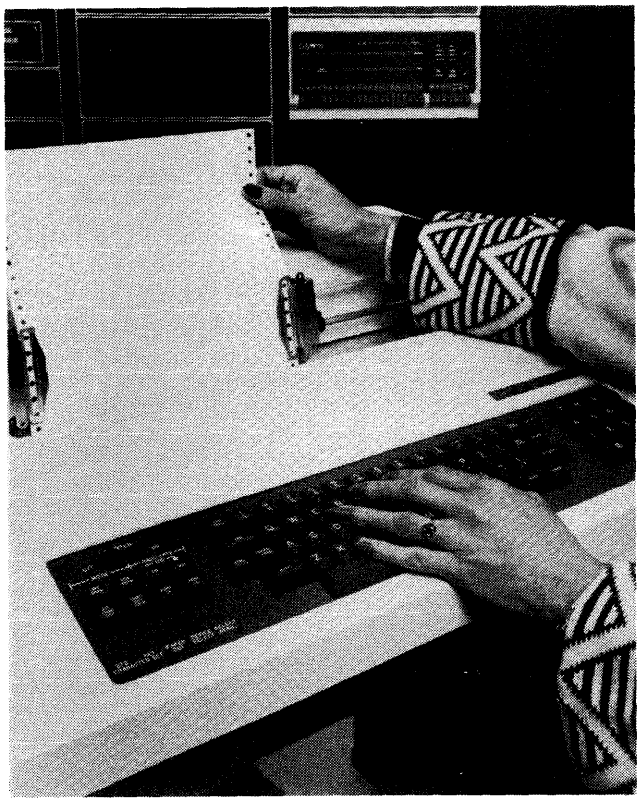
DEC PDP-11 Family



The PDP-11/70 represents the high end of one of the most extensive minicomputer product lines in existence today. In the foreground is the LA37 DECwriter II terminal, one of the numerous terminals now offered with the PDP-11 processors. The PDP-11/70 is a high-performance machine with integral cache memory and high-speed 32-bit data paths. The system also has memory management, look-ahead, and internal memory expansion capability up to 4096K bytes.

DEC's broad PDP-11 family of 16-bit processors includes products ranging from the low-priced LSI-11 microcomputer to the powerful PDP-11/70 minicomputer. Nine processors are active members of the family at present, and they are available either as stand-alone products or as part of packaged systems. Most members of the PDP-11 product line are available for both OEM and end-user sales.

MANAGEMENT SUMMARY

During its relatively short history, Digital Equipment Corporation has pioneered the minicomputer concept, taken advantage of its early lead, and maintained its position as the largest minicomputer manufacturer in the world. In large part, the company's success can be attributed to the PDP-11 family of processors and packaged systems. Introduced in 1970, the PDP-11 product line remains highly viable, due primarily to the continual growth and strengthening of the line with new products and technologies on a timely basis. Digital's moves, while successfully maintaining product viability, can be characterized as conservative in an industry not known for conservatism. These moves have, however, ensured the production of consistently reliable and generally cost-effective systems.

EVOLUTION OF THE LINE

The original PDP-11, the 11/20, introduced in March 1970, defined the architecture that was eventually to become 15 models using 4 basic processors. Over a year later, in April 1971, an OEM version of the PDP-11/20, the ➢

CHARACTERISTICS

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

DEC is a worldwide corporation and the world's largest manufacturer of minicomputer systems. The company employs about 44,000 persons and maintains sales and service offices in all major U.S. cities and in major cities through-out Canada and the Western world.

MODELS: See Model Availability Chart on page M11-384-302.

DATE ANNOUNCED: See Model Availability Chart on page M11-384-302.

DATE OF FIRST DELIVERY: See Model Availability Chart on page M11-384-302.

NUMBER INSTALLED TO DATE: See Model Availability Chart on page M11-384-302.

DATA FORMATS

BASIC UNIT: 16-bit word plus two parity bits. The processor can also handle 8-bit bytes, and is capable of bit manipulation.

FIXED-POINT OPERANDS: 16-bit words or 8-bit bytes are used as operands in both single- and double-operand instructions. Bit manipulation is provided through Boolean AND/OR instructions.

FLOATING-POINT OPERANDS: Optional 32-bit single-precision operands with an 8-bit exponent and signed 24-bit fraction on the LSI-11, LSI-11/2, LSI-11/23, and the 11/34A and larger models; or 64-bit double-precision operands with an 8-bit exponent and signed 56-bit fraction on the 11/34A, 11/44, 11/60, and 11/70.

The sign is the high-order bit in both single- and double-precision operands and precedes the exponent. The exponent is in excess 128 notation, allowing exponent values between -128 and +127. All fractions are assumed to be normalized, so that the high-order fraction bit (which is always 1) is not represented directly. This allows one extra bit of resolution to be achieved.

Single- and double-precision hardware via a floating-point processor is optionally available on the 11/23, 11/34A, 11/44, 11/60, and 11/70. This hardware includes a dedicated set of six 64-bit accumulators. The LSI-11 can have an optional plug-in, ROM-implemented extended instruction set (EIS) for fixed-point arithmetic and a floating-point instruction set ➢

DEC PDP-11 Family

DISTINGUISHING CHARACTERISTICS OF THE PDP-11 FAMILY MEMBERS

	LSI-11/2	11/03	11/04	LSI-11/23, 11/23	11/34A	11/44	11/60	11/70
Processor Characteristics	Uses same basic four-chip set as the LSI-11; 350-nanosecond microcycle time; CPU mounted on 5 by 8.5 inch board; optional floating-point instructions	11/34 instruction set; unique internal architecture; floating-point optional	"Standard" PDP-11 architecture first appears; standard instruction repertoire; ROM hardware diagnostics	11/34 instruction set; two 5.2 x 8.9 inch boards; floating point optional; plug-compatible with LSI-11/2	400 instructions; extended instruction set; self-test diagnostics; automatic bootstrap loader; microprogrammed	Expanded internal implementation of PDP-11 architecture; extended instruction set; cartridge tape standard	Twice the CPU power of the 11/34; choice of firmware or fast floating-point processor (FPP)	300-nanosecond CPU using Schottky logic; 64-bit fast floating-point through FPP
Memory Usage	No CPU on-board memory; 16K dynamic MOS chips employed; memory refresh every 1.67 ms by on-board logic	Supports up to 64K in addressing capability, less in std. chassis; core, dynamic RAM, PROM	Supports up to 64K in address capability; core or MOS	Supports up to 256K in address capability; memory management feature; bootstrap/ diagnostics/ terminator and ROM module	Integral memory management hardware provides program protection, memory relocation, and addressing to 256K; core or MOS	Supports up to 1M; cache; memory management; 256K modules	532-ns effective cycle time; 2K cache memory; user, extended, and diagnostic control store options; memory management	Memory management (map) feature; interleaved core & cache memory management
Bus Structure	LSI Bus ("Sub-Unibus") that is low-cost & asynchronous		Standard Unibus, which lends flexibility across this range of the PDP-11 family	LSI Bus	Standard Unibus	Standard Unibus, Unibus Map converts 18-bit addresses to 22-bit addresses	Standard 56-line Unibus	Unibus plus 32-bit internal data buses between core & cache and between high-speed controllers & cache
Operating Software	Run-time version of RT-11	RT-11 & RSX-11S support	RSX-11M, RT-11, RSX-11S	RT-11, RSX-11M	RT-11, RSX-11M, or RSTS/E	RSX-11M, RSX-11M PLUS, RSTS/E	RT-11, RSX-11M, IAS	IAS, RSTS/E, RSX-11M-PLUS

PDP-11/15, was introduced. This new model employed the same CPU as the 11/20, and differed only in market orientation.

In October 1971, the first update to the infant PDP-11 line appeared in the form of the OEM-oriented PDP-11/05. This new unit, announced with the PDP-11/45 and 11/50, was a functional replacement for the 11/20 (and the OEM 11/15), repackaged into a more cost-effective unit that offered performance comparable to that of the older 11/20. Introduced at the same time, the 11/45 and 11/50 models each featured extensions to the PDP-11/20 capabilities, as well as the newer packaging techniques found in the 11/05. The PDP-11/45, like the other PDP-11's, was a core-only machine, but this new model included memory management circuitry that raised the maximum memory capacity from 56K bytes to 248K bytes.

(FIS) for single-precision numbers. ROM implementation of EIS is available for the 11/34 and 11/44. The 11/60 has a full firmware-implemented instruction set as standard. Floating-point software subroutines are available for all PDP-11's.

INSTRUCTIONS: PDP-11 instructions are 16 bits long. If program counter addressing is employed, then an additional 16 bits are added to the instruction length. Instruction formats are numerous, varying from one PDP-11 model to another. Common formats throughout the PDP-11 line occur in instructions of the single operand group, the double operand group, branch group, subroutine return, and condition code operators group. Operation codes vary from 4 bits to 16 bits in length.

INTERNAL CODE: ASCII for text-oriented data; binary for calculations.

PDP-11 MODEL AVAILABILITY SUMMARY

	LSI-11/2	11/03	11/04	LSI-11/23, PDP-11/23	11/34A	11/44	11/60	11/70
Date Announced	1/78	12/75	11/74	3/79	2/76	11/79	3/77	2/25
First Delivery	3/78	—	7/75	7/79	3/76	—	5/77	5/75
Typical Purchase	$1.1K	$10K	$17.3K	—	$20.9K	—	$40K	$100K
Number Installed	Over 100,000 (All PDP-11 models)							

DEC PDP-11 Family

PERIPHERALS/TERMINALS

DEVICE	DESCRIPTION & SPEED
MAGNETIC TAPE	
TS11-BA	Subsystem; 9-track, 45 ips, 1600 bpi
TJE16-AA/TWE16-AA	Subsystem; 9-track, 45 ips, 800/1600 bpi
TJU77-AB/TWU77-AB	Subsystem; 9-track, 12.5 ips, 800/1600 bpi
TME11-EA	Subsystem; 9-track, 45 ips, 800 bpi
PRINTERS	
LA11-P	Serial impact; 7 x 7 dot matrix, 132 positions, 128-ASCII character set, 3 to 14.9-inch paper, 6 lines per inch, 10 characters per inch; 180 cps
LP11-A	Drum; 132 positions, 64-character set, 4- to 19-inch paper, 6 lines per inch, 10 characters per inch, 12-channel VFU; 285 lpm
LP11-B	Drum; 132 positions, 64- and 96-character set; 285 and 204 lpm
LP11-C	Drum; 132 positions, 64-character set, 4- to 19-inch paper (width) 6 or 8 lines per inch, 10 characters per inch; 900 lpm
LP11-D	Same as LP11-C but 96-character set; 660 lpm
LP11-V	Drum; 132 positions, 64-character set, 4- to 16.8-inch paper (width), 6 or 8 lines per inch, 10 characters per inch; 300 lpm
LP11-W	Same as LP11-V but 96-character set; 240 lpm
LP11-Y	Same as LP11-V but 600 lpm
LP11-Z	Same as LP11-Y but 96-character set; 436 lpm
PUNCHED CARD UNIT	
CR11-A	Reader subsystem; 80-column, 300 cpm reader and control unit
TERMINALS	
LA35	DECwriter II; serial impact printer, 7 x 7 dot matrix, 132 positions, 63 or 95 ASCII character set, 3 to 14.9-inch paper (width), 6 lines per inch, 10 characters per inch, 20-ma interface; 10/15/30 cps
LA36	Same as LA35 but with keyboard; 96 or 128 keyboard characters, keyboard includes 14-key numeric pad; 20-ma interface, full or half duplex operation; 110 to 300 bps
LA37	Same as LA36 but with full APL keyboard; EIA or 20-ma interface: 110 to 300 bps
LA38	Tabletop or freestanding DECwriter IV printing terminal, 18-button numeric keypad, 30 cps, 300 bps
LA120	EIA version high speed interactive hardcopy terminal; 7 x 7 dot matrix, typewriter-style keyboard, 180 cps, 50 to 9600 bps
VT55	Graphic Display; capabilities as an alphanumeric CRT, graphic display, and printer/plotter; two displays of up to 512 data points at a screen resolution of 512 x 236; alphanumeric display is by 7 x 7 dot matrix on 24 lines of 80 characters each; hard copy via electrolytic process; keyboard is of multiple-key rollover construction and is of typewriter style with separate numeric keypad; full or half duplex, 20-ma interface; 75 to 9600 bps
VT100	Video Display Terminal; 80 columns by 24 lines or 132 columns by 14 lines, detached keyboard, scrolling, reverse video or underlining

The 11/45 actually represented a new processor that incorporated Schottky TTL logic and had a special high-speed internal memory bus in addition to the normal Unibus. This new bus was identical to the Unibus, and in some systems was connected to it as an extension. But the major purpose of the new bus was to interface DEC's new dual-ported 300-nanosecond bipolar and 450-nanosecond MOS memories, which represented significant enhancements to the system. The new memories, although more expensive at that time, enabled the 11/45 to perform at levels twice those of the PDP-11/20. In addition to the new memories, the 11/45 also featured an optional FP11-b floating-point processor, capable of handling 64-bit double-precision operands. The PDP-11/50, announced along with the 11/05 and 11/45 models, was merely a PDP-11/45 with MOS memory instead of core.

MAIN STORAGE

General aspects, including type, cycle time, and capacity, are covered for the entire family in the Main Storage Characteristics table (page M11-384-305). The categorized entries in the text that follows emphasize exceptions and noteworthy features. It should be noted that all storage capacities allow for the 8192 bytes (4096 words) that are reserved for use by the I/O system. Non-DEC storage choices are listed in Report M13-100-101, Minicomputer Add-On Memories.

STORAGE TYPE: Magnetic core, dynamic MOS, and bipolar are the three types most commonly used within the PDP-11 family. Core is available in a variety of speeds and can be used in every PDP-11 except the LSI-11/2 and 11/23, and the PDP-11/23 and 11/44. Bipolar cache memory is available only for the 11/44, 11/60, and 11/70. Dynamic MOS is available for all models.

Read-only memories (ROM's) and programmable ROM's (PROM's) are available for dedicated-function processors

DEC PDP-11 Family

The next PDP-11 model, the 11/40, announced in August 1972, could be considered a fill-in-the-gap model. It uses the memory management circuitry originally introduced in the 11/45 and 11/50 models, operates at about twice the speed of the original 11/20 in integer operations, but can have up to 248K bytes of core memory.

The PDP-11/40, 11/45, and 11/50 were primarily end-user processors chiefly because of the size of the systems for which they were intended. As OEM's began offering progressively larger systems, it became apparent that an OEM unit with large memory capability was highly desirable. For this market, DEC announced the PDP-11/35, a CPU identical with the 11/40, offering many 11/40 standard features as options and packaged in a 10.5-inch box.

For over a year after the 11/35 announcement, the PDP-11 family remained stable, at least in terms of CPU's. During this period, DEC turned its attention to packaged systems and support software.

In November 1974, the PDP-11/04 was introduced with a totally new low-end processor. Again, as in the case of the PDP-11/05, this new CPU had the same architecture as the existing family members and incorporated several technological innovations to achieve substantially improved price/performance characteristics. Designated the successor to the PDP-11/05 and PDP-11/10, this new processor, 11/04, used MSI components to reduce the CPU from two boards to a single hex board. While offering slightly better performance levels than the 11/05 and 11/10, the new 11/04 could accept either core or MOS memory. Priced about the same as the PDP-11/05 (a core-only machine), the 11/04 employed a newly developed power supply and less expensive memory modules to provide about 15 percent greater performance levels.

Early in 1975, two innovative PDP-11's were announced at opposite ends of the family line. The LSI-11 microcomputer, for OEM applications, and the PDP-11/70, for very large systems, were both introduced in February 1975. The LSI-11 addressed the rapidly growing market for smaller, less powerful computers for inclusion in very small systems such as intelligent terminals and process controllers. Built from an LSI microprocessor chip, this entirely new low-end PDP-11 featured the same instruction set as the PDP-11/40, but offered only half the performance of the other PDP-11 members, due chiefly to the architecture of the CPU.

At the other end of the scale, the PDP-11/70 still represents the top of the PDP-11 line. (It should be noted, however, that PDP-11 users who outgrow the 11/70's capabilities can now move up to the VAX-11/780, a powerful 32-bit processor, introduced in October 1977, that can be operated in PDP-11 compatibility mode. The VAX-11/780 is fully described in Report M11-384-401.)

Announced in February 1975, the PDP-11/70 appeared amidst the flurry of 32-bit minicomputers from other companies that reached the market in late 1974 and early

(e.g., the LSI-11 used in some other machine) or for specific processor functions (e.g., bootstrap loader or ASCII device console simulation in the 11/04). These take the form of diode ROM, ultraviolet-programmable ROM, and fusible-link ROM. Much of the ROM usage cannot really be classified as storage (e.g., floating-point ROM in the LSI-11).

CYCLE TIME: Both cycle and access times are listed in the Main Storage Characteristics table on page M11-384-305. Cache memory on the 11/34A (optional) has a 150-nanosecond cycle time; on the 11/44, 275 nanoseconds; on the 11/60, 170 nanoseconds; on the 11/70, 240 nanoseconds.

In some models, the storage access cycle *rate* (as opposed to the access cycle-time capability of the storage) is a function of the processor, not of the storage; e.g., the constant 1.2-microsecond cycle time of the LSI-11/2 regardless of storage technology. On the 11/70, DEC states that the main storage bandwidth is easily raised from the basic 4 million bytes per second to 5.8 million bytes per second by interleaving. All 11/70's with more than the minimum memory use memory interleaving. The company also states that a 90 to 95 percent cache "hit" rate on the 11/70 yields an effective 11/70 memory cycle time of less than 400 nanoseconds. On the 11/60, a 77 to 92 percent cache "hit" rate yields an effective memory cycle time of less than 550 nanoseconds. An 86 percent cache "hit" rate on the 11/34A and 11/60 brings about an effective cycle time of less than 554 nanoseconds.

CAPACITY: See Main Storage Characteristics table on page M11-384-305. Capacity is a function of packaging and/or marketing, of busing structure (the Unibus requires the uppermost 8K bytes to be dedicated as I/O registers, thus limiting direct address space to 56K bytes), and of whether memory mapping is available. Memory mapping is automatic effective address translation that enables a 16-bit computer to address memory in excess of 64K words.

CHECKING: Parity on the basis of one bit per byte is available with dynamic MOS memory for the LSI-11/2, 11/23, and 11/34A and with core memory for all PDP-11's except the LSI-11/2. Bipolar memory, available for the 11/44, 11/60, and 11/70, also features partiy on the basis of one bit per byte. Error correcting and checking (ECC) is a feature of dynamic MOS memory for the 11/44, 11/60, and 11/70. ECC corrects all single-bit errors and detects all double-bit errors and most multiple-bit errors.

STORAGE PROTECTION: Via the memory management function on the 11/23, 11/34A, 11/44, 11/60, and 11/70. Mapping automatically provides hardware storage protection.

RESERVED STORAGE: The uppermost 8192 bytes on all models with a Unibus are reserved for I/O registers. This apparent "waste" of storage is more than compensated for by the resulting I/O programming flexibility.

All PDP-11's reserve at most 511 locations (168 in the 11/03) at the low end of memory for interrupt vectors, trap vectors, and floating vectors (not in the 11/03). Floating vectors are assigned for communications and other devices that interface with the PDP-11.

CENTRAL PROCESSORS

The "mainstream," or original, PDP-11 family architecture began with the 11/20 and its closely related, stripped-down 11/15 version, each of which contained about 19 boards and some 600 integrated circuits (IC's). The 11/05 and 11/10 were identical to one another, about 20 percent slower internally than the 11/15 and 11/20, and had improved architectural implementation over their predecessors, using only 2 boards and about 200 IC's. The 11/04 and 11/34A processors use one and two boards, respectively.

DEC PDP-11 Family

MAIN STORAGE CHARACTERISTICS

Model	Storage Type	Cycle Time (nanoseconds per word)	Storage Capacity (bytes)	Increment Sizes (bytes)
LSI-11/2	Dynamic MOS and/or PROM	570 MOS	8K to 64K 1K to 8K	8K, 16K, 32K, 64K 512-bytes x 4-bit PROM chip
LSI-11/23, PDP-11/23	Dynamic MOS, ROM, PROM	500 MOS	128K to 256K MOS, 64K ROM/PROM	64K MOS, 4K ROM/PROM
PDP-11/03	Dynamic MOS, core, and/or PROM	550 MOS 390 MOS 1150 core	8K to 64K 32K to 64K 8K to 64K	8K 32K 8K 512-byte x 4-bit PROM chip
PDP-11/04	Dynamic MOS and/or core	700 MOS 980 core	16K to 64K 16K to 64K	16K to 128K 16K to 128K
PDP-11/34A	Dynamic MOS and/or core	510, 700 MOS; 1000 core	32K to 256K	32K or 128K MOS, 32K core
PDP-11/44	ECC MOS	480	256K to 1024K	256K
PDP-11/60	ECC MOS or core	800 MOS, 1200 core	64K to 256K	64K, 128K, 192K MOS, 64K core
PDP-11/70	ECC MOS and/or core	700 MOS, 1200 core	128K to 4096K	128K

1975. Intended for very large systems, and said to be capable of delivering 75 percent of the throughput of an IBM 370/158, the 11/70 is essentially a PDP-11/45 with a 32-bit bipolar cache memory placed between the CPU and main memory. In addition, the memory management feature used in the 11/70 permits addressing over 4 million bytes, although physical limitations reduce this capacity to 2 million (2048K) bytes. Specially designed mass storage controllers that access the 32-bit cache memory bus also substantially increase system performance.

