executive communicates with the PDP-15 operating system by means of interrupts, shared memory, and control words that are transferred over the communications interface.

PROGRAMMING LANGUAGES: The PDP-15 MACRO assembler and FORTRAN compiler are heavily used in the laboratory and research environments into which most PDP-15's have been placed. ALGOL and FOCAL are also available, but are not as frequently encountered.

MACRO-15 is the machine-language assembler for the PDP-15. It features full macro-instruction capabilities, including conditionals and repeats, and also allows device-independent programming at a machine-language level.

Other features of MACRO-15 include: ability to define and call nested macros, conditional assembly based on the computational results of symbols or expressions, repeat functions, boolean manipulation, optional octal/symbolic listing, two number bases (octal and decimal) and two text modes (ASCII and 6-bit ASCII), global symbols for linking ▶

DEC PDP-15 and XVM Systems

PDP-15 systems use RSX Plus III. DEC personnel note that the figure is closer to 10 percent, but that these users constitute between 30 and 50 percent of all *large* PDP-15 configurations. MUMPS, the time-sharing, multi-programming systems was rated excellent for data base work, although one user felt that DEC's MUMPS system slowed down considerably after the ninth user.

On the bad news sides, DEC's FORTRAN compiler was given one "poor" rating, the two most significant complaints being the long blocks of object code generated in the run-time packages and the lack of re-entrancy in the FORTRAN routines. The latter problem permits only one FORTRAN job to be run in systems with smaller memories. Many programs can be run simultaneously under RSX if sufficient memory is present. Three of the five FORTRAN users also mentioned "severe" inaccuracies in the FORTRAN error recovery routines. Further, all five of these users felt that DEC's software support for the PDP-15 needed substantial increases and, specifically, that the FORTRAN compiler should be upgraded and streamlined to more recent standards. Other complaints included the communications modules in the RSX software. For example, when first delivered, the advertised plotter communications interface did not contain an interrupt for the plotter, according to one user. DEC was quick to point out, however, that a five-word patch cured this problem and subsequent versions worked fine.

PIREX, the peripheral executive which runs in the PDP-11 Unichannel processors, also drew fire for not having a stronger priority system and swapping ability. As it stands now, a task must wait until the current task relinquishes control, regardless of the priority of the waiting task. DEC does have a "time-slice" technique built into this software, but it was deemed inefficient by the users we contacted.

The results of Datapro's standard questions are tabulated below, except that the category of application programs was omitted since five out of six users wrote their own and the sixth was using a turnkey MUMPS system. There are only five responses to the maintenance questions because one user supplied all his own maintenance internally.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	2	4	0	0	3.3
Reliability of mainframe	6	0	0	0	4.0
Reliability of peripherals	2	4	0	0	3.3
Responsiveness of maintenance service**	5	0	0	0	4.0
Effectiveness of maintenance service**	3	2	0	0	3.6
Technical support	0	4	2	0	2.7
Compilers and assemblers**	1	2	1	1	2.6
Operating systems	3	3	0	0	3.5
Overall satisfaction	2	4	0	0	3.3

* Weighted Average on a scale of 4.0 for Excellent.
**Fewer than 6 users responded to this question.

separately assembled programs, and choice of output format: relocatable, absolute binary (checksummed), or full binary (unchecksummed).

The output of the MACRO-15 assembler is completely compatible with the output of the FORTRAN and ALGOL compilers.

PDP-15 FORTRAN IV is a disk-oriented version of FORTRAN IV. Some extended features of this version are: free-format I/O, encode and decode commands, multiple subroutine entry and exit points, bit and byte manipulation, and negative step DO loops.

The FORTRAN IV compiler resides permanently on disk and is brought into core memory when required. Source programs are spooled onto disk and compiled from the disk. The compiled programs are then stored on disk and loaded with supporting subroutines from disk into memory for execution. During execution, FORTRAN IV programs can access non-sequential data records via direct disk statements or sequential records via standard formatted I/O statements.

FORTRAN source programs can be input for compilation from any of the PDP-15's standard devices: DECtape, disk, punched cards, paper tape, or teletypewriter.

The compiler provides four outputs during compilation to help the user debug and document FORTRAN IV programs: source listing, object listing, internal and external program symbols, and source program errors. These listings are normally output to the line printer but may be spooled to mass storage for off-line listing.