The PDP-11/55 was next to appear. Announced in December 1975, the 11/55 is a very specialized version of the 11/45 designed primarily for the scientific market, and specifically for use in FORTRAN systems. The 11/55 attains its faster operation through three specific improvements over the 11/45: the use of 300-nanosecond bipolar main memory; incorporation of the more efficient PDP-11/70 microcode (the 11/70 is also 11/45-based); and the use of the FP11-C, a new floating-point processor that is twice as fast as the FP11-B, the standard unit for the 11/45.

In close succession, the PDP-11/03 and 11/34 were introduced. The 11/03, announced in January 1976, responded to OEM buyers' desires for a packaged LSI-11. It is housed in a 3.5-inch chassis, contains a power supply and space for up to 16K bytes of memory, and is intended for use as a single-user terminal system or even as a small distributed processing system.

The 11/34, announced in February 1976, is an outgrowth of the PDP-11/04 and, in fact, uses the same backplane and memories. It bears the same relationship to the 11/04 that the 11/40 had with the 11/05; the PDP-11/34 is based on the same CPU as the 11/04, but has the memory management feature that permits main memory capacities

Subsequent PDP-11 family models offer design improvements that relate closely to each product's intended market objectives. For example, LSI-11/2 design drops the Unibus in order to lower cost, and the 11/44 and larger models augment the Unibus for performance gains.

The 11/04 uses TTL in a single-board processor. Multiplexer printed-circuit models, which provide cost advantages from a packaging standpoint and speed advantages due to reduced signal path lengths, are now used throughout the PDP-11 family. The 11/34 uses the same technology, backplane, and chassis as the 11/04, differing only in the addition of memory management to extend user addressing capabilities to 248K bytes. Schottky TTL logic appears in the 11/44 and larger models, as does an autonomous Floating-Point Processor; bipolar cache memory, user control store, extended control store, diagnostic control store, and bipolar cache memory appear in the 11/60; and 32-bit internal data paths and the bipolar cache memory appear in the 11/70.

Mapped memory in any 16-bit machine will limit the address space of any one program to that which is directly addressable within the mapped-to-memory region. Also, the automatic mapping process may add processor overhead. In the 11/34A, this amounts to 120 nanoseconds per address mapped. In the 11/70, however, mapping is concurrent, with no overhead time. DEC has not made these timings available for the 11/44 or the 11/60.

The 11/23, 11/34A, and 11/60 can access up to 248K bytes of main memory, through memory mapping. In the 11/70, mapping allows up to 4 million bytes to be accessed, and in the 11/44, one million bytes.

With memory management, the 11/23, 11/34A, or 11/60 operates in either a "kernel" or a "user" mode; the user mode prevents programs from modifying key machine state relating to memory mapping and protection. The 11/44 or 11/70 with memory management has three modes: kernel, user, or supervisor. The supervisor mode is intended to facilitate multiprogramming by providing a control program state for more efficient and secure system management. A program operating in kernel mode can map users' programs anywhere

DEC PDP-11 Family

of up to 248K bytes. Like the 11/04, the 11/34 can use either MOS or core memories. From a performance standpoint, the 11/34 is more than 50 percent faster than the 11/04; and, since both computers use the same backplane, the 11/04 can be upgraded to 11/34 status. Cache memory has been made available in the PDP-11/34A, the latest version of the 11/34.

In March 1977, DEC added a new mid-range member, the 11/60, to its extensive PDP-11 minicomputer line. The PDP-11/60 offers performance levels between those of the PDP-11/34 and the PDP-11/70. Designed as a FORTRAN machine, the 11/60 has memory expandable to 256K bytes, and memory relocation and protection are built in. Hardware multiply, divide, and 32- and 64-bit single- and double-precision floating-point arithmetic are standard.

The 11/60 CPU represents a new design and incorporates a combination of features found in the smaller PDP-11's and the high-end PDP-11/70, plus a few features that represent innovations for the company. From the PDP-11/70 have come the 11/60's cache memory feature and floating-point instruction set. From the other PDP-11 models, the 11/60 draws the fundamental 16-bit architecture, with none of the 32-bit buses found in the 11/70. Innovations in the new CPU include user-accessible microprogramming and a special firmware diagnostic module for improved availability.

User microprogramming marks an important new direction for the world's largest minicomputer manufacturer. DEC had long been a holdout against permitting user microprogramming of its products, but increasing user understanding of this previously "black magic" technology has increased the demand for the capability. DEC is still barring extensive incursions into the inner machine by limiting the amount of control storage available to the users to 1024 words. In comparison, the Hewlett-Packard 21 MX-E can accommodate up to 8.5K words of user control storage, and the Data General microNova allows up to 4K words.

The 11/60 offers two different types of floating-point processors. The integral floating-processor is a firmware implementation added to the standard PDP-11 instruction set. The second version is a new, faster auxiliary floating-point processor, designated the FP11-E. Using this floating-point unit, the PDP-11/60 is said to be capable of performance levels between 85 and 90 percent of the 11/70 level.

The 11/60 does not have the high-speed Mass-bus used in the PDP-11/45 and 11/70 CPU's, but instead features a Unibus with a broader bandwidth than that of the PDP-11/34. With its unique combination of the Unibus and processor cache memory, the PDP-11/60, like the 11/70, allows I/O transfers to memory to occur simultaneously with central processor accesses from cache memory. I/O transfers do not cause the CPU to halt, and multi-port memories with a more complex bus structure are not necessary.

in memory and thus explicitly protect key areas including the device registers and PSW from the user operating environment. All other PDP-11 family systems operate in basic kernel mode only, i.e., with all available memory (always 64K bytes or less) acessible by all.

Each mode has its own set of active page (address translation) registers and can access up to 8 pages of data and 8 pages of instructions. Each page may be from 64 to 8192 bytes. In the 11/23, 11/34A, and 11/60, there are 8 active page registers per mode. These processors employ 16-bit virtual and 18-bit Unibus/physical address spaces. In the 11/44 and 11/70, there are 16 active page registers per mode. The 11/70 and 11/44 employs 16-bit virtual, 18-bit Unibus, and 22-bit physical address spaces.

Two or more sets of length registers are used to delineate the bounds of addressability for individual programs, and these together with associated status registers give memory protection for multiprogramming.

All PDP-11 family processors have an instruction stack capability to facilitate the implementation of sharable (reentrant) routines. The size of the pushdown stacks is limited only by the size of available memory.

CONTROL STORAGE: The LSI-11, LSI-11/2, and 11/03 are controlled by microcoded read-only memories (MICROM's), among whose functions are provision of PDP-11/35 instruction set emulation and automatic refreshing of any dynamic MOS RAM used. Also, the LSI-11 extended arithmetic option (fixed-point multiply/divide and floating-point arithmetic) is achieved by the use of a plug-in ROM chip. Users can create special LSI-11, LSI-11/2, and 11/03 operations by purchasing fusible-link programmable ROM (PROM) chips. These PROM's are packaged 256 words per chip, two chips to a half-board; the LSI-11 accepts half-boards in its backplane sockets. Other ROM-supplied LSI-11, LSI-11/2, and 11/03 functions are standard. They include resident initialization, power fail/auto restart, bootstrap loading, and debugging routines. ROM and PROM speeds in the LSI-11 are largely irrelevant, since they are at least an order of magnitude faster than the 1.2-microsecond overall LSI-11 processor cycle.

Control storage on the Unibus PDP-11's is not available to the user except on the 11/60. On this processor, a total of 4K words, consisting of 8 pages of 512 words each, can be installed. The first 2560 words (5 pages) of this address space are reserved for the base machine. The remaining 1536 words (3 pages) of address space are used for three immediately available firmware products that offer some user flexibility and provide for future enhancements. Two of the products are User Control Store (UCS—1K address space) and Extended Control Store (ECS—1.5K address space). These products are general-purpose options for use in the development of specific microcode routines for critical applications. The third product is Diagnostic Control Store (DCS—2K address space) and represents a specific, hardware-supported application of ECS. DCS is a fault isolator which facilitates fault isolation in the central processor to the module level.

The PDP-11/60 User Control Store, which permits users to develop their own microprograms for specialized functions, is a significant new addition to the PDP-11 capabilities. UCS provides 1024 48-bit words of RAM for microprogram storage, while ECS offers 1536 48-bit words of ROM for permanent non-destructive storage of microprograms developed with the UCS option.

REGISTERS: The 11/03, 11/04, 11/23, 11/34A, and 11/60 have eight user-accessible 16-bit registers (six general-purpose, one stack pointer, and one program counter), and a 16-bit processor status register.

DEC PDP-11 Family

specifically for real-time, scientific/engineering, and educational environments.

The multi-function PDP-11/70 can handle simultaneous batch, real-time, and time-sharing applications in its larger configurations, or pairs of these in smaller configurations. It incorporates such advances as integral bipolar cache memory and interleaved core memory to reduce effective memory cycle times to below 400 nanoseconds, fast mass storage devices, and a special high-speed 32-bit data bus to accommodate them.

MARKETING GROUPS

One aspect of the PDP-11 family (as well as other DEC products) that often causes confusion to both prospective and current DEC customers is the many marketing groups within Digital Equipment Corporation. Spokesmen for the manufacturer pictured the company as eight different small companies, each specializing in different applicational markets that have been carefully delineated to have little or no jurisdictional overlap. Each group has been given the freedom to develop products and markets within its own sphere of responsibility, independently of other groups. All groups, however, draw equipment for their products from the common pool of DEC hardware and, to a lesser degree, develop software from the major DEC operating systems.

PPD-11's are sold by DEC's OEM Marketing Group, Industrial Products Group, Distributed Data Processing Group (responsible for data communications, finance, transportation, and government markets), Telco and Engineering Computation Group, Laboratory Data Products Group, and—in Datasystem 500 and Datasystem 320/350 packaging—by the Business Products Group, Education Products Group, and Graphic Arts (Typeset) Group.

The laboratory was one of DEC's first markets, and is still one of its best application areas. The Lab Data Products Group has the charter of developing and promoting laboratory and scientific systems based mainly on the PDP-11 family.

The Business Products Group is responsible for the development and marketing of special PDP-11-based systems for the business market. DEC's business products have become popular with major users in the insurance, manufacturing, finance, transportation, and wholesale distribution fields to perform such functions as order entry, inventory control, billing, payroll, accounts receivable, and other classic general accounting and information handling applications.

The orientation of the Education Products and Graphic Arts Group is implied in their names. Both are forces with constantly evolving products to offer their respective fields. However, this report does not dwell on their specialized offerings.

Each PDP-11 has a basic chassis with a unique number of "system unit" positions in it. Each system unit (SU) is a space for mounting a backplane (backpanel mounting unit). The backplane is a printed circuit board with sockets. Each row of sockets is a slot. Currently available SU's can accommodate either seven hex and two quad slot modules or two hex and two quad slot modules. Quad slot modules have four connector fingers, while hex slot modules have six connector fingers. Each finger fits in its corresponding socket.

In order to expand memory and/or peripherals beyond the space limits permitted by the basic chassis, certain kinds of expander boxes must be used, depending upon the PDP-11 family model.

The basic prewired backplane used in the LSI-11, 11/03, and 11/23 has 16 slots that are grouped in to eight pairs. Each pair can accommodate one LSI-11-type module. The CPU module, with or without the integral 8K-byte memory, requires two pairs, leaving six pairs for peripherals and options. Most peripherals require only one pair of slots. Semiconductor memory modules, like the CPU Module, require two pairs of slots. Core memory modules are thicker than semiconductor memory modules and, while requiring only two pairs, preclude the use of the adjacent two pairs of slots. Customers must provide DC power for the LSI-11.

The 11/04 and 11/34A are available in either a small chassis with a 9-slot backplane or a large chassis which can mount backplanes with a total of 9 to 22 slots. Additional system expansion is available via BA11 expansion chassis. Beside the basic processors, numerous packaged configurations are offered. Available SU slots (backplane space) and hex and quad slots to be used for expansion in the basic processors and their packaged systems are specified in the equipment price list.

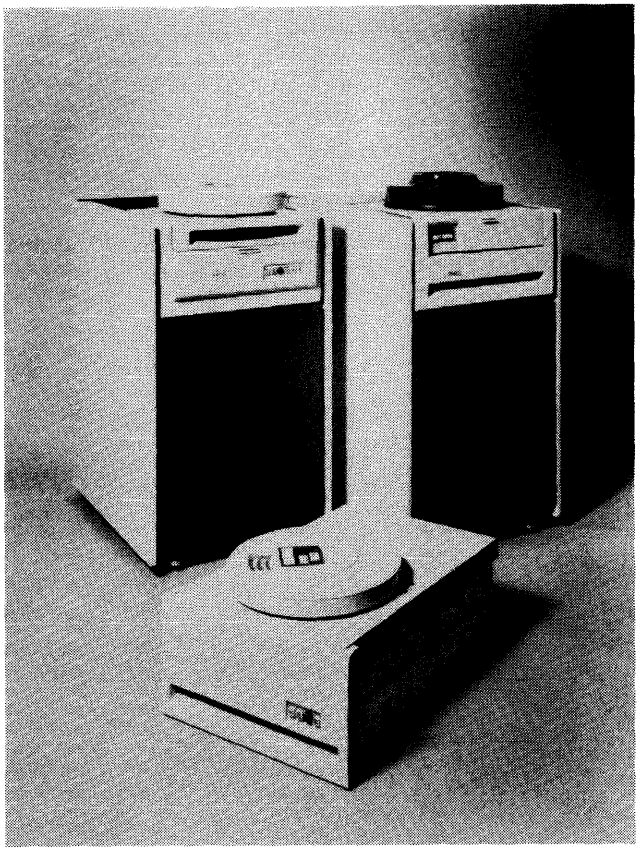
The basic 11/44 is available in a 10.5-inch box with a 14-slot backplane, power supply, CPU, 256K bytes of memory, and two cabinets. The backplane contains prewired areas for expansion of optional equipment.

The 11/60 is currently available a packaged or cabinetless system. As a package, it is supplied in either a dual-width H9600-AA High Boy Expansion Cabinet or a 72-inch-high H961-AA Standard RETMA Cabinet. Available Su slots and hex and/or quad slots to be used for expansion are provided in the equipment price list.

The 11/70 contains the CPU, KW11-L Line Frequency Clock, hardware memory management, direct memory access, M9301-YC ROM Multidevice Bootstrap Loader, operator's console, prewired slots for up to four high-speed mass storage control units, floating-point processor, 2K-byte cache memory, LA36 DECwriter II console, and two H960 Equipment Cabinets with fans and power supplies. The 11/70 is also available as a packaged system. Available backplane slots and hex and/or quad slots provided with supplied backplanes are all given in the equipment price list.

Slot requirements for memory, special processor interface features, and peripherals include: FP11-A FPP, one hex slot; FP11-C FPP, dedicated 11/44 or 11/70 slots (four); FP11-EA FPP, dedicated 11/60 slots (four); real-time clock for 11/03, double slot; other real-time clocks, one hex slot; memory module for 11/03, single or double slot; cache memory for 11/34A, one hex slot; memory modules for 11/34A, one or two hex slots; memory for 11/60, dedicated 11/60 slot or 2 SU slots; bootstrap loaders, double hex or quad slot; floppy disk subsystem, one quad slot or double 11/03 slot; cartridge disk subsystem, one quad slot or double 11/03 slot; cartridge disk subsystem, one or two SU slots or double 11/03 slot; pack disk subsystem, two SU slots or dedicated 11/70 slot; fixed-head disk subsystem, two SU slots; magnetic tape subsystem, either one or two SU slots or 11/70 slot; most communications options, one

DEC PDP-11 Family



These disk drives exemplify DEC's vigorous efforts toward vertical integration of its product line. The RL01 (foreground) employs 5-megabyte disks and can be used with all PDP-11 computers, including the microprocessor-based PDP-11/03. The free-standing RK07 drive (left rear) can be used with PDP-11/04 and -11/34 through -11/70 computers; it has a capacity of 28 megabytes. The RM02 drive (right rear) is used with PDP-11/34 through PDP-11/60 computers and has a capacity of 67 megabytes. All these disk units are now available for volume deliveries, and their prices range from $3,800 to $23,000.

The OEM Marketing Group is really composed of two groups, OEM Computer Marketing and Components. OEM (Original Equipment Manufacturers) Marketing sells computers in quantity to industrial and commercial firms who then add value to the computer (e.g., develop a package system for resale) and market it. The Components Group sells the DEC-built minicomputer peripheral line, composed of such products as the LA36 and LA180 DECwriter II, the VT50 and VT52 DECscope CRT terminals, and the LSI-11/2 and PDP-11/03 microcomputers. This group also operates a direct sales facility open to both OEM's and end users who wish to reduce maintenance and repair costs by performing some of this activity through their own qualified personnel. For this purpose, the Components Group has issued a Direct Sales Catalog that permits ordering supplies, modules, chassis, power supplies, terminals, and microcomputers in the same way consumers order merchandise from mail order houses. DEC is one of a few pioneers in this service that allows users to take advantage of the substantial savings that can be realized through this do-it-yourself approach.

hex slot, two hex slots, one quad slot, or single 11/03 slot; asynchronous multiplexers (NPR output), two SU slots; auto dial interface, one SU slot; line printer subsystems, one quad slot; punched card subsystems, one SU or quad slot; punched tape subsystems, one quad slot; backplanes, one or two SU slots; and Unibus extension hardware, one SU slot.

MASS STORAGE

RX02 FLOPPY DISK: A floppy disk subsystem consisting of a controller and two drives. Each drive has a capacity of 512K bytes, for a capacity of 1024K bytes per subsystem. Data is recorded on 77 tracks on one side of the diskette. Each track is formatted into 26 sectors of 128 bytes each. Head movement time is 10 milliseconds per track plus 20 milliseconds head settling time. Rotational speed is 360 rpm, giving an average rotational delay of 83 milliseconds. Average access time is 357 milliseconds. The data transfer rate is 61,000 bytes per second. Track capacity is 3328 bytes, and the total capacity of one diskette is 256,256 bytes. The subsystem is manufactured by DEC.

RL01 5.2-MEGABYTE CARTRIDGE DISK DRIVE: This is a top-loading drive employing a removable cartridge. Features provided in the RL01 include an embedded servo, allowing control information to be dispersed on each data track for data integrity. Disk rotational speed is 2400 rpm, and average rotational delay is 12.5 milliseconds. Average head positioning time is 55 milliseconds. Data transfer rate is 512K bytes per second.

RL01 packaged products include the RLV11-AK subsystem for the 11/03 and the RL11-AK subsystem for all PDP-11 systems except the 11/03. All subsystems consist of one drive and a controller for up to four drives. The RL01 and related subsystems are manufactured by DEC.

RL02 10.4-MEGABYTE CARTRIDGE DISK DRIVE: A dual-density version of the RL01, announced in November 1979.

RK07 28-MEGABYTE CARTRIDGE DISK DRIVE: This drive accepts a top-loading, dual-platter disk cartridge employing a technology similar to that of the IBM 3330 through the use of a track-following servo system. With this system, the bottom surface of one platter is dedicated to servo control and tracking information. Disk rotational speed is 2400 rpm, and average rotational delay is 12.5 microseconds. The data transfer rate is 538K bytes per second (3.72 microseconds per 16-bit word). Average access time is 49 milliseconds.

RK07 packaged products include the RK711-EA subsystem for the Unibus PDP-11 and the RK711-PA for the PDP-11/44. Both subsystems consist of one drive and a controller for up to eight drives. RK07 drives may not be used with the PDP-11/03. The RK07 drives are manufactured by DEC.

RM02 67-MEGABYTE DISK PACK DRIVE: This drive, like other disk pack drives offered by DEC for the PDP-11, employs a technology similar to that of the IBM 3330 through the use of a track-following servo system. In this system, one disk surface of each pack is dedicated to servo control and tracking information. The pack contains five platters, with the top and bottom platters employed for protection. Data is recorded on five surfaces. The drives rotate at 2400 rpm, resulting in an average rotational delay of 12.5 milliseconds. Average head positioning time is 30 milliseconds, and data transfer rate is 806K bytes per second.

RM02 packaged products include the RJM02-AA single-access subsystem and the RJM02-BA dual-access subsystem. Both subsystems consist of one drive and a controller for up to eight drives. The RM02 drives can be used on the PDP-11/34A through the PDP-11/60.

DEC PDP-11 Family

INSTRUCTION TIMES IN MICROSECONDS

Instruction	11/04 (MOS)	11/23 (MOS)	11/34		11/44 (MOS)	11/60 (MOS)	11/70 (MOS)
			MOS	Core			
Fixed-Point (16 bits):							
Load/Store	2.9/3.5	—	2.5	—	—	—	0.95/1.4
Add/Subtract	3.2	1.72	—	2.03/2.03	0.87	0.53	0.30
Multiply/Divide	9.9/11.3	—	8.9/12.6	8.82/2.78	—	—	3.4/7.9
Branch/No Branch	2.6/1.9	—	2.3/1.76	—	—	—	0.4/0.7
Floating Point (32 bits)*:							
Add/Subtract	NA	37.05/37.95 (42.45/43.35)	—	7.5/7.9 (7.5/7.9)	6.6/7.0 (6.6/7.0)	1.02 (1.02)	0.90 (0.90)
Multiply/Divide	NA	79.95/91.05 (193.05/239.25)	—	13.4/13.3 (20.7/20.6)	12.5/12.4 (19.8/19.7)	1.53/6.8 (3.74/12.58)	1.8/1.92 (3.06/3.12)

*Times for double precision are shown in parenthesis.