ALGOL 60, which runs on the PDP-15, is an alternative to FORTRAN for coding scientific programs. The language is a subset of the ECMA 1 level report, with some added features which include: externally compiled procedures for ALGOL, FORTRAN, or MACRO, full and mutual recursion between procedures, OWN variables, which are directly equivalent with BLANK COMMON variables in FORTRAN, data for overlays need not be in COMMON to pass from one overlay to the next, and free-fomat I/O.

FOCAL-15 is an on-line, interactive (conversational) algebraic language designed to assist scientists, engineers, and students in solving numerical problems. The language consists of concise English imperative statements, with mathematical expressions usually typed in standard notation. FOCAL can be used to simulate mathematical models, for curve plotting, and for handling sets of simultaneous equations in n-dimensional arrays.

UTILITIES: DEC provides an extensive offering in utility software. A partial list includes: The Dynamic Debugging Tool (DDT) interactive debugging package, the Graphic Text Editor, Library Update, Magnetic Tape Utility Dump, Peripheral Interchange Program, Systems Generator Program Sort/Merge, Text File Comparator, and Text File Preprocessor.

APPLICATIONS SOFTWARE: DEC offers extensive applications packages for the PDP-15 and XVM systems in such areas as process control and laboratory automation, nuclear physics (PHA-15), engineering design computer aids (Graphic 15), architectural design (ARK2), printed circuit layouts (REDAC), computation, statistics (STATPAC), and a commercial subroutine package.

PRICING

DEC provides PDP-15 and XVM systems on a purchase basis only. Maintenance agreements are priced separately, ▶

DEC PDP-15 and XVM Systems

▷ The only categories earning average user ratings below 3.0, or Good, were technical support and compilers and assemblers. The relatively low ratings given to technical support were due largely to the previously described problems encountered with software packages. Still, in spite of the criticisms put forth, the PDP-15 earned a . healthy overall score, with 89 percent of all the users' ratings in the Good and Excellent categories.

Generally, the users queried, including one who was a DECUS member and who conveyed some general impressions noted during meetings, would like to see improved software support for the PDP-15. Among their suggestions were more specific application packages, a more powerful executive in PIREX, streamlined FORTRAN modules with re-entrancy, and more extensive communication modules, especially in the area of multiple-terminal I/O support. In the line of hardware, two of the six users mentioned that they would like to see a floppy disk system offered for the Unichannel. At present, DEC offers software support only for line priners, card readers, plotters, disks, and both PDP-15 and PDP-11 communications interfaces connected to the PDP-11 Unichannel peripheral processors. Users can connect any PDP-11 peripheral to the PDP-11 Unibus, but must write their own software to support the devices.□

▶ except in DEC's turnkey packages which include software installation and one year of service in the purchase price. Otherwise, hardware, maintenance, and software licenses are all priced separately.

DEC offers two subscription plans for software support: Plan A and Plan B. Plan A provides a monthly newsletter describing new software developments, user techniques, and outstanding software problems. Plan B includes the features of Plan A plus updating of tapes at least once a year, manual updating at least once a year, and priority SPR (Software Performance Report) support. Both plans are specifically tailored toward the major operating systems.

Monthly maintenance prices for one-shift service are given in the price lists following. Twelve- and 16-hour service contracts are also available. A 5 percent prepayment discount is given to contract customers who pay for service one year in advance (12 times the normal monthly rate).

DEC offers separately priced training courses and seminars covering all aspects of PDP-15/XVM programming, system operation, and maintenance. Some package systems include training credits which are applicable to these courses. Classes are conducted at DEC's Marlboro, Massachusetts facilities or at several Regional Educational Centers.

EQUIPMENT: The following systems include all hardware, software, installation, and service for one year in the purchase price.

XVM/DOS MINIMUM SYSTEM: Includes KP15C processor, XM15 memory processor, 32K words of core memory, extended arithmetic element, real-time clock, paper tape reader/punch, LA36 DECwriter II, power fail/restart, PDP-11/10 peripheral processor with 8K words of core memory, 1.28M-word cartridge disk system, dual DECtape system, two cabinets, and XVM/DOS-BOSS software. Purchase price is $72,600. Add $3,000 if the XVM/RSX software is also desired.

XVM/MUMPS MINIMUM SYSTEM: Includes KP15C processor, XM15 memory processor, 32K words of core memory, extended arithmetic element, real-time clock, power fail/restart, paper tape reader/punch, LA36 DECwriter II, 9-track, 45-ips magnetic tape system, 10.2M-word disk system, DC01 8-station terminal control interface, and XVM/MUMPS software. Purchase price is $93,430.