In January 1978, Digital introduced the LSI-11/2, a fully compatible version of the LSI-11 mounted on a 5-by-8.5-inch board, but without the on-board memory. Associated with the LSI-11/2 are a new family of memory and interface modules, also mounted on 5-by-8.5-inch boards. In addition to size reduction and increased modularity, the LSI-11/2 offers a lower price for a typical system with memory and fewer restrictions on configuring a system.

In March 1979, DEC added the LSI-11/23 and its rack-mounted packaged counterpart, the PDP-11/23. The LSI-11/23 features 256K bytes of memory, four times the capacity of the low-end LSI-11/2. It uses the full instruction set of the PDP-11/34, and software-supported memory segmentation features of the RSX-11M and -11S multitasking, multiuser operating systems. The LSI-11/23 also offers an optional floating point processor chip. The 11/23 offers hardware plug-compatibility with LSI-11/2 and PDP-11/03 at board level, plug-level compatibility with PDP-11 minicomputer input-output devices, and employs LSI-11 bus structure.

Besides accommodating RSX-11M and -11S software, the LSI-11/23 and PDP-11/23 run all software developed for the LSI-11 family without modification. This includes the RT-11 operating system and high-level languages including BASIC, FORTRAN IV, and FOCAL. Depending on configuration, the LSI-11/23 is from 2 to 5 times faster than previous LSI-11 family members.

In November 1979, the midrange PDP-11/44 was announced. With PDP-11/70 features and twice the performance of the 11/34, the 11/44 offers up to one megabyte of main memory, an integral 8K-byte cache memory, a microprocessor-controlled programmer's console, a magnetic tape subsystem, and provisions for optional floating point and commercial instruction set processors. The PDP-11/44 supports RSX-11M, RSX-11M-PLUS, and RSTS/E. It features the full instruction set of the PDP-11/70, 256K-byte ECC MOS memory modules, an Extended Instruction Set, and an optional Commercial Instruction Set for faster COBOL execution.

The 11/44 has 10 general registers which can be used as accumulators, index registers, or as stack pointers. One of the general registers is used as 11/44's program counter, and three others are used as the processor stack pointers, one for each operational mode.

The 11/70 has 16 user-accessible 16-bit registers (two sets of six general-purpose registers, three stack pointers, and a program counter) and a 16-bit processor status register. It should be noted that any one set of general-purpose registers and one stack pointer can be user-accessible at any given time. All user-accessible registers are located in the upper 8K bytes of memory. The FFP's, available with the larger PDP-11 processors, contain a dedicated set of six 64-bit accumulators. Numerous other non-accessible, 16-bit, internal registers are present in various members of the PDP-11 processor family. These include a CPU error register, hit/miss register, maintenance register, control register, memory system error register, high error address register, and low error address register.

ADDRESSING: Eight address modes are provided, with each operand address consisting of three bits to specify address mode and three bits that specify the register used to calculate the address. The modes consist of Register (operand in register), Register Indirect (operand address in register), Auto Increment/Decrement (self-incrementing/decrementing operand address in register), Auto Increment/Decrement Indirect (self-incrementing/decrementing register which points to an address in memory), Indexed, and Indexed Indirect. The eight modes can allow a specific operation code (e.g., MOV, for move) to accomplish register/register, register/memory, memory/memory, memory/stack, and register/stack manipulation.

INSTRUCTION REPERTOIRE: The PDP-11/03 has 66 standard instructions and eight optional instructions. All other PDP-11 models have in excess of 400 instructions. The instruction classes are listed below.

- **Single Operand—General (e.g., clear, increment, decrement, complement, negate, test); Shifts; Multiple Precision (e.g., add and subtract with carry, extend sign); and Rotate. Many of these instructions have word and byte operand versions.**

- **Double Operand—General (e.g., storage-to-storage move, add, subtract, compare); Register Destination (e.g., multiply, divide. Exclusive OR); and Logical. Move and Compare can have word and byte versions; logical instructions can have bit and byte versions.**

DEC PDP-11 Family

ARCHITECTURE

A distinguishing characteristic of the PDP-11 family is its common physical architecture, arising primarily from the patented DEC Unibus, a single high-speed, asynchronous, bidirectional communications path to which all system components (CPU, memories, and I/O controllers) are connected. This common bus structure enables all functional elements to communicate with one another independently of the CPU. This ability reduces the time spent by the CPU in supervising I/O operations and allows it to devote more time to actual data processing.

Since memory and I/O controllers alike are residents of the same bus, they are addressed alike. The result is that the PDP-11's do not employ I/O instructions as a separate class; instead, certain addresses are reserved for I/O devices, and each controller can read and write to memory in the same manner as the CPU. Hence, transfers to and from I/O controllers are accomplished in the same way that data is transferred between general-purpose registers and memory. More specifically, the highest 4096 memory addresses (8192 bytes) in any PDP-11 system are reserved for use by I/O controllers and cannot be used for memory.

Two small disadvantages arise from this I/O scheme. First, since 4096 addresses are reserved for I/O usage, they cannot be used for memory. Hence, the maximum physical memory that can be incorporated in a particular system is always 4096 words (8192 bytes) less than the *theoretical* maximums. For example, the PDP-11/04 is *theoretically* capable of addressing 65,536 bytes, but only 57,344 bytes can actually be implemented. This limitation arises only in the case of the maximum memory configuration. If the system only required 16,384 words there would not be a problem.

Secondly, the instructions for the I/O controllers address various controller registers as memory locations. Generally, these must be loaded individually through load- and store-type commands. While presenting an easy and understandable I/O system, this technique also precludes the implementation of instructions that perform more complex I/O functions, resulting in higher I/O overhead times.

The second salient characteristic of the PDP-11's, software compatibility, is a result of all CPU's, from the LSI-11 up to the PDP-11/70, using the same basic instruction set. It should be noted, however, that the LSI-11 and -23, and PDP-11/03 and PDP-11/23 have "pseudo-Unibus" structure in place of the standard Unibus and cannot presently use DEC's standard Unibus-compatible I/O controllers. Instead, DEC offers two low-to-medium-speed "universal" controllers, one parallel and one serial, that can be adapted to handle most standard peripherals.

CURRENT MODELS

Currently DEC offers the LSI-11/2 and LSI-11/23 microcomputers, sold by the Microcomputer Marketing Group,

- **Memory Management—Move From Previous Data Space, move From Previous Instruction Space, Move to Previous Data Space, and Move to Previous Instruction Space.**
- **Branches—Unconditional; Simple Conditional Branches; Signed Conditional Branches (for testing values of 2's complement arithmetic); and Unsigned Conditional Branches (for testing results of comparing unsigned operands).**
- **Subroutine—e.g., Jump to Subroutine, Mark, and Return from Subroutine.**
- **Program Control—e.g., Jump, Subtract One and Branch, and, in some models, Set Priority Level.**
- **Traps—these are calls to emulators, I/O monitors, debuggers, and user-defined interpreters.**
- **Miscellaneous—e.g., Halt, Wait, Reset, and in various models, No Op, Move to/from Previous Instruction/Data Space.**
- **Condition Code Operators—Set/Clear conditionally or unconditionally all of each of the four PDP-11 condition code bits.**
- **Floating Point—the four arithmetic functions for floating-point arithmetic. In models with both single- and double-precision floating-point arithmetic, these instructions have single- and double-precision versions. In the 11/34A, 11/45, 11/55, 11/60, and 11/70, which have autonomous floating-point processors, and in the 11/60 firmware set, the floating point instruction repertoire includes loads/stores for full operands and exponents only, similar compares, floating-point processor condition code operators and set/clear floating-point/integer mode, tests, load/store status, make absolute value, etc.**
- **User Control Store—Extended Function Code appears in one form only.**
- **Maintenance—Maintenance Exam and Dep, Load Microbreak Register, Maintenance Normalization Shift, Maintenance Partial Product, and Maintenance Alignment Shift.**

INTERRUPTS: All models except the LSI-11 and 11/03 have four automatic hardware priority level interrupts. The 11/60, and 11/70 can also use any of seven programmable software-supported additional interrupt levels; these have an automatic vectoring instruction held in a reserved main storage location. Each of the interrupt levels can accommodate independently prioritized peripheral devices.

PHYSICAL SPECIFICATIONS: Nominal operating environments for the PDP-11 processors are 50 to 104 degrees Fahrenheit (10 to 40 degrees Centigrade), at 10 to 90 percent relative humidity, with maximum wet bulb of 82 degrees Fahrenheit and minimum dew point of 36 degrees Fahrenheit. These are processor specifications; electromechanical peripherals may be more sensitive to their environments. Recommended operating conditions for a typical system are 70 degrees Fahrenheit ±2 degrees with a noncondensing relative humidity of 45 percent ±5 percent.

DEC offers a vast array of PDP-11 family equipment, and it is beyond the scope of this report to present more than generalized information regarding the physical specifications of the processors. Please note that all cabinet-mounting components except the 11/60 processor fit in RETMA-standard (19-inch) cabinet interiors, and that the cabinets generally measure 21 inches wide, 30 inches deep, and 72 or 50 inches high. The standard cabinet for the 11/60 is 27.5 or 46.5

DEC PDP-11 Family

PDP-11 TECHNICAL SUMMARY

Model	11/03	11/04	11/23	11/34A	11/44	11/60	11/70
Standard Processor Features							
Word size, bits	16	16	16	16	16	16	16
Number of instructions	66, 8 opt.	400+	400+	400+	400+	400+	400+
Instruction size, bits	16	16	16	16	16	16	16
Number of general registers	8	8	8	8	10	8	16
Byte manipulation capability	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hardware stacks	No	2	No	2	No	2	No
Memory management hardware	No	No	No	Yes	Yes	Yes	Yes
Bootstrap loader	No	No	No	No	Yes	No	Yes
Line frequency clock	No	No	No	No	Yes	Yes	Yes
Cache memory	No	No	No	No	8K	2K	2K
Battery backup	No	No	No	No	No	Yes	Yes
Processor Options							
Extended arithmetic	Yes	Yes	Yes	No	No	No	No
Battery backup	No	Yes	No	Yes	Yes	No	No
Real-time clock	No	Yes	No	Yes	No	No	No
Power fail/auto restart	No	No	Yes	No	No	No	No
Line clock	No	No	Yes	No	No	No	No
Floating point processor	No	No	Yes	Yes	Yes	Yes	Yes
Cache memory	No	No	No	Yes	No	No	No
Commercial Instruction Set processor	No	No	No	No	Yes	No	No
User control store	No	No	No	No	No	Yes	No
Extended control store	No	No	No	No	No	Yes	No
Diagnostic control store	No	No	No	No	No	Yes	No
Input/Output							
I/O word size, bits	16	16	16	16	16	16	16/32
Direct Memory Access	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maximum DMA transfer rate, bytes/second	1666K	1.7M	1666K	1.7	900K	2000K	5.8M
Number of interrupt levels	1	4	4	8	8	8	8
Maximum I/O transfer rate, bytes/second	180K	1.7M	180K	1.7M	900K	2000K	5.8M
Software							
Operating systems	RT-11	RT-11, RSX-11M/S	RT-11, RSX-11M/S	CAPS 11, DOS, PT-11, DSM-11, RSX-11M/S, RSTS/E	RSX-11M/S, RSX-11M-PLUS, RSTS/E, CTS-500	RT-11, RSX-11M/S, RSX-11D, IAS, RSTS/E, DSM-11, TRAX-11	RSTS/E, CTS-500, RSX-11M-PLUS, RSX-11D, IAS, DSM-11
High-level languages	BASIC, FORTRAN	APL, BASIC, MU BASIC, DIBOL, FOCAL, FORTRAN IV, FORTRAN IV PLUS	FORTRAN IV, FORTRAN IV PLUS, BASIC, BASIC-PLUS-2, APL, FOCAL	APL, BASIC, MU BASIC, DIBOL, FOCAL, FORTRAN IV, FORTRAN IV PLUS, DSM-11	COBOL, APL, FORTRAN IV, FORTRAN IV PLUS, CORAL 66, BASIC, BASIC-PLUS-2	APL, BASIC, BASIC-PLUS, BASIC-PLUS-2, Multi-user BASIC, DIBOL, FOCAL, COBOL, RPG, FORTRAN IV, FORTRAN IV PLUS, DSM-11, CORAL 66	BASIC, BASIC PLUS, BASIC PLUS 2, FORTRAN IV, FORTRAN IV PLUS, COBOL, APL, RPG

and the PDP-11/03, -11/04, -11/23, -11/34A, -11/44, -11/60, and -11/70, sold by DEC's other seven market groups.

DEC groups the current PDP-11 line into four application levels:

- *Microcomputers*—the LSI-11/2 and LSI-11/23, for board-level integration into dedicated applications, and the PDP-11/23, for packaged microcomputer applications.
- *Minicomputers*—the PDP-11/03 and PDP-11/04, for dedicated applications.

inches wide, 30 inches deep, and 50.5 or 60.5 inches high. A 19-inch rack-mounted version is available for OEM's.

DEC recommends that the air distribution system provide cool, well-filtered air with room air pressure kept higher than the pressure of adjacent areas to prevent dust infiltration. Metal walls and partitions are not recommended unless they are insulated on the conditioned surface. For efficient cooling, a minimum 30-inch clearance above the equipment should be employed. To avoid static electricity problems, the floor surface material should have a surface resistance of 0.5 megohms to 20,000 megohms at 40 to 50 percent relative humidity and a temperature of 68 to 72 degrees Fahrenheit.

BTU output per hour varies from 4240 for the 11/03 processor to 5889 for the 11/70 processor. A typical 11/60 system would output 17,000 BTU per hour.

DEC PDP-11 Family

- *Systems computers*—the PDP-11/34A and PDP-11/44, for multi-task applications.
- *Multi-function computers*—the PDP-11/60 and PDP-11/70, for real-time, batch, and time-sharing applications.

The LSI-11/2 is a board-level microcomputer product specifically designed for sophisticated users who can incorporate the LSI-11/2 into a product, taking advantage of the PDP-11 family capabilities that were previously unavailable in such packaging. The LSI-11/23 is also a board-level microcomputer that features 256K bytes of memory, four times more than the LSI-11/2. It uses the full instruction set of the 11/34, and software-supported memory segmentation and protection features of the RSX-11M and -11S multitasking, multiuser operating systems. Depending on configuration, the LSI-11/23 is from 2 to 5 times faster than the LSI-11/2.

The PDP-11/23 is a rack-mountable, packaged version of the LSI-11/23.

The PDP-11/03 is a complete minicomputer on four integrated circuit chips mounted on a single 8.5 by 10.5 inch board within a rack mountable 19 inch assembly. The 11/03 offers more than 400 instructions, and features hardware stack processing, eight general purpose registers, vectored interrupts, and single and double operand addressing.

The PDP-11/04 minicomputer provides solutions to dedicated applications in which the computer is used to solve one or two problems and run one or two programs. It is used, for example, in data acquisition, to convert analog signals to digital signals, to analyze pulse heights, and to store data on magnetic tape. As little as 8K bytes of memory can suffice in straightforward applications, but the systems can be expanded to up to 56K bytes in order to handle more complex applications, perhaps coded in a high-level language such as FORTRAN IV or BASIC.

The PDP-11/34 and 11/44 system computers are used in multiple-task applications where the computer must solve many problems or run multiple programs. They are being used to automate entire industrial processes, for example, monitoring and controlling multiple operations in real-time while preparing and printing production reports for management. Memory sizes can range from 32K to 1048K bytes to accommodate several programs in memory simultaneously.

The PDP-11/44 is a midrange minicomputer with features of the PDP-11/70 and twice the performance of the PDP-11/34. It offers up to one megabyte of main memory, an integral 8K cache, a microprocessor-controlled programmer's console, and provisions for optional floating-point and commercial instruction set processors.

The 11/60 is oriented toward high-performance real-time applications and medium-performance, multi-user, multi-task, time-shared applications. This model is targeted

INPUT/OUTPUT CONTROL

UNIBUS: The patented Unibus, a single common data path that treats all components or modules of a PDP-11 family system as equal-level devices for data access and transfers, including the processor, memory modules, and peripheral controllers, is part of all PDP-11 family members with the exception of the LSI-11 and the 11/03. The 11/60 has a pair of Unibuses for I/O and memory reference overlapping. The 11/70 incorporates a standard Unibus and 32-bit internal buses between core memory and cache memory and between high-speed peripheral controllers (e.g., disk and 1600-bpi magnetic tape) and cache memory. The LSI-11 and 11/03 have a "pseudo-Unibus" structure that eliminates some lines by doubling-up address and data lines through timesharing them.

The priority of any device connected to the Unibus is determined by its physical position; hence, the processor is normally attached so as to give it the highest priority. There is no logical limit to the number of devices that can be attached to the Unibus, with bus access and control handled by the interrupt system.

The theoretical maximum Unibus data transfer rate is 5 million bytes per second, and attached components communicate in a master/slave manner. On the 11/70, the 32-bit bus is fast enough (i.e., 2 million 8-bit bytes per second) to permit overlapped use by the CPU, Unibus, and/or several mass storage units, the fastest of which presently operates at 1 million bytes per second. DEC also states that interleaved core memory raises this 32-bit bus bandwidth to 5.8 million bytes per second. Interleaving is done whenever more than minimum memory is purchased.

It should be noted that the 32-bit bus of the 11/70 connects high-speed peripheral controllers to main memory, through cache memory, for data transfer purposes. The priority arbitration logic within the cache memory controls the timing of data transfers. Cache is not affected except that the involved 4-byte block is "flagged" whenever a write hit on an I/O transfer occurs, so as to indicate that the data in the cache is invalid, but that correct data is in core memory. The Unibus, meanwhile, handles the interrupt requests and transfer protocols for the high-speed units.

It is important to note that the 11/60 lacks the 32-bit internal I/O bus found in the 11/70. Cache in the 11/60 therefore does not function in the timing of data transfers.

The LSI-11, PDP-11/03, and PDP-11/23 bus has a maximum data transfer rate of 1666K bytes per second.

SIMULTANEOUS OPERATIONS: While I/O using the programmed interrupt structure cannot be simultaneous with processing or other I/O, NPR (non-processor data transfers) can. These are DMA (direct memory access) data transfers via the Unibus (or other buses in the large processors). Examples of NPR data transfers are memory to/from main storage and directly between devices (e.g, disk refreshing a CRT display) in an 11/70. NPR is available to all PDP-11 family members.

CONFIGURATION RULES

In general, all PDP-11 devices that tie into the Unibus impose a single "bus load." (CPU's and the multi-device bulk storage bootstrap loader impose two bus loads each.) The Unibus can support 20 bus loads before a Bus Repeater must be added. A Unibus repeater allows an additional 18 unit loads and an additional 50 feet of Unibus cable to be added to a system.

In order to physically attach devices to a PDP-11, sufficient mounting hardware must be present. Free-standing and cabinet-mounted devices do not tie up space on the system's chassis.

DEC PDP-11 Family

The final group, the Industrial Products Group, sells hardware and software solutions for data acquisition and process control applications.

SOFTWARE

DEC's approach to software has been to avoid situations that require much "handholding" with customers. Instead, the company prefers to provide users with advanced data processing tools that facilitate development of specialized applications software. With the exception of certain packages offered as integral parts of its specialized product lines, such as Typeset, DEC offers only operating systems, language processors, communications software, and some management tools.

There are five basic operating systems offered for the PDP-11, one of which has three distinct versions, making a total of seven. *RT-11,* one of the oldest and smallest, is a single-user system for interactive program development. It can support both single-job and foreground/background modes of operation. The single-job version requires a 16K-byte system, and the two-partition version requires 32K bytes. RT11 supports both the FORTRAN IV and BASIC languages for program development.

There are five basic operating systems offered for the PDP-11. *RT-11*, one of the oldest and smallest, is a single-user system for interactive program development. It can support both single-job and foreground/background modes of operation. The single-job version requires a 16K-byte system, and the two-partition version requires 32K bytes. RT11 supports both the FORTRAN IV and BASIC languages for program development.

RSX-11 is a real-time operating system available in three versions that vary widely in functionality and in system requirements.

RSX-11D, the original and most powerful of the three, is an event-driven, disk-based multiprogramming system for the PDP-11/34 and larger systems. Using the memory management functions of these CPU's, RSX-11D permits user programs to be loaded and executed anywhere in memory, without modification. At least 96K bytes of main memory and two hard disks (no floppy disk) are required for single-user operations, and 112K bytes of main memory with 4 megabytes of disk storage are needed for multi-user operations.

RSX-11M, also a disk-based real-time operating system, extends the functions of RSX-11D to lesser PDP-11 systems, and can be run on any PDP-11 except the LSI-11/2. RSX-11M requires a minimum of 32K bytes of main memory and one hard disk plus one other disk (which can be a floppy). To perform concurrent program development and real-time processing, at least 48K bytes of memory are required.

In April 1979, DEC announced RSX-11M-PLUS, an extended version of RSX-11M. With appropriate hard-

RM03 67-MEGABYTE DISK PACK DRIVE: This drive is functionally similar to the RM02 drive. Recording is on five surfaces at 6038 bits per inch and 384 tracks per inch. Data is recorded at 512 bytes per sector and 823 tracks per surface (including 15 spare tracks). Formatted capacity is 67 megabytes. The drives rotate at 3600 rpm, resulting in an average rotational delay of 8.3 milliseconds. Track-to-track, average, and across-all-tracks head positioning times are 6, 30, and 55 milliseconds, respectively. Head positioning is performed by a closed-loop proportional servo system driving a voice-coil actuator. Data transfer rate is 1.2 megabytes per second.

RM03 packaged products include the RWM03-A single-access subsystem and the RWM03-B dual-access subsystem. Both subsystems consist of one drive and a controller for up to eight drives. The RM03 drives are for use in PDP-11/70 systems only. The RM03 is manufactured by Control Data (9762).

RP06 176-MEGABYTE DISK PACK DRIVES: Employs a 12-platter disk pack and utilizes a technology similar to that of the IBM 3330, through the use of a track-following servo system. The bottom surface of the pack is dedicated to servo control and tracking. The drive rotates a 360 rpm, resulting in an average delay of 8.3 milliseconds. The peak data transfer rate is 806K bytes per second (2.5 microseconds per 16-bit word). Average access time is 38.3 milliseconds.

Each subsystem includes a controller for up to 8 drives. Two types of controllers are offered: the "W" controller, which takes advantage of the higher I/O rate of the PDP-11/70; and the "J" controllers, usable with all current PDP-11's. The "W" subsystems include either a single-access or dual-access disk drive and controller. A dual-port kit is optional, permitting single-access disk drive to be converted to the dual-access models. Both the "J" and "W" controller can connect to a dual-ported disk pack drive.

INPUT/OUTPUT UNITS

Please refer to the Peripherals/Terminals Table on page M11-384-303 for information on the DEC peripheral equipment for the PDP-11 computers. Non-DEC peripheral devices that can be used with these and other popular minicomputers are summarized in Reports M13-100-301 through M13-100-601.

DATA COMMUNICATIONS

A discussion of data communications capabilities for the PDP-11 family involves more than a collection of hardware interfaces and a few software packages. Rather, it involves a marketing and engineering group—the Distributed Data Processing Group—which is chartered to develop, market, and generally further DEC's position in data communications. This group has taken its assigned tasks quite seriously and has developed hardware components, systems, and software packages in great numbers—so great, in fact, that the offerings of this *group* to the market are greater than those of many *companies* dedicated entirely to data communications.

Of the numerous DEC processor lines, the PDP-11 family was chosen for data communications emphasis. That doesn't mean that only 11's are found in these systems. Quite the contrary. The PDP-8's (see Report M11-384-101) were there initially also, and this family has its representatives in every DEC application line, due mostly to longevity.

Members of the PDP-11 line were selected for data communications use because of the wide spectrum of models with varying capabilities, ranging from the PDP-11/03 to the PDP-11/70. DEC states that it has placed much emphasis on giving all the PDP-11's considerable data communications capabilities, pointing to their byte-handling capabilities and

DEC PDP-11 Family

ware, RSX-11M-PLUS will support twice the users and tasks of RSX-11M.

Both RSX-11D and -11M use the same file management modules, providing automatic space allocation and file structures for any block-structured file device.

RSX-11S is a memory-based subset of RSX-11M and does not require any disk storage. It does not support program development or a file system, and merely provides a run-time environment for application programs developed on larger host systems. RSX-11S requires only a 16K-byte CPU and a loading device and supports only the smaller mass storage devices.

RSTS/E is DEC's resource-sharing, time-sharing system that supports up to 63 simultaneous users performing either interactive data processing using the BASIC-PLUS language or batch-mode operations using COBOL. RSTS/E also has a more sophisticated file system than RSX-11, supporting both random and sequential files. In addition, the newly announced RMS-11 adds multi-keyed indexed sequential (ISAM) files to the list. RMS-11 enhances the RSTS/E file capabilities with multi-level privacy control and allows both generic and approximate key searches. RSTS/E requires an 11/34 or larger with a minimum of 64K bytes of memory, hard disk, magnetic tape, and a console terminal.

DMS-11 is an interactive multi-user operating system that is optimized for data base management functions, including the random retrieval of string-oriented data from large tree-structured files.

IAS, originally developed to take advantage of the new PDP-11/70 functions, can also run on a PDP-11/45 and PDP-11/60. IAS permits three concurrent operating modes— real-time, interactive, and batch—providing interactive multi-language services for up to 32 simultaneous users. IAS uses the same file management modules as RSX-11D and -11M as well as other control modules. In addition, IAS provides output spooling services to printers and non-interactive terminals, accounting information for both interactive and batch users showing CPU and memory utilization and connect time, automatic error logging on disk, and user-initiated diagnostic routines for confidence checks.

In programming languages, DEC offers PDP-11 users APL-11 under RSTS/E and RT-11; several versions of BASIC under various operating systems; COBOL under RSX-11D, RSTS/E and IAS/RSX-11M; CORAL-66 under IAS/RSX-11M; DIBOL-11; FOCAL under RT-11; several versions of FORTRAN IV under various operating systems; MUMPS-11 under DSM-11; and RPG-11.

Communications software products include IBM HASP, 2780, and 3271 emulators, Control Data 200 and Univac 1004 emulators, and the extensive DECnet communications network software.

the Unibus architecture, which does not require additional multiplexing hardware for multiple communications channels or for DMA transfers. Also, all PDP-11 communications interfaces follow standard PDP-11 configuration rules. Special chassis and/or backplanes for communications options are not required, as is the case with some other vendors' equipment.

This section covers both the hardware and software aspects of the PDP-11 data communication equipment, including systems offerings. The software packages, which are the breath of life to the various hardware configurations, are often used to name a specific product line, such as an RSTS/2780 system. RSTS is the name of a software package. This name is also given to product systems which use RSTS to control the associated hardware that makes up the *physical* system. This point has been brought out because the ensuing section will mention product names that may otherwise be considered additional hardware offerings, but which are merely standard components configurations with particular software packages controlling them.

Data communications control for all PDP-11's is supplied by numerous interface controllers. However, each of these has a number of variants and options so that PDP-11's can be connected to almost any type of communication channel (private phone, dial-up phone, 20-ma line, telegraph line), almost any type of terminal, or almost any type of modem. Supplementing these interfaces is additional data communications hardware to provide flexibility in unique situations.

Communications Hardware Interface	Line Adapter	Line Adapter Type
DV11-AA	DV11-BA	8-line; synchronous
	DV11-BB	8-line; asynchronous
	DV11-BC	8-line; 4 lines asynchronous, 4 lines synchronous
DMC11-AL	DMC11-MA	1-line, 1,000K bps, 6000 ft.
	DMC11-MD	1-line; 56K bps; 18,000 ft.
DMC11-AR	DMC11-DA	1-line; Bell 200 Series up to 19,200 bps

The characteristics of the available interface controllers are summarized in the Communications Hardware Interfaces table on page M11-384-315. The available communications line adapters and their specifications are tabulated below.

The *DL11 Asynchronous Serial Line Interfaces* provide full- or half-duplex line control, changeable under program control. Mode changing, however, is the only programmed change that can be made to this unit. All other characteristics are set when the device is ordered, usually by straps on the board. Those features include a choice of 13 standard data rates between 50 and 9600 bits per second, choice of character size (5, 6, 7, or 8 bits) and stop element size (1, 1.5, or 2 bits), and selection of parity (odd, even, or none). Appropriate parity is appended to outgoing characters, and parity is checked on incoming characters. The unit contains independent two-character buffers (one to transmit data and one to receive data), permitting longer delays between interrupt servicing without annoying rate errors. The DL11 can operate with different input and output line speeds *except* when the 110 or 134.5 bps speeds have been selected. The DL11 is contained on one board.

The *DZ11 Asynchronous Multiplexers* have characteristics similar to those of the DJ11, but each line can be individually programmed through software control for one of 15 line speeds between 50 and 9600 bps. The DZ11 is a lower-cost, reduced-performance multiplexer and does not have DMA facilities. However, the DZ11 includes enough modem controls to operate a 300-bps data set. Interrupts can be programmed to occur for each character or after 16 characters. The DZ11 is generally transparent to data, but can report

DEC PDP-11 Family

COMMUNICATIONS HARDWARE INTERFACES

Unit	Line Interface	Max. Line Speed, bps	Mode	DMA Data Transfer In	DMA Data Transfer Out	Lines per Unit	Max. Units per System (1)	Max. System Throughput, cps	Backplane Requirement	DECnet Support	Operating System Support (2)	Comments
Single-Line Asynchronous:												
DL11-F	20-ma current loop	2400	Fdx/Hdx	No	No	1	16	—	1 quad	—	—	
DL11-FA	20-ma current loop	9600	Fdx/Hdx	No	No	1	31	—	1 quad	—	—	
DL11-FB	EIA/CCITT	9600	Fdx/Adx	No	No	1	31	—	1 quad	—	—	
DL11-E	EIA/CCITT	9600	Fdx/Hdx	No	No	1	31	2400	1 quad	Yes	All	For Bell 103A, E, F; 113A; 202C or D
DL11-WA	20-ma current loop	9600	Fdx	No	No	1	16	2400	1 quad	Yes	All	Inc. Line Frequency real-time clock
DL11-WB	EIA/CCITT	9600	Fdx	No	No	1	16	2400	1 quad	Yes	All	Inc. line frequency real-time clock
DLV11	20-ma/EIA/CCITT	9600	—	—	—	1	—	—	1 sgl. 11/03	—	RT-11	No modem control
DLV11-E	EIA/CCITT	—	—	—	—	1	—	—	—	—	—	For Bell modems
DLV11-J	EIA	38,400	—	—	—	1	—	—	—	—	—	4 independent units; RS-422, -423
Asynchronous Multiplexers (Programmed I/O):												
DZ11-A	EIA/CCITT	9600	Fdx	No	No	8	16	19,200	1 hex	No	All	Inc. control fo rBell 103 or 113
DZ11-B	DZ11-A expansion	9600	Fdx	No	No	8	—	—	1 hex	—	All	
DZ11-C	20-ma current loop	9600	Fdx	No	No	8	16	19,250	1 hex	No	All	
DZ11-D	DZ11-C expansion	9600	Fdx	No	No	8	8	38.4K	1 hex	No	All	
DZ11-E	EIA/CCITT	9600	—	—	—	16	—	—	2 hex	—	All	Inc. control for Bell 103 or 113
DZ11-F	20-ma current loop	9600	—	—	—	16	—	—	2 hex	—	All	
DZV11-B	EIA/CCITT	9600	—	—	—	4	—	—	1 sgl. 11/03	—	—	Inc. control for Bell 103 or 113
Asynchronous Multiplexers (NPR Output):												
DH11-AD	EIA/CCITT	9600	Fdx/Hdx	No	Yes	16	16	38.4K	2SU	No	RSTS,11M,IAS	Includes control for Bell modems
DH11-AE	EIA/CCITT	—	—	—	—	—	16	—	2SU	—	All but RT-11	No modem control
Single-Line Synchronous:												
DUP11-DA	Bell 200 Series	9600	Fdx/Hdx	No	No	1	16	2400	1 hex	Yes	—	DDCMP, Bisync, SDLC, HDLC protocols
DUV11-DA	Bell 200 Series	9600	Fdx	—	—	1	—	—	—	—	—	
DMC11-AL	Local Line	1000K	Fdx/Hdx	Yes	Yes	1	2	250K	1 hex	Yes	All	DDCMP microprocessor module
DMC11-AR	Remote line	19.2K	Fdx/Hdx	Yes	Yes	1	16	4800	1 hex	Yes	All	DDCMP microprocessor module
DQ11-DA	EIA/CCITT	10,000	Fdx/Hdx	Yes	Yes	1	16	2400	1SU	Yes	IAS, RSX	For Bell 201, 208, or 209
DQ11-EA	EIA/CCITT	1000K	Fdx/Hdx	Yes	Yes	1	16	250K	1SU	Yes	IAS, RSX	For Bell 303
Multiple-Line Synchronous/Asynchronous:												
DV11-AA	EIA/CCITT	9600	Fdx/Hdx	Yes	Yes	16	2	38.4K	2SU	Yes	—	NPR I/O transfers; tbl.-driven char. proc.
General-Purpose:												
DR11-B	16-bit parallel direct attach.	—	—	Yes	Yes	—	32	—	1SU	No	RT-11, 11M	NPR operation
DR11-C	16-bit parallel direct attach.	—	—	No	No	—	32	—	1 quad	No	RT-11, 11M	Bidirectional
DR11-K	16-bit parallel direct attach.	—	—	—	—	—	—	—	1 hex	—	RT-11, RSTS	Bidirectional; each line can interrupt
DRV11-B	16-bit parallel direct attach.	—	—	Yes	Yes	—	—	500K	—	—	RT-11	

(1) Usually, more than the number indicated can be physically attached; message processing throughput is the limiting factor.
(2) RSTS=RSTS/E; RSX=RSX-11S, -11D, -11M; 11M=RSX-11M.

TRAX, introduced in May 1978, is an interactive transaction processing system that runs on PDP-11/34, PDP-11/60, and PDP-11/70 computers. The user interface to TRAX is a new microprocessor-controlled application terminal, the VT62. Available only in packaged system form, TRAX supports up to 16 simultaneously active terminals on a PDP-11/34 system and up to 64 terminals on a PDP-11/70 system.

TRAX includes extensive file organization and record access services, restart/recovery, data protection, and forms handling capabilities. Application programs are written in small, structured modules in either the COBOL or BASIC-PLUS II high-level language; terminal screens are formatted using the ATL forms language. Programs are both created and tested interactively. Built-in communications options, using either COBOL or BASIC-PLUS II, enable several TRAX systems to exchange data and process inquiries. TRAX systems can also communicate with mainframe systems using TRAX 3271 protocol emulation.

For data base users, DEC offers DBMS-11, a data base management software system based on Cullinane Cor-

parity errors and framing errors. Input characters are buffered with identification hardware in a first-in/first-out (FIFO) buffer or "silo" (in DEC terms).

The *DUP-11 Synchronous Line Interface* is a single-line, program-controlled, double-buffered controller capable of handling both byte-oriented protocols, such as binary synchronous and DEC's DDCMP, and bit-oriented protocols, such as SDLC, HDLC, and ADDCP. The DUP-11 is restricted to 8-bit characters. Bit- or byte-oriented operations are software-selectable. Modem controls are provided, permitting operation with Bell 200 Series or equivalent synchronous data sets at speeds up to 9600 bps.

Additional features of the DUP-11 including calculating and checking of CRC-16 block check characters and bit stuffing. The latter is used in several of the new data communication protocols to preclude data characters from being confused with control characters. Specifically, the DUP-11 inserts "0" bits in bit streams containing five or more consecutive "1" bits so that the receiving device will not interpret this stream as a FLAG control character.

The *DQ11 Synchronous Line Interfaces* offer many of the features of the DU11 plus a number of unique qualities. The similar characteristics are modem-controlled data rates (up to 1 megabit per second in this case), optional clock (DQ11-KA) for local connection, and programmable selection of sync character and character size (to 16 bits this time). Unlike the

poration's IDMS. This makes two powerful data base management systems available for PDP-11 systems, since Cincom Systems has developed a version of its popular TOTAL system for use on PDP-11's. DEC chose to go with the Cullinane system because it conforms to CODASYL recommendations.

A substantial library of user-generated, but not DEC-supported, software is available from two groups within DEC. DECUS, the DEC USers Society, offers a catalog of software packages that includes languages, editors, numerical functions, utilities, display routines, and various other types of applications software. Also, the Educational Products Group publishes the Index and Description of Educational Applicational Software (IDEAS), which lists software packages developed by users specifically for educational purposes. Some of the programs listed in the IDEAS catalog are from the DECUS catalog. Users can obtain copies of these programs on various media for a nominal charge by contacting either of these organizations.

Although DEC sells most of its products on a purchase basis, leasing arrangements are available through DEC's Customer Finance Department. Available are full payout leases with 3 to 5 year terms and 3 to 5 years conditional sales agreements.

Hardware and software maintenance are offered through several levels of optional service. Hardware maintenance options vary from several off-site plans to on-call service and guaranteed four-hour service. Software maintenance is offered through several levels of optional service ranging from a periodic software newsletter to automatic updates of software and manuals via a subscription service.

USER REACTION

Datapro received responses from 112 users of DEC PDP-11 systems in the 1980 of computer users. The survey included users with LSI-11, PDP-11/03, 11/04, 11/05, 11/10, 11/23, 11/35, 11/40, 11/45, 11/50, 11/55, and 11/60 systems. In this year's survey we received no responses from users who identified their system specifically as a PDP-11/70.

The bulk of the users with systems smaller than the 11/35 were using RTS-11, while the most popular operating system with the larger systems was RSTS/E. A few users were using non-DEC products. BASIC was the most popular language among these users, but also in use were the assembly, Macro-11, DIBOL, FORTRAN, MU BASIC, PASCAL, and RPG.

These systems had been installed for periods ranging from 3 months to about 42 months. The majority of these users had purchased their systems, although some were leasing.

The ratings assigned by these users are shown below.

DU11, the DQ11 makes use of DMA, through on-board word count and address registers, for data transfers, which explains the high rate that is possible. Although sync characters are program-selectable, the choice as to whether there will be one or two sync characters per frame is made through a switch on the board. Three different operating modes—auto idle, strip sync, and half-duplex—are also program-selectable. In auto idle mode, sync characters are transmitted continuously until either the CPU or terminal signals its intention to send data. In strip sync mode, only the text portions of received messages are sent to the CPU and main memory. Sync characters are discarded after detection. Straps are provided for the user to designate any three characters as control characters. When any of these characters is received, a vectored interrupt will be generated to the CPU.

Another useful feature of the DQ11 is programmable selection of parity on received data (odd, even, or none) and programmable LRC/CRC generation and checking in hardware. If desired, LRC and/or CRC characters are appended to the transmitted data stream and checked when arriving with the input data stream.

Input and output sides of the DQ11 have two sets of word count and address registers. The DQ11 can be set to automatically switch from one set to another when a buffer is exhausted. This permits longer delays between interrupt servicing without incurring annoying rate errors. This unit furnishes RS-232C/CCITT V.24-compatible control Bell 201 or 303 modems or equivalents. It occupies one slot in a DD11 peripheral mounting panel.

The *DMC11 Network Link* is a complement to the DQ11 and is designed for high-performance interconnection of PDP-11 computers in network applications. Data rates of up to 1 million bps can be obtained over coaxial cable at distances of up to 6000 feet. Lesser data rates can be realized over greater distances.

The DMC11 is a microprocessor-based unit consisting of two modules, the DMC11-AD microprocessor module and one of the DMC11-MA, DMC11-MD, or the DMC11-DA line unit modules. Even though the line units are also mounted on hex-sized modules, they only require an SPC (quad) slot having been cut away to permit mounting over the normal Unibus connector in a DD11 peripheral mounting panel.

The three line modules adapt the DMC11 to various applications. The DMC11-MA contains a built-in modem and is used for local operation at 1 million bps over coaxial cable up to 6000 feet long. The DMC11-MD also contains a built-in modem but is used to send data over distances up to 18,000 feet at rates up to 56,000 bps. The DMC11-DA does not have a built-in modem, and only includes an EIA RS-232C interface. It is intended for use with Bell 208, 209, or equivalent modems at data rates up to 19,200 bps.

The DMC11 is intended specifically for the DDCMP protocol. The microprocessor communicates with the host computer through DMA operations and is assigned a 256-byte memory block by the operating software, for use as a control and status block. Up to seven input and seven output messages can be queued in main memory by the DMC11.

The DMC11 also features a built-in bootstrap, permitting remote program loading and control transfer on CPU's that do not have bootstrap facilities.

The *DV11 Synchronous Preprocessor* is a high-performance, microprocessor-based multiplexer that features DMA data transfers and data rates of up to 9600 bits per second for each of 16 full-duplex lines. (Total throughput capacity is 38,400 characters per second). It can relieve up to 95 percent of the central processor's load in terms of interrupt handling, generating block characters, and special character handling.

DEC PDP-11 Family

	Excellent	Good	Fair	Poor	WA*
Ease of operation	45	55	10	2	3.3
Reliability of mainframe	60	41	10	1	3.4
Reliability of peripherals	34	51	18	4	3.1
Maintenance service:					
Responsiveness	25	44	21	7	2.9
Effectiveness	21	54	13	9	2.9
Technical support:					
Trouble-shooting	12	41	32	12	2.5
Education	11	43	34	8	2.6
Documentation	14	46	33	11	2.6
Manufcturer's software:					
Operating system	32	60	9	4	3.1
Compilers & assemblers	25	66	14	3	3.0
Applications programs	9	34	17	3	2.8
Ease of programming	35	55	8	8	3.1
Ease of conversion	20	45	12	7	2.9
Overall satisfaction	28	70	9	5	3.1

*Weighted Average on a scale of 4.0 for Excellent.

The comments from these users were extremely varied, as might be expected. On the positive side, the advantages of the systems most cited were that the system is easy to expand/reconfigure, that programs and data carried over from other systems are compatible, and that peripherals and terminals carried over from other systems are compatible. A number of users also indicated that they were happy with response time.

On the negative side, a number of users said that delivery and/or installation was late, and that DEC did not provide all the promised software or support or that the software was late being delivered. One user also said that he was very unhappy with DEC and that they "can't deliver parts for 12 months."

Perhaps the most significant indication of the feeling of these users was their response to the question "Would you recommend this system to another user in your situation." Of the 104 users who responded to this question, 89 said yes and only 15 said no, and several of the no responses qualified this by saying that they would recommend a *different* DEC system (in most cases a larger system).□

A control table scheme tells the DV11 how to act on each incoming data or control character. Table entries specify a number of choices for each possible character: to store or not to store the character in the data buffer, to include or to exclude the character from the block check calculation, to cause or not to cause a vectored interrupt to the CPU. In addition, receipt of a character can designate that a different table is to be used for subsequent characters, thereby enabling the DV11 to detect sequences of control characters without CPU intervention. The DV11 consists of a double system unit and a distribution panel.

The *DR11 General Device Interfaces* are described here because of their possible use in PDP-11 to PDP-11 communications.