XVM/RSX 5-TERMINAL RESOURCE-SHARING SYSTEM: Includes KP15C processor, XM15 memory processor, 64K words of core memory, extended arithmetic element, real-time clock, power fail/restart, paper tape reader/punch, LA36 DECwriter II, 9-track, 45 ips magnetic tape system, 10.2M-word disk system, LT19 5-station terminal control with five line units, five VT50 video terminals, and XVM/DOS-BOSS and XVM/RSX software. Purchase price is $109,700.

XVM 2-STATION GRAPHICS SYSTEM FOR CAD: This specialized application system includes a KP15C processor, XM15 memory processor, 64K words of core memory, extended arithmetic element, real-time clock, paper tape reader/punch, LA36 DECwriter II, power fail/restart, PDP-11/10 peripheral processor with 8K words of core memory, 1.28M-word cartridge disk system, dual DECtape system, two GT15 graphics processors with 17-inch displays, two cabinets, and XVM/DOS-BOSS and XVM/RSX software. Purchase price is $132,600.■

DEC PDP-15 and XVM Systems

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
PDP-15 PACKAGED COMPUTER SYSTEMS			
PDP-15/76-CE	KP15 processor with 32K words of core memory, extended arithmetic element, real-time clock, dual DECtape system, 128M-word cartridge disk sytem with Unichannel-15 peripheral processor and 8K words of core memory, and cabinets; includes 6 training credits	$68,500	$634
PDP-15/76-CK	Same as PDP-15/76-CE above, with 12K words of core memory in peripheral processor	71,200	655
PDP-15/76-CP	Same as PDP-15/76-CE above, with industry-compatible 7 or 9-track magnetic tape instead of DECtape	75,000	687
PDP-15/76-CS	Same as PDP-15/76-CE above, with 12K words of core memory in peripheral processor and industry-compatible 7 or 9-track magnetic tape instead of DECtape	77,700	708
PDP-15/78-AA	KP15C processor with 24K words of core memory, extended arithmetic element, real-time clock, LA36 DECwriter II, paper tape reader/punch, and cabinets; includes 5 training credits	35,000	318
PDP-15/78-8A	Same as PDP-15/78-AA above, plus dual DECtape system	44,000	371
XVM PACKAGED COMPUTER SYSTEMS			
XVM-100-AA	KP15C processor and XM15 memory processor with 32K wrods of core memory, extended arithmetic element, real-time clock, power fail/restart, paper tape reader/punch, LA36 DECwriter II terminal, and one cabinet	37,500	410
XVM-100-BA	Same as XVM-100-AA, with 64K words of core memory	46,500	464
XVM-100-CA	Same as XVM-100-AA, with 96K words of core memory	55,000	518
XVM-200-AA	Includes XVM-100-AA above, plus PDP-11/10 peripheral processor with 8K words of core memory and RK15 Unichannel disk system (see below)	57,500	617
XVM-200-BA	Same as XVM-200-AA, with 64K words of core memory	66,500	671
XVM-200-CA	Same as XVM-200-AA, with 96K words of core memory	75,500	725

		Purchase Price	Monthly Maint.	Field Install.
XVM MEMORY AND PROCESSOR OPTIONS				
XM-15-BA	Includes instruction lookahead hardware, automatic priority interrupt, memory protect and relocate, wide address mode hardware, split segment register, task accounting clock, power supplies, and 19-inch cabinet; requires prior purchase of 32K of ME15 memory (PDP-15 to XVM upgrade)	$ 9,000	$ 98	—
XM-15-UJ	Same as XM15-BA, with 32K words of MF15 core memory (PDP-15 to XVM upgrade)	17,500	152	713
XM-15-UL	Same as XM15-BA, with 64K words of MF15 core memory (PDP-15 to XVM upgrade)	26,500	222	713
XM-15-UN	Same as XM-15-BA, with 96K words of MF15 core memory (PDP-15 to XVM upgrade)	35,500	276	713
RK15-LE	Includes XM15-UJ, PDP-11/10 with 8K words of core memory, real-time clock, interprocessor interrupt link, shared memory adapter, and RK11-E 1.28M-word disk system (PDP-15 to XVM upgrade)	35,000	359	916
PERIPHERAL PROCESSORS				
UC15-WE	PDP-11/10 with 8K words of core memory, memory multiplexer, interprocessor interrupt link, and cabinet; requires real-time clock (PDP-15 upgrade)	15,000	154	500
UC15-HK	Same as UC15-HE, with 12K words of core memory	17,700	175	500
PROCESSOR OPTIONS (For PDP-15/10 through PDP-15/50)				
KE15*	Extended Arithmetic Element	2,800	27	60
KA15*	Automatic Priority Interrupt	2,000	21	100
KM15*	Memory Protect	1,000	15	100
KT15*	Memory Relocation	2,000	32	100
KS15*	Memory Management/Automatic Priority Interrupt	5,000	75	340
KF15*	Power-Fail	1,000	3	60
FP15	Floating-Point Processor	9,750	80	400
KW15*	Real-Time Clock	500	3	60
MX15-A*	Memory Multiplexer for MM15 memory (one MX15 required for each 32K above first 32K)	5,000	53	300
DW15	Positive to Negative Bus Converter; permits use of PDP-9 options	2,160	21	100