The DR11-B is a general-purpose DMA interface to the Unibus. This interface is bidirectional and operates between the Unibus and a user device. Transfers are made at a user-defined rate.

The DR11-C is a general-purpose interface between the PDP-11 Unibus and a user's peripheral device. The DR11-C can also be used as an interprocessor buffer to allow two PDP-11 processors to transfer data between each other. In this case, one DR11-C is connected to each processor bus, and the two DR11-C's are cabled together, thereby permitting the two processors to communicate.

The DR11-k is an integral logic module that forms a self-contained digital I/O interface between the PDP-11 Unibus and a user's peripheral. The DR11-k performs all the necessary tasks to communicate with the PDP-11. Like the DR11-C, the DR11-k may be used as an interprocessor buffer to exchange data.

The following units provide support functions to the line interfaces previously described:

The *DN11 Automatic Call Unit Interface* provides a buffered interface for up to four Bell 801A, 801C, or equivalent automatic all units. The DN11 uses programmed I/O for data transfers and occupies one system unit.

The *KG-11A Communications Arithmetic Option* is a programmable hardware block check character generator. It computes three different cycle redundancy check (CRC) polynomials and two different longitudinal redundancy check (LRC) characters. This single-board unit replaces software routines for generating and checking the standard check characters listed above. The choice of checking polynomials is made through program control. The unit can be used with any PDP-11 synchronous interface.

The KG11-A can be shared between multiple lines by storing interim check characters in main memory and passing the interim character to the KG11-A along with each new character. The KG11-A then computes the desired polynomial, which is read back to the CPU and stored again in main memory as the updated interim check character. In this way, several lines can make use of one unit.

COMMUNICATIONS CONTROL

A variety of communications-oriented software packages is available from DEC. These can be divided into two classes: software for communications between PDP-11's and non-DEC mainframes, and software for communications between PDP-11's and other DEC computers.

For communications with non-DEC systems, emulators provide the necessary software interfaces. DEC offers five IBM 2780 batch terminal emulators that augment the appropriate operating system and permit communications with IBM System/360 or 370 computers. All of these emulators: 1) support operations over synchronous data links, in point-to-point contention mode, at speeds up to 4800 bps; 2) can transmit data from card readers and mass storage devices; 3) can print received data on a line printer or write it on a mass storage device; 4) can support Bell 201 or 208 or equivalent modems and OS/RTE, OS/HASP, OS/ASP, and DOS/Power; and 5) can receive data in binary form or in the EBCDIC subset that is equivalent to ASCII.

IAS/2780 requires any standard configuration and a DU11 or DUP11 and KG11. Output devices supported include a line printer or any Files-11 device except DECtape and paper tape punch. Input devices supported include a card reader or any Files-11 device except DECtape. Spooling is supported on reception but not transmission. Forms control supported includes top of form; skip 1, 2, or 3 lines; skip module 8; and horizontal control.

Specifications for RSX-11D/2780 and RSX-11M/2780 are the same as for IAS/2780 except that the RSX-11M version requires 64K bytes of memory and the RSX-11D version requires 112K bytes of memory.

DEC PDP-11 Family

RSTS-E/2780 requires a minimum system consistent with the number of users and expected application plus 16K bytes of memory and DU11 or DUP11 and KG11. Output devices supported include a line printer or any mass storage device except diskette drives. Input devices supported include a card reader, any mass storage devices, or, to a limited extent, magnetic tape units. Spooling is supported. Forms control includes top of forms; horizontal control; and skip 1, 2, or 3 lines.

RT-11/2780 requires a disk-based foreground/background RT-11 system with 32K bytes of memory and DU11 or DUP11 and KW11-L, KG11. Output devices supported include a line printer or any disk supported under RT11. Input devices supported include a card reader, paper tape reader, or any disk supported by RT-11. Forms control consists of top of forms; skip 1, 2, or 3 lines; skip modulo 8; and horizontal control. Spooling is not supported.

For all-DEC computer networks, there is *DECNET,* which is actually a number of specific products aimed at several broad markets. Announced in April 1975 as a series of hardware and software extensions to standard systems, DECNET permits users to create communications networks merely by adding appropriate software and hardware to existing computer systems.

DECNET is not a turnkey solution. At the very least, customers must purchase communications links such as a telephone line or private wire, one or more of DEC's communications interfaces for each computer in the network, and often a modem for each end of every link. Some of the more complicated applications will require considerable programming, as well.

DECNET allows customers to:

- Transmit data files across a room or around the world, with less expense and greater speed than is generally possible through other media.
- Share expensive peripherals among several CPU's, some of which may be remote.
- Use another tool in the creation of high-availability (super-reliable) systems, adding to the Unibus links and multi-port options that Digital already supplies.
- Make more extensive use of memory-only systems.

DECNET is also the collective name for the set of software products which extend various DEC operating systems so they can be interconnected with each other to form computer networks. The DECNET user can configure a variety of networks by choosing the appropriate CPU's, line interfaces (and speeds), and operating systems software. Such networks typically fall into one of three classes: 1) these that move data from one physical location to another; 2) file-oriented networks, often the case for remote job entry systems; or 3) line-oriented networks, as occurs with the concentration of interactive terminal data.

DECNET includes a set of network protocols, each designed to fulfill specific functions within the network. Collectively, these protocols are known as the Digital Network Architecture, or DNA. The major protocols, and their functions, are as follows. Digital Data Communications Message Protocol (DDCMP) handles the link traffic control and error recovery within DECNET (physical link between the line and the processor). DDCMP has been designed to operate over full- and half-duplex facilities, using synchronous, asynchronous, and parallel facilities. Network Services Protocol (NSP) handles network management functions within DECNET (logical link between the physical line and the user programs) including the routing of messages between systems and within any given system. Data Access Protocol (DAP) enables programs on one node of the network to utilize the I/O services available on other network nodes. Each operating system in DECNET provides facilities for translating its own unique I/O calls into the DAP standard, and vice versa. DAP thus allows remote file access, including OPEN, READ, WRITE, CLOSE and DELETE for sequential and random files, and remote device access for unit record devices.

DDCMP performs the physical line control only for the interfaces noted in the Communications Hardware Interfaces table as DECnet-supported. DDCMP performs line scanning, error detection and error recovery. On half-duplex lines, DDCMP controls the direction of traffic, while on full-duplex lines, DDCMP controls bidirectional traffic; on multi-point lines DDCMP performs the polling function. Outgoing transmissions are enveloped with control characters mainly to enable the receiving device to perform error detection. The CRC-16 polynomial checking technique is employed in creating an error detection code. Incoming transmissions are stripped of control characters after passing error detection checks. To accommodate the relatively long transit times for satellite-destined messages, DDCMP can support the transmitting of up to 255 messages before halting transmission to await acknowledgements for the previously transmitted messages.

DECnet software to handle the DDCMP protocol line handling is intended for use with low or medium-speed communications systems. The software will perform the function for both the program-interrupt and the DMA types of communications hardware interfaces. When volume increases substantially and begins to consume too much central processor overhead, or when high-speed communications lines are used, the DMC11 interface can be employed. Containing a dedicated microprocessor, the DMC11 will perform, via firmware, the line handling function, thus relieving the central processor's DECnet software of this time-costly burden. With the DMC11, a user could employ DDCMP protocol without using the other functions of DECnet.

When NSP receives a message for transmission from a program, NSP affixes the receiving program's identifier and sends it to the appropriate physical link for DDCMP protocol line handling. Incoming messages are stripped of their envelope characters and given to the appropriate program. When two remotely located programs must talk to each other by passing a high volume of a particular type of data (as in remote program loading), NSP can establish a Dynamic Logical Link between the programs and will pass only the specified type of data through the link.

When a remotely located program wants access to a file, NSP does not supply the request to a user program, but to the DAP DECnet module. This module goes through the same steps a local user program would take to get at data from mass storage. Namely, it issues an open and a read/write command to the File Management System. If the remote command was a Read, DAP would obtain the data and pass it to NSP for transmission. NSP will treat the data as just another outgoing message from just another user. DAP will also interface with the Device Handler software that controls unit record equipment and locally attached terminals.

A goal for the set of DEC products has been to provide as general an interconnection mechanism between specific products as possible, limited only by the technology and cost considerations which constrain each individual member of DECnet. Those latter constraints make totally general interconnectability impractical. The individual DEC Software Product Descriptions for each product should be consulted in order to ascertain whether any particular configuration violates the guidelines for the individual product.

DEC has extended the range of its DECnet communications software to include networking among most DEC operating systems and processors ranging from the LSI-11 microcomputer to the 32-bit VAX-11/780.

DEC PDP-11 Family

In 1978, DEC made changes to the Network Service Protocol (NSP), Data Access Protocol (DAP), and Digital Data Communications Message Protocols (DDCMP) within DEC's Digital Network Architecture. Among the changes are improved support for various systems under DAP and the ability to prevent network overloads under NSP.

Basically, the revised DECnet programs were designed to simplify network configuration and generation and to provide computing networks for industrial, commercial, scientific, and educational markets. The programs allow "dynamic reconfiguration," the ability to switch lines without interrupting service in case of malfunction. A full point-to-point interconnect capability allows disk-to-task communications by which programs running on separate networks can exchange data. Remote resource access for use of peripherals at another node and remote sequential I/O files are also supported.

While DECNET represents a generalized approach to computer networks within the DEC family, the company is continuing development of a series of remote terminal emulators for other manufacturers' host mainframes. In the PDP-11 family, the previously discussed IBM 2780 emulator is now available under RSX-11D, RSX-11M, RSTS/E, IAS, and RT-11. Multi-leaving HASP emulation is now available under RSX-11D and RSX-11M, as well as in a stand-alone version. Direct channel interfaces to IBM computers via the DX11 have also been sold in custom situations under RSX-11M.

Remote job entry to Control Data and Univac mainframes is also available under RSX-11D and RSX-11M. Sold under the names MUS-200 and MUS-1004, DEC's RJE emulators offer sophisticated replacements for the Control Data 200 User Terminal and the Univac 1004. The power of DEC's real-time operating systems, coupled with the RJE emulation, provides an attractive price/performance mix.

In February 1980, DEC opened DECnet, Phase III, by introducing DECnet-11M-PLUS, DECnet-11M, and DECnet-11S for PDP-11 computers using the RSX-11 family of operating systems. According to DEC, there will be equivalent announcements over the next two years for other major operating systems. In addition to the above, DEC also announced a new communications interface giving PDP-11 systems interactive access to IBM Systems Network Architecture (SNA) host machines, and a commitment to support of X.25 packet-switching network technology.

The major new features of DECnet Phase III products include:

Adaptive path routing. One DECnet network node may send messages to another through intermediate nodes. Each node maintains a routing table for the entire network, and where more than one path exists between source and destination nodes, the network automatically selects the least-cost path according to line values assigned by the network manager. Routing tables are updated whenever changes in line or system status occur; if service is interrupted on any line, the network automatically reroutes the message across the next-least-cost path.

DECnet Phase III networks comprise both routing nodes, which can send, receive, and forward messages, and end nodes, which only send and receive. Multitasking, mapped systems running under RSX-11M or RSX-11M-PLUS can function as either routing or end nodes, while small, unmapped RSX-11M or 11S systems participate as end nodes only.

Multipoint. Also called multidrop, this feature allows up to six remote (or "slave") systems to communicate over a single line with a host (or "master") system, which controls communication and polls each slave system in turn. Slaves can communicate with each other through the host. Multipoint configurations can exist as subgroups within larger networks, enabling both master and slave systems to participate in message routing, file transfer and resource access with other systems.

Multipoint networks are designed as low-cost installations for applications with low intersystem communication requirements.

Network command terminals. Terminal users at one DECnet node can perform standard terminal functions on any other node utilizing the same operating software (e.g., any RSX-11 system). Interaction proceeds as if the terminal were local to the remote system, and the network interface is user-transparent. Network command terminals provide users direct access to programs and devices on remote systems anywhere in the network.

Network management. Management functions can be either centralized or fully distributed across all nodes for efficient monitoring of communication loads, error rates, line condition and node status at all points in the network. Management software enables network managers to evaluate overall network efficiency and to optimize traffic flow by dynamic adjustment of line values. Managers can perform system, interface and line testing while network operation continues.

The RSX-11M/SNA Protocol Emulator permits PDP-11 computers using the RSX-11M real-time operating system to engage in interactive communication with an IBM host computer that supports an SNA network. The software offers three levels of access to SNA protocols. These range from interaction with applications in a CICS (Customer Information Control System) or IMS (Information Management System) environment to SNA session initiation, termination, and data flow control. The emulator can be used as a memory-resident package, or in conjunction with a KMC-11A microprocessor-equipped communications interface for enhanced performance.

The software package makes possible distribution of transaction processing and database management applications within an SNA hierarchy by allowing general purpose PDP-11 systems to emulate remote SNA devices with direct access to the host mainframe.

The RSX-11M/SNA Protocol Emulator facilitates exchange of data between programs residing in an IBM host and in a PDP-11 system. The software causes the PDP-11 to appear to the IBM system as a programmable cluster controller, and can maintain up to 61 concurrent, interactive "sessions" (logical connections) with one or more programs in the SNA host machine. The protocol emulator uses IBM's SDLC (Synchronous Data Link Control) line protocol and supports as many as four synchronous lines at speeds up to 9,600 bits per second per line. With the emulator, a PDP-11 system can function either on a point-to-point line to the IBM host or on a multipoint line with other SNA devices.

SOFTWARE

OPERATING SYSTEMS: The major operating systems for the PDP-11 include: 1) the single-user RT-11 disk-based system; 2) the RSTS/E resource-sharing time-sharing system; 3) the RSX-11 real-time multiprogramming systems: RSX-11D, RSX-11M, and RSX-11S; 4) DSM-11 (Massachusetts General Hospital Utility Multi-Programming System); and 5) the multifunction, multilingual IAS operating system. The discussion of these operating systems is augmented by the Operating Systems Comparison Table which appears on pages M11-384-320 and -321.

RT-11 Disk-Based Operating System: RT-11 is an easy-to-use yet powerful operating system that includes two monitors:

DEC PDP-11 Family

OPERATING SYSTEMS COMPARISON TABLE

	RT-11	RSTS/E	RSX-11M	RSX-11S	IAS	DSM-11	RSX-11D
Hardware utilization:							
LSI-11/2	Yes	No	No	No	No	No	No
LSI-11	Yes	No	No	Yes	No	No	No
PDP-11/03	Yes	No	No	Yes	No	No	No
PDP-11/04	Yes	No	Yes	Yes	No	No	No
PDP-11/34A	Yes	Yes	Yes	Yes	No	Yes	Yes
PDP-11/35	Yes	Yes	Yes	Yes	No	Yes	Yes
PDP-11/45	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PDP-11/55	Yes	Yes	Yes	Yes	Yes	Yes	No
PDP-11/60	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PDP-11/70	No	Yes	Yes	Yes	Yes	Yes	Yes
Programming language support:							
APL	Optional	Optional	No	No	No	No	No
BASIC	Optional	Standard#	Optional	Runtime only	Optional	No	Optional
BASIC-Plus-Two	No	Optional#	Optional#	Runtime only	Optional#	No	No
COBOL	No	Optional	Optional#	Runtime only	Optional#	No	Optional
CORAL 66	No	No	Optional	No	Optional	No	Optional
DIBOL	Optional	Optional	No	No	No	No	No
FOCAL	Optional	No	No	No	No	No	No
FORTRAN IV	Optional	Optional	Optional#	Runtime only	Optional#	No	Standard
FORTRAN IV Plus	No	No	Optional#	Runtime only	Optional#	No	Optional
Macro Assembler	Standard	Standard	Standard#	Runtime only	Standard#	No	Standard
DSM-11	No	No	No	No	No	Yes	No
RPG II	No	Optional	Optional	No	Optional	No	No
Type of operating system:							
Single-user	Yes	No	No	No	No	No	No
Multi-user	No	Yes	Yes	Yes	Yes	Yes	Yes
Single-job	Yes	No	No	No	No	No	No
Foreground/background	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Multiprogramming	No	No	Yes	Yes	Yes	Yes	Yes
Time-sharing	No	Yes	Yes (quasi)	No	Yes	Yes	No
Multi-user data base mgmt.	No	No	No	No	No	Yes	No
Libraries:							
System subroutine	Yes	No	—	—	—	Yes	—
Object	Yes	Yes	Yes	No	Yes	No	Yes
Task checkpointing	No	Yes	Yes	No	Yes	Yes	Yes
Dynamic memory allocation	—	Yes	Optional	No	Yes	Yes	—
Memory mgmt. support (swapping)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Min./max. nonmapped memory (bytes)**	16K/56K	96K/—	32K/56K	16K/56K	—	64K/—	—
Min./max. mapped memory (bytes)**	64K/248K	—/1920K	48K/3840K	24K/3840K	128K/3840K	—/1024K	96K/3840K
Overlays	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mapped segments per process	—	2	8	—	8	—	8
Program scheduling:							
By operator	Yes	Yes	Yes	Yes	Yes	Yes	Yes
By event interrupt	Yes	No	Yes	Yes	Yes	Yes	Yes
By another program/task	Yes	Yes	Yes	—	Yes	Yes	Yes
By time of day	Yes	No	Yes	Optional	Yes	Yes	Yes
No. of on-line terminals allowed	16	127	NSL*	NSL*	NSL*	80	NSL*
No. of terminals in use simultaneously	16	63	16	NSL*	32	65	NSL*
Number of concurrent jobs	2	63	NSL*	NSL*	NSL*	65	NSL*
Min. memory required for monitor (bytes)	4K	48K	16K	5K	—	48K	—
Monitor completely memory-resident	No	No	No	Yes	No	Yes	No
DBMS-11 support	No	No	Yes	No	Yes	No	No
Re-entrant I/O	—	—	Yes	No	Yes	No	Yes

* NSL (no software limitation); limited by hardware configuration or performance.

**The upper 8K bytes of memory are reserved for system use. Min./max. represents the smallest/largest processor on which the software runs; individual processor requirements will vary.

Sharable library is included.

a single-job and a foreground/background (F/B) monitor. The single-job monitor can support program development or a real-time application for one user, while the F/B monitor can support concurrent real-time execution in the foreground and program development in the background, typically for one user. RT-11 is generally disk-based, with a cassette, magnetic tape, or additional cartridge disk drive needed for backup.

RT-11 also supports punched card equipment; punched tape equipment; laboratory peripheral systems (LPS-11) through BASIC, FORTRAN, and a laboratory applications library (LA-11); an analog real-time system through FORTRAN or LA-11; a graphics display system (VT11) through BASIC, FORTRAN or LA-11; and an electrostatic printer/plotter with plotting supported by BASIC and FORTRAN.

Programs supported by RT-11 include a MACRO assembler, Editor, scientific subroutine package, linker, librarian, PIP file transfer program, and utilities for file converting, dumping, comparing, and verifying. A contiguous file structure is implemented to provide fast response. Program

DEC PDP-11 Family

OPERATING SYSTEMS COMPARISON TABLE (Continued)

	RT-11	RSTS/E	RSX-11M	RSX-11S	IAS	DSM-11	RSX-11D
I/O spooling	—	Yes	Yes	Yes	Yes	Yes	Yes
Line printer	—	Yes	Yes	—	Yes	—	Yes
Multiple copies	No	Yes	No	No	Yes	—	No
Specific priority, forms type	No	Yes	No	No	Yes	—	No
Time of day, generic queues	No	Yes	No	No	No	—	No
Card reader	—	No	No	No	Yes	—	No
Output buffering	—	Yes	Yes	Yes	Yes	Yes	Yes
Concurrent batch & I/O spooling	Yes (batch)	Yes	Yes	—	Yes	No	Yes
Disk file support	Yes	Yes	Yes	No	Yes	Yes	Yes
Linked	No	Yes	No	No	No	No	No
Contiguous	Yes	Yes	Yes	No	Yes	Yes	Yes
Mapped	No	No	Yes	No	Yes	Yes	Yes
Fixed & variable-length records	No	Yes	Yes	No	Yes	Yes	Yes
File access methods:							
Sequential	Yes	Yes	Yes	No	Yes	No	Yes
Index sequential	No	Optional	Yes	No	Yes	No	No
Direct access	Yes	Yes	Yes	No	Yes	No	Yes
Multi-keyed index sequential	No	Optional	Optional	No	Optional	No	No
Hierarchical	No	No	No	No	No	Yes	No
Device allocation control	No	Yes	Yes	Yes	Yes	Yes	Yes
Usage accounting	No	Yes	No	No	Yes	No	Yes
Intertask communications	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sharable data files	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sharable libraries	No	No	Yes	Yes	Yes	Yes	Yes
Sharable data areas	No	Yes	Yes	Yes	Yes	Yes	Yes
Task size (bytes) with/without mgmt.	—	56K/—	2000K/20K	2000K/20K	32K/—	1-16K/—	32K/—
Program priority levels	2	255	250	250	250	—	250
Disk/memory program swapping	No	Yes	Yes	No	Yes	—	Yes
System generation on target equip.	Optional	Yes	Yes	—	Yes	Yes	Yes
Security:							
System level	—	Yes	Yes	No	Yes	Yes	Yes
File level	—	Yes	Yes	No	Yes	Yes	Yes
Read/Write	—	Yes	Yes	No	Yes	—	Yes
Execute	—	Yes	No	No	No	—	No
Extend/delete	—	No	Yes	No	Yes	—	Yes
Item level	—	No	No	No	No	Yes	No
Shared data read/write	—	No	Yes	No	Yes	—	Yes
Distribution media:							
DECtape	Yes	No	No	Yes	No	No	No
RK05 disk cartridge	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RK06 disk cartridge	Yes	Yes	Yes	Yes	No	Yes	No
Floppy disk	Yes	No	No	Yes	No	No	No
DECassette	No	No	No	Yes	No	No	No
9-track magnetic tape	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RL01 disk cartridge	Yes	No	Yes	No	No	No	No
RK07 disk cartridge	No	No	Yes	No	No	No	No

development may be done interactively through the console terminal, or in batch mode. Batch streams can be entered through a card reader or stored and initiated from a mass storage device such as the system disk.

RT-11 Version 3, an enhanced version, is usable on systems ranging from the microprocessor-based PDP-11/03 (LSI-11/2) through the PDP-11/60 with cache memory. The set of English-like monitor commands has been expanded from previous verions of RT-11, and the documentation accompanying the software is now contained in eight manuals written for different levels of expertise ranging from novice to expert.

High-level languages available with RT-11 are the same as in previous versions of RT-11 (see table). Storage media supported by RT-11 include magnetic disks (from diskette to 12-megabyte cartridge drives), magnetic tapes, DECtapes, and cassettes.

When RT-11 Version 3 is used in conjunction with a KT-11 memory management unit, applications programs running under the operating system can access up to 248K bytes of main memory. An optional sysgen program is available for users requiring customized systems with special user-specified options. Up to 15 terminals can be accessed on a system running under RT-11 through use of a foreground/background monitor.

RSTS/E (Resource-Sharing Timesharing System/Extended): RSTS/E is a time-sharing system designed to accommodate large numbers of interactive users. The interactive language is BASIC-PLUS, an enriched version of the popular BASIC language. RSTS/E requires a PDP-11/34A, 11/35, 11/40, 11/45, 11/60, or 11/70 with hardware memory management for memory expansion and protection. A wide range of communications interfaces is supported to allow mixes of local and remote terminals with varying characteristics. For a normal job mix, up to 24 concurrent users can be supported on a PDP-11/34A or 11/35-based system, while up to 32 can be supported on an 11/45 and 63 on an 11/70.

RSTS/E supports a wide range of peripherals, including up to eight line printers, punched card equipment, punched tape

DEC PDP-11 Family

equipment, all types of mass storage devices, communications interfaces, and IBM 2741-compatible terminals.

RSTS/E supplies a comprehensive file system. User files may be random or sequential, numeric or alphanumeric. Files can be created, updated, extended, and deleted interactively from a user terminal or under program control. Files can be protected from access on an individual, group, or universal basis; can be accessed by many terminal users simultaneously; and can be updated on-line.

RMS-11K is a file management system designed to run under RSTS/E on a PDP-11/34A, 11/45, 11/60, or 11/70. RMS-11K is a multi-key indexed sequential (ISAM) file management system that supports the ANSI-74 COBOL Level 2 Indexed I/O Module specification. The system permits both fixed- and variable-length records and provides RSTS/E users with sequential, relative, and indexed file organization. This allows sequential, random, dynamic, or direct physical access to data records. Combinations of the above modes can also be invoked. Other significant features of RMS-11K are multi-level privacy control and both generic and approximate key searches in multi-keyed indexed processing. The system manager can, for each user, specify the programmer and project number, the password, the maximum logged-out disk space, and the maximum number of files.

Access to peripheral devices is generally open to all RSTS/E users under the resource sharing concept on a first-come, first-served basis. However, the capability is available to the system manager to intervene in peripheral assignment and permit assignment as he sees fit.

RSTS/E requires a system with a console terminal, real-time clock, and 64K bytes of parity memory with the memory management option (at least 128K bytes of memory are required to support RMS-11-based languages). In addition, the system requires a disk pack system or a dual-drive fixed-head disk or disk cartridge. Magnetic tape is also generally required for software distribution.

RSX-11 Real-Time Operating Systems: The RSX-11 family consists of three compatible operating systems: RSX-11D, RSX-11M, and RSX-11S. Each features event-driven multi-programmed responses to real-time stimuli. The RSX-11 systems handle many tasks (programs) concurrently, with requests for system resources handled on a priority basis. The compatibility among systems is achieved by a hierarchical structure of Monitor Console Requests (MCR's), File Control System (FCS), and common language processors. RSX-11S is a subset of RSX-11M, which is in turn a subset of RSX-11D. As a result, programs developed for RSX-11S run directly under RSX-11M, and, by relinking, under RSX-11D. The file systems allow easy transportability of data and programs between systems.

RSX-11D Advanced Real-Time Operating System: RSX-11D is the largest and most flexible RSX-11 system. It requires an 11/34 or larger processor with hardware memory management, 96K bytes of main memory, and adequate disk and backup storage for full operation. RSX-11D has the capability to keep many tasks going at once, each with a set priority at one of 250 levels which may be amended as necessary, and all in a totally hardware-protected environment. Tasks are scheduled and executed in response to external stimuli, operator commands, or a function of time, in a multiprogrammed environment. Flexibility is obtained by the use of checkpointing (suspending an executing task, storing it on disk, substituting a higher priority task in its place, and swapping the original task back when the higher priority task is finished) and dynamic allocation of memory (which can change the partitioning of memory and the tasks assigned to partitions in real-time).

Program development can take place concurrently with real-time execution, in either batch mode or interactively. The text Editor is sharable, as can be application program developed under FORTRAN IV-PLUS. The PDP-11 COBOL language processor is also available under RSX-11D, to supplement the business data processing requirements of the real-time operations. A full set of utility programs is included.

Files-11 is a general-purpose file system that provides a facility for the dynamic creation, extension, and deletion of files on disk. The file system employs two types of directory files: the master file directory, created when a volume is initialized, and user file directories, created as needed and used to store pointers to all files associated with a given file name and account number. Files can be organized either randomly or sequentially. Designed into Files-11 is a scheme for volume and file protection which allows the owner of a volume or file to deny all access or certain kinds of access to all users, groups of users, or particular users in the system.

In addition to the RSX-11 Files-11 file system, RSX-11D supports ANSI standard Level 3 format for single- or multi-volume, multi-reel magnetic tape files.

The Monitor Console Routine (MCR) is the interactive terminal interface between the user and the RSX-11 operating system. MCR includes initialization commands, informational messages, task control commands, and system maintenance commands. Some commands are privileged and can be invoked only by privileged users, as defined by the system manager. The organization of MCR allows users to add commands to meet special application needs.

The minimum configuration for RSX-11D includes a central processor with memory management unit and at least 96K bytes of memory, a console terminal, a disk system, and a magnetic tape system. If concurrent program development and applications execution is desired, at least 112K bytes of memory are required.

RSX-11D supports a variety of laboratory, industrial control, and communications equipment, including the AD01 Analog/Digital Converter, LPS11 Lab Peripheral System, ICS/ICR Industrial Control Systems (local and remote), and modem control multiplexers. Standard peripheral devices, such as a card reader, paper tape reader/punch, and line printer, are also supported.

RSX-11M is a subset of RSX-11D that provides less flexibility at a lower overhead. Real-time execution is event-driven by priority in a multiprogrammed environment, as in RSX-11D, RSX-11M supports checkpointing, and memory allocation is dynamic. The lower overhead allows RSX-11M to operate on PDP-11/04 systems as well as on 11/34's, 11/35's, 11/45's, and up. On the latter systems, hardware memory management is not required, but it can be utilized for memory protection and expansion.

Multi-user program development is accomplished using either of two supplied editors from terminals. The full range of language processors is available. A foreground-only (i.e., real-time execution only) system can operate in as little as 32K bytes, with program development taking place when no tasks are executing. RSX-11M is disk-based and requires a backup/distribution device in addition to the system disk drive.

The RSX-11M file management system is the same file system used in RSX-11D (Files-11), providing automatic allocation and file structures for all block-structured devices, including the RX11 floppy disk. Files can be organized as either random or sequential and can be accessed by file name. A selective protection feature permits file access to specified users. As an option, RMS-11K is available (see RSTS/E).

RSX-11M has a program logical space extension feature that allows execution of very large application programs without

DEC PDP-11 Family

requiring disk overlays. A single program can occupy all user space (less the resident system). This feature permits faster execution of larger programs, but at some expense to smaller lower-priority programs that must be stored on disk while the larger program occupies main memory.

RSX-11M runs on any of the PDP-11 processors except the LSI-11-based processors. The minimum configuration requires a central processor with a clock and at least 32K bytes of memory, a console terminal, a disk system, and a backup device. The minimum system requires 16K bytes of memory for the operating system, leaving 16K bytes of memory available for user tasks. If concurrent program development and applications execution is desired, at least 48K bytes of memory are required. Memory can expand to 56K bytes of user memory on systems without the memory management options, to 248K bytes on systems with the memory management unit, or to 3840K bytes on the PDP-11/70.

RSX-11M, like RSX-11D, supports a wide range of laboratory, industrial control, and communications equipment, including the AR11 Analog Real-Time Subsystem, LPS11 Lab Peripheral System, ICS/ICR Industrial Control Systems (local and remote), modem control multiplexers, and the DMS Unibus link. Standard peripheral devices, such as floppy disks, cassettes, a card reader, paper tape reader/punch, and line printer, are also supported.

In April 1979, DEC announced RSX-11M-PLUS, an extended version of RSX-11M that supports major PDP-11 high-level languages and is compatible with command languages of DEC's VAX/VMS and RT-11 operating systems. With appropriate hardware, the new operating system will support twice the users and tasks of the current version of RSX-11M.

RSX-11M-PLUS supports FORTRAN IV, FORTRAN IV-PLUS, BASIC-11, BASIC-PLUS-2, and PDP-11 COBOL, as well as data-related software including DBMS-11, DATATRIEVE, RPG II, and DECnet.

RSX-11M-PLUS features include transparent spooling and a per-user accounting facility of system operation. A "shadowed disk" feature enables users to maintain redundant disk storage of data for applications requiring a high degree of data reliability. A complete batch facility similar in format and power to VAX/VMS batch is also provided. The operating system also features two command languages: the standard RSX-11M language (MCR) and the Digital Command Language (DCL), which is compatible with RT-11, TRAX, IAS, and VAX/VMS. RSX-11M-PLUS is upward compatible with current RSX-11M operating systems.

RSX-11S is a memory-based subset of RSX-11M that requires no disk storage for operation. It is an execute-only system, with program development accomplished on an RSX-11M system. Since there is no disk storage, checkpointing is not supported. The application programs are transported from the RSX-11M development system to the RSX-11S target system through a mutual exchange medium such as cassette. The priority structure and execution of tasks is compatible with RSX-11M.

RSX-11S is suitable for use where harsh environments prohibit disk-based operation, or where dedicated applications do not require the expense and flexibility of a disk. However, RSX-11S supports all the disks (and other peripherals) supported by RSX-11M. Devices with full file directory support (such as disks) under RSX-11M are utilized without directory support under RSX-11S. The system can operate on a PDP-11 with as little as 16K bytes of memory, a terminal, and a program loading device. The system can support a console terminal if operator communication is desired. At least 32K bytes of memory are needed to support on-line task loading or the execution of tasks written in FORTRAN.

DSM-11 is an interactive multi-user operating system that is optimized for data base management functions, including the random retrieval of string-oriented data from large tree-structured files. Processors with up to 56K bytes of user memory can have up to 16 user partitions, while larger memory configurations can have up to 40 user partitions. Each partition holds one active user's program, local data, and system overhead data and may or may not be associated with a terminal. Recommended partition size is 4K bytes, but variable sizes are permissible depending on the application.

DSM-11 operates by employing a checkpoint form of time-sharing, whereby a program is allowed to execute until its time slice has expired, plus any additional time required to complete a current operation.

DSM-11 is completely memory-resident and consists of an executive for the supervision of time-sharing/multiprogramming operations; an I/O monitor for terminal supervision, peripheral device I/O, and peripheral device interrupt processing; a language interpreter for MUMPS-language (DSM-11) programs; and a data base supervisor designed to perform all logical and physical control of the data base.

The executive uses a set of priority-weighted queues to administer its scheduling algorithm. These queues include one or more wait-queues and a run-queue (where it receives its time slice). Communication between the DSM-11 language interpreter and the I/O monitor is via buffers, filled and emptied asynchronously by the monitor so as to overlap output with that of the program's processing when possible.

The data base supervisor is actually a group of routines which provide both physical and logical control of mass storage. All file information is referenced symbolically, in the context of hierarchical global variables and arrays. Under this technique, the context and structure of the tree-structured symbol tables are logically mapped into the physical mass storage of the system.

Each user of the DSM-11 system gains access to the system's programs using a special log-in sequence which involves one or two access codes (depending on the privileges of the user). These codes, provided by the system manager, are the User Class Identifier code (or UCI) and the Programmer Access Code (or PAC).

The DSM-11 system can have up to 16 UCI's (classes of users). The UCI code must be entered by everyone who wishes to use the system. It allows access to the programs and globals listed in the program and global directories for that UCI. A user who is permitted simply to run programs needs to know only the UCI and the name of the programs for that UCI.

Users who are allowed to create or modify programs and global files must know the system's PAC. This code permits system operation in direct mode. In direct mode, a programmer can issue DSM-11 commands at the keyboard, as well as create, modify, and delete global data and programs associated with the UCI under which the user logged-in.

The system manager may designate any terminal as "tied" to a given program. During operation, simply striking one key on the tied terminal will cause it to begin executing the assigned program. It is then impossible for the user to go through the log-in procedure.

DSM-11 requires a console terminal, a disk system, and a magnetic tape system in the minimum configuration. The user can add user terminals up to a system total of 64, and these can be connected by as many as 16 remote or local lines and as many as 48 multiplexed local lines. The system supports

DEC PDP-11 Family

additional disk controllers (up to a maximum of eight drives per controller), up to four magnetic tape drives, and up to four dual DECtape transports. A line printer, card reader, and paper tape reader/punch are also supported.

IAS (Interactive Application System): IAS is a multi-function, multilingual operating system that can support a mix of concurrent time-sharing, batch, and real-time processing activities. It is geared for operation on a PDP-11/70, but can also be utilized with larger 11/45, 11/55, and 11/60 configurations. IAS is disk-based and supports a wide range of standard peripherals and up to 32 time-sharing users.

The heart of the IAS system is a real-time executive compatible with RSX-11D. When not servicing real-time requests, the executive yields control to the time-sharing and batch supervisor to allow priority processing by interactive terminals and any job that may be active in the batch system. The key to the IAS system's flexibility is its ability to support multiple user interfaces. The system-supplied interface provides program development and execution facilities to an interactive terminal. A number of user-supplied, application-specific interfaces can also be active, and certain terminals can be attached to them. Thus, some terminals can be attached and dedicated to, say, editing, while others are dedicated to data base updating or retrieval, and the rest to general program development.

The IAS executive manages multiprogrammed operations using two schedulers: the event-driven priority scheduler for privileged real-time tasks, and the time-sharing scheduler for control of both interactive and batch processing. IAS employs the RSX-11 family's Files-11 file system.

The interactive time-sharing user's interface program is called PDS (Program Development System). PDS controls access to the system by allowing only valid users to log in at a terminal and gain access to user file accounts assigned by the system manager. PDS accepts and interprets commands typed on the user's terminal and performs the requested operation. The commands are English words that describe the operation to be performed. They can be abbreviated to as many letters as make the command name unique.

The interactive user (when connected to the system interface) can develop programs, call any system utility (such as the editor, linker, or a file utility), execute a program, submit a program into the batch stream, or combine these functions, all from his terminal.

IAS requires a system with at least 128K bytes of memory, two terminals, a disk system and a magnetic tape system. A 192K-byte PDP-11/70 with RP04 system disk is recommended for support of 10 to 12 terminal users performing interactive and batch processing concurrently with real-time processing.

IAS supports the same variety of laboratory, industrial control, and communications equipment as specified under RSX-11M.

Version 2 of IAS, released in December 1977, extends support ot the 11/60 and increases peripheral coverage to include subsystems containing RP05 and RP06 disk drives, RX01 floppy disk drives, and LA180 matrix line printers. Additional optional software available with Version 2 includes RMS-11K (see RSTS/E for a description) and DATATRIEVE-11, a conversational query language and report writing system. Version 2 also contains new systems utilities, provides support for execution of real-time and time-sharing tasks in the same partition, and establishes multi-tasking and sub-tasking capabilities for time-sharing users.

IAS Version 3, released in December 1978, combines the real-time RSX-11D and multifunction IAS operating systems into one integrated software product. IAS Version 3 runs on PDP-11/34, 11/60, and 11/70 computers and is upward-compatible with previous versions of RSX-11D and IAS. Three different implementations of IAS Version 3 can be selected during the system generation process to accommodate the broad range of applications currently served by the two separate operating systems. Depending on the options chosen, the system takes on the characteristics of a real-time system, a multi-user system with a heuristic scheduler, or a full timesharing, system that runs concurrent timesharing, batch, and real-time tasks. The real-time and multi-user options are compatible with RSX-11D in both performance and user interface, while the timesharing option represents an enhancement of IAS Version 2, serving up to 32 interactive users on PDP-11/70 systems. IAS Version 3 supports BASIC-PLUS-2, RPG II, COBOL, CORAL-66, FORTRAN IV, and FORTRAN IV-PLUS. In addition, IAS Version 3 data services include the multi-keyed ISAM capability of RMS, DBMS, SORT, and DATATRIEVE.

LANGUAGES: The major programming languages for the PDP-11 include: APL-11, which operates under RT-11 and RSTS/E; BASIC (several versions), which operates under RT-11, RSTS/E, RSX-11D, RSX-11M, and IAS; COBOL, which operates under RSTS/E, RSX-11M, RSX-11D, and IAS; CORAL 66, which operates under RSX-11M, RSX-11D, and IAS; DIBOL, which operates under RT-11 and RSTS/E; FOCAL, which operates under RT-11; FORTRAN (several versions), which operates under RT-11, RSTS/E, RSX-11D, RSX-11M, and IAS; Macro Assembler, which operates under RT-11, RSTS/E, RSX-11D, RSX-11M, and IAS; MUMPS-11, which operates under DSM-11; and RPG II, which operates under RSTS/E and IAS.

APL-11 is a conversational language that is particularly well suited for operating on numeric and character array-structured data. Using APL-11, variables can be examined and changed; statements can be altered without recompilation; and program action can be readily traced. Features of APL-11 include dynamically variable user's workspace size, chaining of APL programs to previously prepared run-time programs, multiple statement lines, standard PDP-11 file naming formats, and extended single operators which allow the user to fully evaluate character strings and write user-defined functions to perform output formatting and function editing. The language is built around a set of unique symbols, each of which represents a desired operation. The nature of the language is such that complex expressions are easily constructed by the programmer. According to DEC, APL-11 produces concise code.

APL-11 requires a processor with 48K bytes of memory and any valid RT-11 or RSTS/E configuration.

BASIC-11 for the PDP-11 is implemented as an incremental interactive interpreter, which retains the interactive nature of the language while providing increased execution speeds over conventional interpreters. It is an enhancement of Dartmouth standard BASIC that includes support for string and arithmetic functions. Peripheral support includes routines that can directly interface to the laboratory peripheral systems (AR11, LPS11) and graphics display systems (VT11, GT41, GT43, GT62) through BASIC. Also featured are a CALL interface well as character terminals, the ability to handle virtual arrays (in memory and on disk), and integer and double-precision support.

The BASIC-PLUS language implemented under RSTS/E is an enhanced verison of Dartmouth BASIC, featuring more than 40 basic commands, 35 built-in functions, and 3 different data types: integer, string, and floating-point (single and double precision). A commercial extension package is available to provide output formatting features such as comma insertion, floating dollar sign, trailing minus, asterisk protect and sort, line printer spooling, and indexed access file method routines.

DEC PDP-11 Family

BASIC-PLUS II is a compiler for a superset of the BASIC-PLUS, Basic-II/IAS-RSX, BASIC/RT-11, and Dartmouth BASIC languages. Specifically, BASIC-PLUS II supports indexed sequential (ISAM) files, and thus supports DEC's RMS-11 record management system. It also features the CALL statement found in BASIC-11 and is compatible with other DEC BASIC language processors. BASIC-PLUS II also includes debugging aids such as breakpoints, step mode, and change of variables. Other important features include support for block-mode terminals, long variable names, record I/O, and a decimal arithmetic package.

BASIC language processors. BASIC-PLUS II also includes debugging aids such as breakpoints, step mode, and change of variables. Other important features include support for block-mode terminals, long variable names, record I/O, and a decimal arithmetic package.

BASIC-11 is implemented under various operating systems, with some differences. The BASIC Comparison Table shows those differences and also gives a comparison with BASIC-PLUS and BASIC-PLUS II.

PDP-11 COBOL is implemented as an intermediate-level compiler conforming in language elements, representation, symbology, and coding format to the ANSI-1974 COBOL specification X.3.23-1974. PDP-11 COBOL meets the ANSI full-level (Level 2) specifications for the nucleus, table handling, sequential I/O, random (relative) I/O, indexed I/O, and segmentation modules. The interprogram communications module is implemented on a low level (Level 1), and the library module is implemented on a low level with high-level REPLACING facility. RERUN, ENTER, and ALTERNATE are not included in the PDP-11 COBOL nucleus code set. The COBOL compiler can accept source program input from cards, console terminals, and disks.

PDP-11 COBOL utilizes RMS-11 for I/O handling, and is therefore capable of handling files created under other languages.

Three utility programs are supplied with PDP-11 COBOL: MERGE, which merges ODL files generated by COBOL compilations into a single ODL file; RFRMT, which converts PDP-11 terminal format COBOL programs into conventional format ANSI COBOL programs; and COBRG, a COBOL Report Generator.