*The equivalent equipment is standard in all XVM systems.

MEMORY

800-nanosecond (for expansion of existing systems only):

MM15-A	4K words with space for additional 4K	8,640	27	100

DEC PDP-15 and XVM Systems

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Field Install.
MEMORY (Continued)				
MK15-A	4K expansion module (expands MM15-A to 8K)	$ 6,480	$ 27	60
MM15-C	8K words	11,880	53	125
MM15-E	16K words (2 x MM15-C)	21,600	106	200
980-nanosecond:				
ME15-A	8K words	6,000	42	200
ME15-E	16K words	9,800	85	250
900 nanosecond (for PDP-11 Unichannel Processor):				
MM11-K	4K 16-bit words (Requires PDP-11 processor)	2,700	21	125
MM11-F	4K 16-bit words; includes expansion chassis and connections for expansion of Unichannel processor to 12K words	3,780	27	150
MASS STORAGE				
RF15	Fixed-head disk controller; max. of 8 RS09 disk drives	6,000	37	220
RS09	Fixed-head disk drive for RF15; 262K words	10,000	48	240
RP152	Moving-head RPR02 disk and controller; max. of 8 RP02 disk drives; 10.2M words per drive (Rebuilt RP02)	21,500	207	600
RPR02	Rebuild disk drive for RP15; 10.2M words	9,500	133	400
RP153	Moving-head RP03 disk and controller; max. of 8 RP03 disk drives; 20M words per drive	32,000	233	600
RP03	Disk drive for RP153; 20M words	20,000	159	425
RP02-P	Disk pack for RP02 or RP03	295	—	—
RK15-HE	Cartridge disk system; includes UC15 peripheral processor, 8K words of core memory, controller, one RK05 1.28M-word cartridge disk drive; max. of 8 RK05 disk drives	20,600	260	700
RK15-HK	Same as RK15-HE, with 12K words of core memory	23,300	281	700
RK05	Cartridge disk drive for RK15-H	5,100	60	260
RK05-K	Cartridge for RK05	99	—	—
TC15	DECtape controller, max. of 4 dual DECtape drives	5,400	27	240
TU56	Dual DECtape drive for TC15; 150K words per tape	4,700	32	60
MAGNETIC TAPE EQUIPMENT				
TC59-D	Magnetic Tape Transport Control; controls up to 8 TU10-E or TU10-F Magnetic Tape Transport Units	6,950	37	400
TU10-F	Magnetic Tape Transport; 7-track, 45 ips, 200, 556, and 800 bpi	9,725	74	400
TU10-E	Magnetic Tape Transport; 9-track, 45 ips, 800 bpi	8,000	74	400
CARD EQUIPMENT				
CR15-F	Card Reader & Control; 300 card/min. optical reader	5,700	80	240
CR15-D	Card Reader & Control; 1000 card/min. optical reader	10,800	80	240
CR11	Card Reader & Control; 300 cpm; requires UCIS or RKIS	5,100	53	240
PAPER TAPE EQUIPMENT				
PC15	Paper Tape Reader/Punch; 300 char/sec. optical reader, 50 char/sec. punch	4,210	38	320
LINE PRINTERS (All have 132 print positions)				
LP15-V	Line Printer and Controller; 300 lpm, 64 characters	11,500	82	230
LP15-W	Line Printer and Controller; 300 lpm, 96 characters	13,500	82	230
LP15-R	Line Printer and Controller; 1200 lpm 64 characters	40,000	154	280
For PDP-11 processor:				
LP11-V	Line Printer and Controller, 300 lpm, 64 characters	10,500	72	220
LP11-W	Line Printer and Controller, 300 lpm, 96 characters	12,500	72	220
LS11	Line Printer and Controller, 60 lpm, 64 characters; requires UC15 or RK 15	5,900	58	120
LV11	Electrostatic Printer/Plotter; 500 lpm, 96 characters; requires UC15 or RK15	11,770	53	225
XY PLOTTERS				
XY15-A	Calcomp 565 Plotter and Controller; 300 steps per second; requires DW15	9,610	32	280
XY15-B	Calcomp 563 Plotter and Controller; 300 steps per second; requires DW15	14,470	37	320
XY11	Incremental Plotter Controller for UC15 or RK15	1,300	5	50
	Calcomp 563 Incremental Plotter; 200/300 steps per second; requires XY11	10,150	35	320
	Calcomp 565 Incremental Plotter; 300 steps per second; requires XY11	5,830	35	320
	Complot DP-1 Incremental Plotter; 300 steps per second; requires XY11	6,050	35	320
	Complot DP-10 Incremental Plotter; 300 steps per second; requires XY11	3,445	35	320