Under IAS/RSX, PDP-11 COBOL will run on any valid configuration supplying a user area of at least 54K bytes of memory, at least 3000 free blocks of on-line disk storage, and an LP11 line printer. Under RSTS/E, PDP-11 COBOL will run on any configuration with at least 128K bytes of memory, a user area of at least 48K bytes, at least 3000 free blocks of on-line disk storage, and an LP11 line printer.

CORAL 66 is a high-level block-structured programming language. It is the standard general-purpose language prescribed by the British Government for real-time and process control applications. This language is designed to replace assembly-level programming in modern industrial and commercial applications. It is used for long-life products where ease of maintenance and flexibility are required.

The PDP-11 CORAL 66 compiler operates under the RSX-11M operating system and provides: BYTE, LONG (32-bit integer) and DOUBLE (64-bit floating point) numeric types; re-entrant code at the procedure level; executable generated code; switchable options to select target PDP-11 computer instruction sets, optimize generated code, and check the bounds of array-type variables; and conditional compilation of defined parts of source code.

CORAL 66 can be supported by any valid RSX-11M or IAS operating system configuration which includes: a 9-track magnetic tape system, an RK11 disk cartridge subsystem, or an RK611 disk cartridge subsystem; a 48K-byte main memory partition; and an FP11 Floating Point Processor.

DIBOL (Digital Business Oriented Language) was designed to permit writing business-oriented programs for a minicomputer. It is structured into data definition and procedures sections, similar to COBOL.

Records and numeric integer or alphanumeric fields are defined in the data definition section. Variable names of up to six characters are supported. Files are associated with record/file definition through OPEN statements in the procedures section. Printed output formatting is accomplished through an edit mask facility much like that of COBOL. In arithmetic operations, a precision of 18 digits is maintained. The language includes complete facilities for handling the display during program execution and for calling external subroutines.

DIBOL programs can be written interactively using the EDIT program. The source module is stored on disk and submitted to the DICOMP language translator when translation is desired. DIBOL programs are executed through a run-time interpreter. A dynamic snapshot facility, called DDT for DIBOL. Debugging Technique, permits stopping a program with display of variable values; the values can be modified and a new checkpoint established.

DIBOL-11 is a compatible extension of the language first used on the PDP-8. It is usable on any system that supports RT-11 or RSTS/E.

FOCAL is a computation language best suited for first-time computer users such as students, scientists, and researchers. FOCAL/RT-11 can be used to interface to real-time devices for experiment control and monitoring under the RT-11 operating system. The FOCAL language is conversational in nature and quite efficient. The RT-11 implementation of FOCAL is an interpreter that provides both stored-program and immediate-mode operations. FOCAL uses the same floating-point package as does FORTRAN/RT-11, so all arithmetic options are supported. The LIBRARY command allows the user to access any RT-11 file-structured device. Other features include scheduling up to eight asynchronous tasks from the clock; processing interrupts in the FOCAL language; user-controlled error processing; and the facility for one or more user-written assembly-language functions.

FOCAL operates on any system that supports RT-11 and requires a processor with at least 16K bytes of memory (32K bytes recommended). FOCAL supports up to 56K bytes of memory, a line frequency clock, extended arithmetic element, EIS, FIS, floating-point unit, line printer, Unibus programmable real-time clock, Unibus A/D and D/A converters, VT11 Graphics Processor System, and VT55 Video Graphics Terminal.

PDP-11 FORTRAN IV is an optimizing compiler that implements a superset of ANSI standard FORTRAN, X3.9-1966. The same basic language processor is implemented under RT-11, RSTS/E, RSX-11M, RSX-11D, and IAS. Some of the extensions added to make the FORTRAN IV language more efficient are the permitting of general expressions wherever a variable or a constant is called for; the addition of the .XOR. and .EQV. logical operators; the elimination of redundant subexpressions within blocks of code; and automatic array vectoring to speed of multiply operations required in array subscripting.

Other extensions found in FORTRAN IV and FORTRAN IV-Plus (see below) include up to seven dimensions for arrays, any arithmetic expression as an array subscript, character strings in place of Hollerith constants, mixed mode expressions containing any data type, end of line comments,

DEC PDP-11 Family

conditional compilation of debugging statements, negative DO increment parameter values, optional statement label list in an Assigned GO TO, and general expressions in I/O lists. Also provided are list-directed I/O statements, ability to read and write files written in any format, end-of-file or error condition transfer in any READ or WRITE statement, byte data type, implicit declaration, ENTRY statements defining multiple entry points in a single program unit, symbolic names given to constants by PARAMETER statements, function selection by data type, incorporation of FORTRAN source text from a separate file by the INCLUDE statement, and numerous other extension for DO loops, data types, and array dimensions.

As a final polish to each program, the FORTRAN IV compiler does extensive "peephole" organization, examining each sequence of operations and substituting a shorter, faster group if possible.

Under RT-11, a system subroutine library (SYSLIB) is provided. SYSLIB is a collection of FORTRAN-callable routines which allow a FORTRAN programmer to use various features of the RT-11 foreground/background (F/B) and single-job (S/J) monitors. SYSLIB also provides various utility functions and a complete character string manipulation package.

RT-11 also provides a library of FORTRAN-callable graphics routines supporting the VT11 and VS60 graphics hardware systems, plotting support for an electrostatic printer/plotter, and laboratory data acquisition and manipulation routines used in conjunction with the LPS11 and AR11 laboratory peripheral hardware.

FORTRAN IV operates in interactive or batch mode under the RSTS/E monitor and provides assembly language subprogram support, using the macro assembler. Although the assembly language subprogram cannot issue any monitor calls, the macro assembler provides a path to further enhance computational performance.

Under RSX-11, RSX-11D, and IAS, the FORTRAN IV compiler runs in a minimum partition of 16K bytes. If run in a larger partition, it uses the extra space for program and symbol table storage.

An RSX-11/IAS library consists of object modules. Two types of libraries exist: shared and relocatable. Relocatable libraries are stored in files. Object modules from relocatable libraries are built into the task image of each task referencing the module. Shared libraries are located in main memory, and a single copy of each library is used by all referencing tasks.

The RSX-11/IAS system relocatable library provides FORTRAN-callable forms of most executive directives. The FORTRAN programmer can schedule the execution tasks and manipulate system resources through these calls.

The ISA extensions for process I/O control are available in FORTRAN-callable format under RSX-11. Support for laboratory and process control peripherals is also included.

FORTRAN IV-PLUS is an optimizing compiler oriented toward minimizing execution times. FORTRAN IV-PLUS is a further superset of FORTRAN IV and operates under the RSX-11M, RSX-11D, and IAS operating systems. Features include specialized flow analysis of DO loops; OPEN and CLOSE (for direct file manipulation) language enhancements; and implementation of the ISA real-time extensions.

The key to the speed of FORTRAN IV-PLUS is the way it uses the general registers, asynchronous FPP registers, and instruction set to generate hard in-line code for increased execution speed. The compiler can generate sharable code (for IAS and RSX-11D) as well, and since it is implemented with software virtual memory, large programs can be compiled efficiently in a relatively small user partition.

FORTRAN IV-PLUS includes all the extensions specifically listed under FORTRAN IV above. The compiler requires a floating-point processor and a minimum partition size of 34K bytes, not including the system library under RSX-11D and IAS. Under RSX-11M, a minimum partition size of 36K bytes is required for both the compiler and the system library.

The *Macro Assembler* produces a relocatable object module and optional assembly listing. This language provides global symbols for linking separately assembled object programs, device and file name specifications for input and output files, user-defined macros, a system macro library, program sectioning directives, conditional assembly directives, assembly and listing control functions at program and command string levels, an alphabetized and formatted symbol table listing, and a default error listing on a command output device.

The RT-11 and RSTS/E versions provide a cross-reference symbol table listing. The RSX and IAS versions add global arithmetic, a global assignment operator, a global label operator, a default global declaration, multiple macro libraries, default register definitions, and an indirect command file facility for controlling the assembly process. The macro assembler provides a total of 48 assembly and macro directives of 15 different types.

Under RT-11 and RSTS/E, the macro assembler requires a partition of 24K bytes or more (for additional symbol table use). A system macro library containing the expanded code for all of the RT-11 monitors' programmed requests is provided. RT-11 also provides a smaller version of the assembler called ASEMBL, which does not recognize assembler directives, does not provide floating-point directives, and does not provide a lower case mode.

Under RSX/IAS, the macro assembler requires a minimum of 28K bytes of partition space to execute. The system macro library includes executive directives and file system calls.

Under the RSX-11M system, a 16K-byte version is available for users who have limited memory space. The 16K version differs from the 18K version in the following ways: It does not search the permanent symbol table for symbols appearing in the operand field of a statement; it does not recognize certain ENABL/DSABL directive function control options; it does not recognize or accept the PAL-11R conditional assembly directives and EOT directive; it does not flag in the assembly listing the instructions which are not common among all members of the PDP-11 family; and it does not accept floating point directives or control operators.

DSM-11 (Digital Standard MUMPS) is a procedural language directed toward the processing of variable-length string and array data. Algebraic, Boolean, and assembly-like bit-manipulation operations are available.

DSM-11 is interpreter-based langauge with two operating modes: program execution mode (indirect mode) and program creation mode (direct mode). Direct mode provides for the creation, modification, debugging, storing, and partial or complete execution of programs.

DSM-11 provides four variables types (simple, subscripted, global, and system) and six types of expression operators (arithmetic, relational, Boolean, string relational, string concatention, and data mode conversion) for use within the basic unit of expression in MUMPS, the command.

DSM-11 is supported by the MUMPS-11 operating system and requires a console terminal, a disk system and a magnetic tape system in the minimum configuration. The user can add user terminals up to a system total of 64, which can be

DEC PDP-11 Family

BASIC COMPARISON TABLE

Language Version	BASIC/ RT-11	MU BASIC/ RT-11	BASIC-PLUS	BASIC-PLUS II	IAS/ RSX-11M BASIC-11
Number of users	1	8	—	—	20
Minimum memory (bytes):					
With LPS11	32K	32K	—	—	32K*
Without LPS11	16K	16K	—	—	16K*
With String Support	24K	—	—	—	16K*
Maximum memory (bytes)	60K	60K	—	—	56K*
File support:					
Sequential	Yes	Yes	Yes	Yes	Yes
Indexed sequential	No	No	No	Yes	Yes
Direct	Yes	Yes	Yes	Yes	Yes
Debugging aids:					
Breakpoints	—	—	—	Yes	—
Step mode	—	—	—	Yes	—
Change of variables	—	—	—	Yes	—
RMS-11K	No	—	No	Yes	Yes
Character terminals	Yes	Yes	Yes	Yes	Yes
Block-mode terminals	Yes	Yes	No	Yes	Yes
Long variable names	No	No	Yes	Yes	No
Decimal arithmetic	Yes	Yes	Yes	Yes	Yes
Data types:					
Integer	Yes	Yes	Yes	Yes	Yes
String	Yes	Yes	Yes	Yes	Yes
Floating point	Yes	Yes	Yes	Yes	Yes
CHAIN	Yes	Yes	Yes	Yes	Yes
OVERLAY	Yes	Yes	No	No	Yes
CALL	Yes	Yes	No	Yes	Yes
On-GOTO	No	Yes	Yes	Yes	Yes
ON-GOSUB	No	Yes	Yes	Yes	Yes
PRINT-USING	Yes	Yes	Yes	Yes	Yes
COMMON	No	Yes	No	Yes	Yes
Dynamic string handling	Yes	Yes	Yes	Yes	Yes
Virtual arrays	Yes	Yes	Yes	Yes	Yes
Interpreter	Yes	Yes	Yes	No	Yes
Compiler	No	No	No	Yes	No

*Partition; BASIC treated as shared single-user system.

connected by as many as 16 remote or local lines and as many as 48 multiplexed local lines. The system supports additional disk controllers (up to a maximum of eight drives per controller), up to four magnetic tape drives, and up to four dual DECtape transports. A line printer, card reader, and paper tape reader/punch are also supported. Minimum hardware requirements for DSM-11 are 32K words of memory and a disk subsystem with a minimum 7.5-megabytes capacity.

RPG II is a compatible subset of standard industry versions of the language and offers almost all the functions found in these versions. PDP-11 RPG II provides a set of 31 instructions and support for card readers, magnetic tape units, mass storage devices, printers, and terminals. PDP-11 RPG II accepts sequential, direct, and indexed file organizations and consecutive, sequential by key, sequential within limits, random by key, random by relative record number, and random utilizing ADDress ROUTing files.

Some of the features of PDP-11 RPG II are a DSPLY operation code that provides the ability to display messages on a user's terminal during program execution and to accept data in reply; support of console devices as normal files; support of ASCII, binary, packed decimal, overpunched, and zoned decimal numeric data; control of page length and overflow via line counter specifications; repetitive printing of the initial first-page output line to assist in the proper alignment of printer forms, and up to nine matching fields to control multi-file processing.

UTILITIES: The paragraphs following are generalized descriptions of some of the PDP-11 family utility programs.

The *Disk Compression Utility (DCU)* consolidates the area used by files on a disk. If the disk is not full, DCU provides the user with larger contiguous free areas on the disk.

DSKINT (Disk Initializer) is a stand-alone program used to format RK11 disks and to build file structures on RK11, RP04, RP05, RP06 or disks. The structures that DSKINT builds include two file directories, two monitor files, and a dummy bootstrap routine. Format and building operations permit the initialization of private disk and public non-system disks, and enable bad-block checking of all disks.

The *Dump Utility (DMP)* allows users to obtain a printout of any file in ASCII or octal format.

DEC PDP-11 Family

Editor is a symbolic editor program that allows users to create and modify source-code programs from the console keyboard (or via a paper tape or card reader). Modifications are entered into memory as they are typed, thus facilitating checking, correction, and further modification. When the editing process is complete, Editor produces a source program that is suitable for creating a binary object program.

FILCOM (File Compare) traces changes to a file by comparing the two files and providing a list of differences. The files must be ASCII. This utility can be a valuable debugging tool when used following editing changes to a file.

FILDMP (File Dump) examines the contents of a file by reading the entire file or specified blocks of that file and creating a dump copy in octal bytes, words, or ASCII characters. The file may be formatted or unformatted binary data or formatted ASCII data. FILDMP can also treat each word as a group of three packed Radix-50 characters and print the characters represented. More than one representation of the file can be specified. Output can be sent direct to the keyboard device or line printer or stored in a file.

File Control Services (FCS), available under RSX-11D, provide the user with record-oriented and block-oriented file I/O and additional functions required for file control such as open, close, wait for event flag, and delete operations. The user issues macro calls to specify desired file control operations. FCS supports both sequential and direct-access files. Sequential access is device-independent and can be used for both record-oriented and file-structured devices. Direct access is used for file-structured devices only.

The *File Transfer Program (FLX)* is a utility that converts files between DOS/BATCH and RSX-11D formats and can also convert files using different data types within the DOS/BATCH and RSX-11D formats. Files converted can be of any data type; i.e., task image, binary, or ASCII.

LINK is a DOS/Batch utility that links program segments to one another when they have been successfully compiled or assembled. It also corporates programs that are held in a library and 1) relocates each object module and assigns absolute addresses; 2) links the modules by correlating the global symbols that are defined in one module and referenced in others; 3) when applicable, implements the overlay structure the user has defined; 4) creates an executable load module, writing it as a data set rather than into memory, allowing it to be used more than once; and 5) provides a cross-reference listing of globals.

The *RT-11 Linker* is very similar. It converts object modules produced by the RT-11 Assembler into a format suitable for loading and execution. It allows users to separately assemble a main program and needed subroutines without assigning absolute load addresses at this time. In addition to the functions performed by the DOS/Batch Link program referenced above, the Linker creates an initial core control block for the linked program and produces a load map showing the load module layout.

The Linker requires at lease 16K bytes of main memory; any additional memory available is used to extend the symbol table. Input is accepted from any binary device on the system. There must be at least one random-access device (disk or DECtape) for "save image" output.

MONEY is an RSTS-11 system accounting that allows a user to obtain printed data concerning his own account status. The program can be called by any user who is logged into the system.

The *On-Line Debugging Technique (ODT)* aids users in debugging programs that have been assembled/compiled and built into tasks. From the keyboard, the user can 1) print the contents of any location in the task for his examination or alteration; 2) run the entire program or any portion of it, using the breakpoint feature to halt its execution at specified points; 3) search the object program for specific bit patterns, words, or references to a particular address; 4) calculate offsets for relative addresses; and 5) fill a block of words or bytes with a designated value.

A *TRACE* program is also provided for FORTRAN debugging.

ROLLIN is a stand-alone utility program used to transfer data quickly between a disk and either DECtape or magnetic tape or between RK11 disk cartridges. Disks handled by ROLLIN are the RF11, RC11, RP02, and RK11. ROLLIN assumes no file structure, and all data transfers are performed in image mode. Magnetic tapes are treated as file-structured devices in that each ROLLIN file is preceded by a DOS-compatible file label.

When transferring data onto either type of tape device, ROLLIN automatically writes an initial record containing a tape sequence number called a reel label. For DECtape transfers, the reel label also contains the number of blocks of data transferred. The reel label guards against mounting tapes out of sequence when returning data to a disk device. Preceding all data records on a DECtape or the first file on a magnetic tape, ROLLIN copies a core image of itself. This image permits ROLLIN to be bootstrapped from the tape to load the remainder of the tape.

The *SYSTAT* program provides current system information in the areas of job, device, disk, and buffer status. SYSTAT can be called by a user logged into the system or from a terminal which is on-line but not logged into the system.

The *RSX-11D Task Builder* creates actual core images from assembled or compiled tasks. It links relocatable object files together and resolves any references to global symbols, the common area, and the shared libraries. The Task Builder also uses an overlay descriptor language to construct task overlays.

The *TTYSET* system program is used to establish the terminal characteristic of the user terminals. TTYSET can be run by any user before or after logging into the system.

VERIFY checks the consistency and accuracy of system files on a file-structured device. It also prints the number of available blocks in a volume, locates files that could not otherwise be accessed, and lists the files that have entries in the system-maintained index file for the volume.

QUOLST allows the PDP-11 user to determine what portion of his disk quota is currently in use or occupied and the number of free blocks that remain on the system disk. Output from QUOLST includes the user account number and information printed under the following headings:

STR—the file structure of the device being reported
USED—the number of 512-byte blocks used under the user account
FREE—the number of free blocks remaining in the user account disk quota
SYSTEM—the number of free blocks remaining to the system on the device indicated.

The *Peripheral Interchange Program (PIP)* is used to transfer files between devices, merge and delete files, and list, zero, and compress directories. PIP accepts up to nine input files and outputs to one 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 must be explicitly specified in the commands to PIP. For the PDP-11 family, PIP is available in two forms. One contains Record I/O copy options and is available only

DEC PDP-11 Family

to systems with the Record I/O feature. The other version can perform only formatted ASCII file transfers.

LOGIN and *LOGOUT* are a pair of PDP-11 family user terminal utilities that operate under RSTS/E.

LOGIN connects a user terminal to RSTS/E, attaches a user to another job already running in the system, or permits the user to run designated system programs from a logged-out terminal. LOGIN can be called either when the user first logs into the system or at a later time.

LOGOUT is called when the user has completed all processing and is ready to leave the terminal. The LOGOUT program is started by a command typed at a user terminal logged into the system. LOGOUT checks the current user's disk quota to ensure that the user does not log out of the system with more than the acceptable disk quota size, LOGOUT disconnects the terminal from the system, removes the current job number from the list of active jobs, and prints information on the duration of the current job.

SORT-11, VERSION 2 is an independent utility that can be run under the control of the RSX-11M (Version 1), RSTS/E, and IAS operating systems. SORT provides four different efficient sorting procedures, which are selectable by user commands. Any RMS file can be taken as input and will be produced as a reordered output file. Files stored in RMS-11 format may be processed with up to 10 sort keys.

Sorting procedures include record sort; tag sort, where a file is reordered by manipulating only the key position of each record, then randomly reaccessing the input file to write out a newly sequenced output file; ADDress ROUTing sort, where one data file may have several addressing files appropriate to alternative sequential processing needs; and index sort, which provides for sequential and direct accessing from a random-data file via an index.

DBMS-11 is DEC's adaptation of Cullinane Corporation's IDMS data base management system. IDMS was originally developed by a *Fortune 500* company in 1970 and 1971, and was put into production in early 1972. In 1973 Cullinane was awarded complete responsibility for the system, including all technical developments, enhancements, field support, and marketing. Enhancements have generally followed the CODASYL guidelines, with emphasis on performance and usability, making DEC the first minicomputer vendor to offer a data base management system consistent with the CODASYL recommendations.

DBMS-11 encompasses a data base design methodology; a language to describe the physical and logical data base (DDL); a data manipulation language (DML); compilers for COBOL and FORTRAN; and a data base manager that provides record storage, control, space management, security, and backup and recovery functions. Also included is a data base dictionary subsystem.

The basic unit of physical space under DBMS-11 is the page, a fixed-length block between 512 and 4096 bytes long. Data bases can be divided into physical areas made up of any number of pages and also into logical files. The entire data base can be assigned to one file, and many logical files can be assigned to a physical area.

DBMS-11 uses the concept of sets. Within a set, one record type functions as the "owner" and one or more record types functions as "members." Using the set concept, hierarchical, network, partially inverted, indexed, and bill of material data bases can easily be defined. Set characteristics are defined by the system designer and consist of independent choices of set order, set membership, and set linkage.