DEC PDP-15 and XVM Systems

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Field Install.

XY PLOTTERS (Continued)

XY311	Plotter and Controller; 1800 steps per second; requires UC15 or RK15	$ 18,900	$ 75	$ 325

GRAPHICS EQUIPMENT

GT15-S	Graphic System; includes VT15 graphics processor, ASCII character generator, 8-direction vector generation, VT04 display console, VL04 light pen, and W15 arbitrary vector generator	24,000	146	1,028
GT15-L	Same as GT15-S, with VT07 display console and VL04 light pen	29,000	173	1,125
VT04	Graphic Display Console, 17-inch CRT	4,360	27	250
VT07	Graphic Display Console, 21-inch CRT	10,800	53	350
VV15-A	Arbitrary Vector Generator	5,000	21	400
VM15	Multiplexer for four VT04/VT07's	5,000	21	200
LK35	Remote Keyboard for VT04; requires VT04 and LT19 interface	1,295	32	120
LK37	Remote Keyboard for VT07 or LT15; requires VT07 and LT19	1,295	32	120
VL04	Light Pen for VT04	755	7	75
VL07	Light Pen for VT07	755	7	75
VW01-BP	Writing Tablet and Controller	3,780	32	200
VW01-MX	Multiplexer for up to 4 VW01-BP's	1,080	5	75
VW01-MA	Writing Tablet and Spark Pen; requires VW01-MX	2,160	11	75
VW01-SP	Spark Pen for VW01-MA	215	5	75
VW01-WT	Writing Tablet for VW01-BP or VW01-MA	810	11	75

NOTE: In addition to the graphics equipment above, DEC also offers a full line of specialized oscilloscope and storage tube displays for computer-aided design purposes.

COMMUNICATIONS TERMINALS

LA36	DECwriter II; 132 columns, 30 character per second	2,175	25	115
VT05	Alphanumeric Display Terminal; CRT display, 20 lines x 72 characters, 110 to 2400 bps	2,795	23	80
VT50	Alphanumeric Display Terminal; CRT display, 12 lines x 80 characters, 64 ASCII characters, speed to 9600 bps	1,250	22	40

COMMUNICATIONS CONTROL

LT19-D	Multistation Terminal Control for up to 5 LT19-E's; max. of 3 LT19-D's per PDP-15; requires DW15 interface; includes cabinet	1,940	11	160
LT19-E	Terminal Line Unit for LT19-D	864	3	60
LT19-F	EIA Line Adatper for LT19-E	108	3	60
DP09-A	Data Communications System; RS-232B compatible, full duplex, 2400 bps, for Bell 201 or 301 data set; requires DW15 interface	6,480	27	20
LT15-A	Single Terminal Interface for second terminal device; max. of 1 per system; requires BA15 interface	500	3	160
DC01	Multistation Terminal Controller for up to 8 serial channels	6,480	21	200
DP11	Synchronous Line Interface for one full or half-duplex line; Bell 201 or equivalent modems; requires UC15 or RK15	2,000	19	125
KG11	CRC Generator/Checker; requires UC15 or RK15	950	6	60

LABORATORY DATA ACQUISITION EQUIPMENT

AD15	A/D Converter; three-cycle DMA device; includes interface and control, ADC, S/H programmable gain amplifier, one AM01-A, and one BA 124; provides expandability to 128 channels by adding 3 AM01-A units; 30KHz max. conversion rate (12 bit + sign) with 22 KHz throughput	6,480	27	350
AM01-A	Expander Unit; permits AD15 expansion in 32-channel blocks; one required for each 32 channel group; AM01-A for first 32 channels is supplied with AD15; four AM01-A units max.; each accommodates 8 BA124 modules	540	5	75
BA 124	Analog Multiplexer Switch; four-channel switch module; one required for each 4-channel group	70	2	8
AD15-C	High-Speed A/D Converter; 100 KHz throughput rate; 96-channel capability in 32 channel groups; wiring for first 32 channels included; six operating modes; similar to AD15	9,720		200
AA15-B	D/A Multiplexer Control; accommodates up to sixteen AAC2 12-bit D/A channels	4,860	7	350
AAC3	D/A Converter; digital-to-analog, single buffered, 0 to ± 10V	375	6	**

INDUSTRIAL CONTROL EQUIPMENT

BD15-	Central Control Unit; controls up to 11 AFC15 options (2048 analog channels) and 11 UDC 15 options (4096 digital points in 16-bit I/O words)	8,100	53	400
AFC15-	Analog Input Scanner; accommodates up to 6 AM07-B's of 32 channels each, to provide a max. of 192 channels; allows sampling of 200 channels/second and 20 samples/second on the same channel using a 12-bit converter (11 bits + sign)	5,400	27	75

DEC PDP-15 and XVM Systems

EQUIPMENT PRICES

INDUSTRIAL CONTROL EQUIPMENT (Continued)

		Purchase Price	Monthly Maint.	Field Install.
AM07-B	Expander Unit; each unit can accommodate a max. of 32 channels	$ 340	$ 3	$ 30
BA 150	Multiplexer Module; eight-channel multiplexer; one required for each 8-channel group	340	4	40
BA903	Direct Signal Module; input range 0 to 10 volts; one required for each 8-channel group; requires BA150	50	4	40
BA904	Voltage Conditioning Module; input signal 0 to 100 volts; 10:1 voltage conditioning; one required for each 8-channel group; requires BA150	90	4	40
BA905	Current Conditioning Module; current input 0 to 50 mA; one required for each 9 channel group; requires BA150	90	4	40
UDC15	Digital Input/Output Controller; basic unit consists of cabinet, one DD02 system unit, and provision for the mounting of five additional DD02's; provides for max. of 24 16-bit I/O words (total of 384 digital points)	3,020	21	60
DD02	System Unit; each unit can accommodate four 16-bit I/O words (64 digital points)	180	2	20

CABINETS AND HARDWARE

H960	Free-Standing Cabinet; includes filter, fan, panels, and door; 72 inches	700	—	—
H961	Same as H960, without end panels	500	—	—
H954	Table for VT04	120	—	—
BA11	Expansion Box with tilt and lock slides; for UC15 and RK15	500	—	—
W720	Power Supply; +5V, 22A; for BA11	700	11	50
DD11	Peripheral Mounting Panel; includes Unibus slots for 4 small peripheral controllers; for UC15, RK, or BA11	250	—	50

SOFTWARE PRICING — MAJOR PDP-15 AND XVM SOFTWARE SYSTEMS

				Software Services and Support	
Software Product	License Price	Support Class*	Recommended Advisory Support	1-Year Subscription Service**	Programming Training Courses
ADSS-15 (not XVM)	$500	Class C	2 days	Plan A: $250 Plan B: $250	PDP-15 systems software; 2 weeks, $540
B/F-15 (not XVM)	$500	Class C	5 days	Plan A: $250 Plan B: $750	Same as ADSS
XVM/DOS Disk Operating System (includes BOSS-15 and 2 training credits)	Binaries and Sources—$2,500	Class C	3 days	Plan A: $250 Plan B: Binaries and Sources—$1,250	Same as ADSS
XVM/RSX (includes extended BASIC and GRAPHICS, previously available separately for $5,000 and 2 training credits; requires XVM/DOS)	$3,500	Class C	2 days	Plan A: $250 Plan B: $1,900 (incl. DOS services)	RSX; 1 week, $325
XVM/MUMPS	$4,500	Class C	10 days (mandatory for first-time users)	Plan B: $1,500	On request

NOTE: Some prices not firm at time of publication.

* Class C is full software support for a fee.

**Plan A provides monthly newsletter on remedial support and new software developments and techniques. Plan B provides same newsletter plus semiannual software updates of binary/source tapes and manuals, as well as software fixes within an average of three weeks.