The designer can select one of five logical orders for each set:

- SORTED—members are stored under control of a logical sort field.
- FIRST—members are stored LIFO (last-in, first-out).
- LAST—members are stored FIFO (first-in, first-out).
- NEXT—members are stored in a descending sequence under control of the application program.
- PRIOR—members are stored in ascending sequence under control of the application program.

The same member record may be in a different sequence in each set in which it participates.

The designer can select one of four membership specifications for each set. The choices are:

- Mandatory Automatic—members are automatically inserted into a set at the time they are stored and remain in the set until erased from the data base.
- Mandatory Manual—members are inserted into a set under program control but remain in the set until erased from the data base.
- Optional Automatic—members are automatically inserted into a set when stored but may be disconnected from one set and connected to another under program control.
- Optional Manual—members are inserted into sets under program control but must remain in that set until erased from the data base.

A member record may have different linkage specifications in each set in which it participates. Four linkage options are available for each set:

- NEXT—the system maintains unidirectional pointers for processing in the forward direction only.
- NEXT and PRIOR—the system maintains bidirectional pointers for processing in forward as well as reverse order.
- NEXT and OWNER—the system maintains pointers back to the respective owner in each member record as well as pointers in the forward direction.
- NEXT, PRIOR, and OWNER—a combination of the second and third options noted above.

Records are stored into the DBMS-11 data base by one of the following three techniques:

- CALC—provides for record storage based on a symbolic key within the data record which the data base management system uses to calculate a relative storage address. CALC is used to define entry points into the data base and is often used for "master" type data. Duplicate keys may be accepted or rejected based on design criteria.
- VIA—provides for storage of member records physically near the owner record to which they are related within the set. VIA is often used for "transaction" type data and provides for more efficient processing because all the associated data are brought into main memory with a single access.
- DIRECT—the application program directs the data base management system to store a record at a given relative location. This techique is useful when the application program desires to establish a custom addressing scheme.

DEC PDP-11 Family

In all cases, actual record storage, space management, buffering, and control are the responsibility of the data base management system.

The subschema provides for a logical subset of the data base and defines the rules by which the individual application system may access the data base. Data independence and data security features are implemented in the subschema, and the user can define additional privacy control through the use of passwords, special keys, or data range analysis. DBMS-11 also provides special routines for data compression and decompression, variable-length records, editing and validation, record substitution, auditing, statistical analysis, and encoding/decoding through the use of special DBA procedures.

Application programs access the data base through use of the DML, which provides the interface to the data base system. DML commands such as STORE, ERASE, CONNECT, DISCONNECT, MODIFY, and OBTAIN minimize the need for coding CALL statements. The DML commands and the host-language statements, which may be COBOL or FORTRAN, are read into a DML compiler which checks the syntax of the DML command, checks its logical consistency with the data base, and inspects the security and privacy locks associated with the application subschema. In addition, the DML compiler builds the user data work areas, data base communication areas, and data base declarative statements.

Currently, DBMS-11 requires a minimum system consisting of a PDP-11/70 with 256K bytes of main memory, a large disk pack drive (RP04 or equivalent), a 9-track, 1600-bpi magnetic tape subsystem, console for DBMS-11 operator interaction, and the IAS or RSX-11M operating system.

DATATRIEVE-11 is an inquiry and report writing system that allows interactive data retrieval, sorting, and updating; report generation and creation; and maintenance and accessing of data dictionary entries that define RMS-11K records. Like RMS-11K, DATATRIEVE-11 runs under IAS, RSTS/E, or RSX-11M. The system has capabilities to handle RMS-11K files created by COBOL, BASIC-PLUS II, DIBOL, and macro assembler programs. DATATRIEVE-11 provides 10 query commands, 6 parameters for report writing, 5 commands for report writing, 5 statistical functions, and a process for storing often-used statements in the data dictionary as procedures.

DATATRIEVE-11 requires an IAS, RSTS/E, or RSX-11M configuration including memory management hardware, 64K bytes of user memory, and hardware multiply/divide.

APPLICATIONS SOFTWARE: DEC PDP-11 applications software packages tend to take the form of advanced tools that can be applied with configured systems that are marketed by groups within the company. DEC issues press releases on new application tools in various applications fields with great regularity, and space limitations preclude complete coverage in this report. Examples of the sophisticated tools DEC can provide are the LA-11 Laboratory Data Processing, COGO-11, ASSIST-11, and WISE packages.

LA-11 is a package of application software modules designed to solve most laboratory automation problems such as data acquisition and instrument control, data display and manipulation, and file storage and retrieval. The library comprises assembly-language routines which are callable at the macro level.

Included in the library is SPARTA, the Signal Processing and Real-Time Analysis program. SPARTA consists of five major components: console interface, data acquisition, interactive graphics, data reduction, and data storage/retrieval. The console interface passes command input from the research user and controls the execution of the other SPARTA components.

SPARTA facilitates interaction through the use of operator-controlled cursors which may either ride along a waveform (fixed) or move freely in two dimensions (free). SPARTA will further display decimal readouts of cursor coordinates and provide display scaling, normalizing, general graphic compressions, and a special zoom-in feature for amplifying regions of interest within a spectrum.

The data reduction functions include both spectrum-to-spectrum and scalar operators for addition, subtraction, multiplication, and division. SPARTA will extract derivatives, both running and absolute integrals, and strip peaks with or without baseline corrections. In addition, the data analysis routines can calculate both forward and inverse complex FFT's (Fast Fourier Transforms) on up to 8192 data points and generate a power spectrum or magnitude and phase angle. With the aid of RT-11's file I/O processor, the program can generate under a scientist's direction a permanent library of laboratory data profiles for future access by SPARTA or any other RT-11 software, e.g. BASIC or FORTRAN.

Other modules included in LA-11 are:

- Interactive Dialog Module—provides a standard interface to facilitate console question-and-answer dialogue for such activity as initiating or controlling an experiment and providing parameters for manipulation routines.
- Output Formatter Module—converts internal data types and prints them in a user-specified format on the console terminal.
- Analog Data Acquisition Modules—sample data from up to 64 analog channels simultaneously.
- Point Plot Display Module—displays single-precision integer data on an XY point plot scope and displays one or two spectra simultaneously with a moving window display and cursors.
- Graphics Display Module—plots byte, single-precision, double-precision, or floating-point data on a CRT under control of an independent asynchronous hardware graphics processor. This processor can also display alphanumeric characters and vectors for axis labeling and decimal readout of XY coordinate pairs.
- FFT Module (Fast Fourier Transform)—completes both forward and inverse complex transformations on any number of data points from 8 to 8,192 in powers of two.

Minimum system requirements for running LA-11 include a PDP-11 processor with an ASCII terminal, 16K bytes of main memory, AR11 or LPS-11 analog front-end, and a dual-drive cassette unit.

GOGO-11 is a problem-oriented language that enables an engineer to solve problems in plane coordinate geometry. Using the COGO commands, the user builds a computer file of points, curves, and lines to define a geometry problem. Starting with known points, new points, lines, and curves can be defined, using COGO to describe the known relationships between these elements. Thus, an engineer can work from a sketch, going through the problem as if solving it by hand.

COGO-11 can be employed with PLOT-11 software to produce plotted output from a coordinate table.

The system was designed for persons with little or no computer experience. Existing functions can be modified and new ones added without the use of a macro language.

COGO-11 may be used in the interactive or batch mode by one or several users. Written in FORTRAN, COGO-11

DEC PDP-11 Family

operates under RSX-11D, RSX-11M, or IAS and consists of 131 programs.

ASSIST-11 permits operators to procure telephone directory information on video display terminals. The system provides as few as 2 or as many as 63 operators with simultaneous acess to as many as 20 million directory entries stored on magnetic disk. The displayed information is in the same format as the familiar paper telephone directories. Arranged in two columns, upper and lower case, the screen can display 44 entries at once. A full screen of entries can be displayed in seconds. Directory space requirements are reduced, and directory files can be updated. With a variety of hardware configurations, the system can be adapted to the needs of both large and small operating companies. It can also be used for internal directory assistance in large corporations.

ASSIST-11 operates under RSTS/E on any system from the 11/34A through the 11/70.

WISE is an integrated, expandable data management system designed within an educational time-sharing framework. WISE consists of a data management system with multi-key indexing, on-line file inquiry and updating, and a report generator; a student information system with grade reports and on-line file maintenance, course registration (including class lists and student schedules), and grade entry; an admissions information system with on-line file maintenance; and an alumni information system with on-line alumni data file maintenance, mailing labels, and donor analysis.

WISE operates under RSTS/E on any system from the 11/34A through the 11/70.

PRICING

POLICY: DEC generally provides the PDP-11 minicomputers on a purchase basis, with separately priced maintenance agreements. DEC's Customer Finance Department is organized to enable customers to acquire a system using a lease, conditional sale, or similar financing agreement rather than outright purchase. CFD's function is to write full payout financing agreements for credit worthy DEC customers who seek financing. Available are full payout leases with 3 to 5 year terms, non-cancellable 3 to 5 year conditional sales agreements, and 3 to 5 year U.S. government lease to ownership agreements.

Software maintenance is offered through several levels of optional service, ranging from a periodic software newsletter to automatic updates of software and manuals (software subscription service). In addition, software components, including documents and updates, can be purchased separately from Digital's Software Distribution Center.

In September 1979, DEC announced a new and expanded warranty policy and contract services for software products including operating systems, programming languages and utility packages. The new services include a toll-free telephone support line for immediate response to questions on software usage and performance. Warranty service was expanded to include more than 150 products. New warranty services covering Digital-supported products include automatic delivery of Software Product Updates released during the 90-day warranty period and use of the Telephone Support Center for selected products. DEC will continue to provide installation service, on-site support, technical newsletters, and a performance reporting service. Software product services extending beyond the warranty period range from comprehensive "DECsupport," which provides continuation of warranty-level support with visits for preventive maintenance, to a Software Product and Documentation Update service for self-maintenance customers. Service contracts carry monthly charges according to product and level of service.

The Digital Equipment Computer Users Society (DECUS) is a voluntary, non-profit users' group supported by DEC. DECUS provides an extensive program library, users' groups, special interest groups, and workshops/symposia. Technical symposia are sponsored twice a year in the United States and once a year in Europe, Canada, and Australia. In terms of documentation, the society has the responsibility of maintaining the DECUS program library and publishing a library catalog, the proceedings of symposia, and a periodic newsletter, *DECUSCOPE.*

Training credits are issued with many of the PDP-11 systems, allowing the customer to obtain free training in programming techniques and systems operation and applications. Each individual student week of instruction or fraction thereof requires one training credit. Training is offered in 17 DEC facilities found in Japan, Australia, Great Britain, Germany, France, The Netherlands, Sweden, Italy, Canada, and throughout the United States. At present, over 100 courses are offered. Digital also offers on-site instruction in both standard and customized courses and self-paced audio/visual (A/V) courses. A/V courses are presented through mixed media of audio/film-strip cartridges, video cassettes, and workbooks. A/V courses include Introduction to the PDP-11, Introduction to Minicomputers, and Introduction to Data Communications Concepts. DEC's Special Systems group offers training in both hardware and software areas on-site and in DEC training centers.

Field service is offered on several levels to meet varying customer needs. For customers with in-house troubleshooting and self-maintenance capabilities, DEC offers the off-site facilities of its Product Repair Center (PRC), with 17 locations throughout the world. Services provided by PRC include return-to-PRC agreements which cover all repairs (user performs troubleshooting) on a specific CPU, peripheral, or system for one year; exchange service providing teletypewriters, punches, and selected disk drive exchange at a flat rate; a fixed quote service, which provides a quote on equipment repair before any work is performed; and a loose piece module repair plan for modules and subassemblies. Under the repair plan, DEC estimates a typical turn-around repair time of 20 working days after receipt at the customer returns area (CRA). PRC also offers a module exchange service on a yearly contract basis, allowing a customer to replace a defective module within seven working days from the time it is received at the CRA. DEC supplies special mailers for both the loose piece module repair plan and the module exchange service. Also available for this class of customer is a customer spares program, which includes component and subassembly spares, engineer-designed spares kits, memory stack spares, maintenance test equipment, maintenance documentation service, and emergency parts service.

On-site field service is offered worldwide through a network of 300 offices, 190 of which are located in North America. These offices provide both field service and spare parts inventory. Over 4000 service representatives are assigned to these offices.

Per Call On Site Service is offered to customers for whom downtime may not be critical and who have sufficient expertise to perform first-line maintenance, or as a supplementary program for standard service agreement customers if remedial maintenance is required outside their normal hours of coverage. Labor rate charges are portal-to-portal; parts and travel expenses are rated separately.

The basic field service agreement includes remedial maintenance; preventive maintenance; an assigned service representative; all parts, material, and labor; engineering modifications; and documentation. Hours of coverage are 8 a.m. to 5 p.m. Monday through Friday. (Preventive maintenance time is extended by 3 hours to 8 p.m. on weekdays.)

DEC PDP-11 Family

Extensions are available to allow coverage up to 24 hours a day, 7 days a week.

The DECservice agreement is the same as the basic field service agreement except for these additions: response time of four hours or less if a call is made during coverage hours; continuous service until system level repairs are complete; and no extra charge for service continued after coverage hours.

The newest field engineering service is Remote Diagnosis for the PDP-11/70. This process consists of an electronic console, the Digital Diagnosis Center (DDC) with its host computer, and the Service Response Hot-Line/Remote Diagnosis. The electronic console replaces the regular PDP-11/70 front panel and permits initiation of operating commands through the system terminal. Both the DDC and the response group operate 24 hours per day and 7 days a week, and are responsible for decisions on the use of remote diagnosis and analysis of results.

EQUIPMENT: A large number of packaged PDP-11 systems appear in the Equipment Price List which follows.■

EQUIPMENT PRICES

Just prior to going to press with this report, DEC announced extensive price changes. To date DEC has not released a price book that reflects these changes, only a press release to the effect that packaged system prices have increased five percent, component prices 7 percent, and service charges have increased five to fifteen percent. As soon as Datapro receives a copy of the new price list, we will revise and reissue the Equipment Prices section of this report.

		Purchase Price	Monthly Maint.
LSI-11 AND LSI-11/2 PROCESSORS*			
KD11-HA	LSI-11/2 CPU with power fail/auto restart, 16-bit I/O DMA port, real-time clock input and vector interrupt handling	$459	NA
KD11-HF	With 8K bytes of MOS on a separate board	990	NA
KD11-HB	With 16K bytes of MOS on a separate board	1,290	NA
KD11-HC	With 32K bytes of MOS on a separate board	1,690	NA
KD11-HD	With 64K bytes of MOS on a separate board	2,490	NA
KD11-HU	With UV PROM/RAM memory board including 512 bytes of RAM and sockets for up to 4K x 16-bit UV PROM chips	2,490	NA
KD11-WA	LSI-11 CPU with 32K byte RAM and Writable Control Store (WCS) module with 1K x 24 RAM; three boards		
PDP-11/03 THROUGH PDP-11/70 PROCESSORS			
PDP-11/03 processors include 8 general-purpose registers, power fail/auto restart, stack architecture, ASCII console emulator, bootstrap loader, single-level vectored priority interrupts, DMA, line frequency clock, cabinet-mountable 3.5-inch-high chassis for up to 56K bytes of user memory, operator's console, vans, and power supply.			
11/03-EA	LS11 CPU with 8K bytes of MOS memory and 6 Sub-Unibus slots	1,995	37
11/03-FA	LS11 CPU with 8K bytes of core memory and 4 Sub-Unibus slots	3,150	37
11/03-SC	LS11 CPU with 32K bytes of MOS memory and 6 Sub-Unibus slots	2,600	42
11/03-SE	LS11 CPU with 64K bytes of MOS memory and 6 Sub-Unibus slots	3,100	52
PDP-11/23 processors include 8 general-purpose registers, power fail/auto-restart, stack and architecture, 4-level vectored priority interrupts, direct memory access, and EIA.			
11/23-AA	11/23 CPU with 128K bytes of MOS memory and 4 quad slots	6,800	85
11/23-AC	11/23 CPU with 256K bytes of MOS memory and 2 quad slots	9,600	135
PDP-11/04 processors include 8 general-purpose registers, power fail/auto restart, stack architecture, a multi-function ROM module with bootstrap loader, automatic self test feature, AS11 console emulator, 4-level vectored priority interrupts, direct memory access, and choice of chassis with fans, power-supply, and operator's console. Chassis holds up to 56K bytes of user memory.			
Cabinet-mountable, 5.25-inch, 9-slot chassis:			
11/04-BC	CPU with 16K bytes of MOS memory and 5 hex, 2 quad small peripheral controller (SPC) slots	4,600	54
11/04-DC	CPU with 32K bytes of MOS memory and 5 hex, 2 quad SPC slots	5,900	57
11/04-LC	CPU with 56K bytes of MOS memory and 4 hex, 2 quad SPC slots	7,600	82
11/04-FC	CPU with 16K bytes of core memory and 4 hex, 2 quad SPC slots	5,600	54
11/04-HC	CPU with 32K bytes of core memory and 4 hex, 2 quad SPC slots	7,200	57
Cabinet-mountable, 10.5-inch, 22-slot chassis:			
11/04-DH	CPU with 32K bytes of MOS memory; 3 Sub-Unibus (SU), 5 hex SPC, and 2 quad SPC slots	6,900	61
11/04-LH	CPU with 64K bytes of MOS memory; 3 SU, 4 hex SPC, and 2 quad SPC slots	8,600	86
11/04-HH	CPU with 32K bytes of core memory; 3 SU, 4 hex SPC, and 2 quad SPC slots	8,200	61
11/04-MH	CPU with 64K bytes of core memory; 3 SU; 4 hex SPC, and 2 quad SPC slots	10,200	78
PDP-11/34A processors include 8 general-purpose registers, power fail/auto restart, stack architecture, multi-function ROM module with ROM bootstrap loader, automatic self test feature, ASCII console emulator, 4-level vectored priority interrupts, direct memory access, hardware memory management, hardware multiply/divide, extended instruction set (EIS), and choice of chassis with fans, power supply and operator's console. Chassis holds up to 128K bytes of user memory.			
Cabinet-mountable, 5.25-inch, 9-slot chassis:			
11/34A-DC	CPU with 32K bytes of MOS memory and 3 hex, 3 quad SPC slots	11,000	87
11/34A-LC	CPU with 64K bytes of MOS memory and 2 hex, 3 quad SPC slots	11,500	112
11/34A-HC	CPU with 32K bytes of core memory and 2 hex, 3 quad SPC slots	11,500	87
11/34A-JC	CPU with 64K bytes of core memory and 3 quad SPC slots	13,600	104

DEC PDP-11 Family

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
Cabinet-mountable, 10.5-inch, 22-slot chassis:			
11/34A-DH	CPU with 32K bytes of MOS memory; 3 SU, 3 hex SPC, and 3 quad SPC slots	12,000	91
11/34A-DE	CPU with 32K bytes of MOS memory; 3 SU, 3 hex SPC, and 1 quad SPC slot	13,200	71
11/34A-LH	CPU with 64K bytes of MOS memory; 3 SU, 2 hex SPC, and 3 quad SPC slots	12,500	116
11/34A-LE	CPU with 64K bytes of MOS memory; 3 SU, 2 hex SPC, and 1 quad SPC slot	13,700	96
11/34A-HH	CPU with 32K bytes of core memory, 3 SU, 2 hex SPC, and 2 quad SPC slots	12,500	91
11/34A-HE	CPU with 32K bytes of core memory, 3 SU, 2 hex SPC, and 2 quad SPC slots	13,700	71
11/34A-JH	CPU with 64K bytes of core memory; 3 SU and 2 quad SPC slots	14,600	108
11/34A-JE	CPU with 64K bytes of core memory; 3 SU and 1 quad SPC slot	15,800	88
PDP-11/44 processors include 10 general-purpose registers, stack architecture, memory management unit, EIS, power fail/auto restart, ASCII console emulator, real-time clock, direct memory access, 8K cache memory, and Unibus map.			
11/44-CA	CPU with 256K of MOS memory	23,900	170
PDP-11/60 processors include 8 general-purpose registers, EIS, power fail/auto restart, stack architecture, 4-level vectored interrupts, memory management unit, direct memory access, integral microcoded floating point instruction set, and 2K-byte bipolar-cache memory buffer.			
11/60-CA	CPU with 64K bytes of MOS memory, 1 SU slot, 1 Hex slot, and 1 quad slot; no cabinet	27,200	200
11/60-EA	CPU with 128K bytes of MOS memory, 1 SU slot, 1 Hex slot, and 1 quad slot; no cabinet	28,200	215
11/60-BA	CPU with 64K bytes of core memory, 1 SU slot, 1 Hex slot, and 1 quad slot	32,200	194
11/60-DA	CPU with 128K bytes of core memory, 1 SU slot, 1 Hex slot, 1 quad slot	33,200	224
PDP-11/70 processors include 16 general-purpose registers, power fail/auto restart, variable stack overflow, 4-level vectored priority interrupts, KW11-L Line Frequency Clock, hardware memory management, EIS, direct memory access, M9301-YC ROM Multidevice Bootstrap Loader, operator's console, prewired slots for up to four high-speed mass storage control units, floating-point processor, 2K-byte cache memory, LA36 DECwriter II console, and two H960-CA Equipment Cabinets with fans and power supplies. Cabinet limit is 2048K bytes of memory.			
11/70-VK	CPU with 128K bytes of memory	66,910	241
11/70-VA	CPU with 128K bytes of parity core memory and 4 SPC slots	70,000	241
11/70-AA	CPU with 512 bytes of interleaved parity core memory and 4 SPC slots	79,000	337
PDP-11/03L PACKAGED SYSTEMS			
SR-VXSSA-AA	Includes 11/036 CPU with 32K bytes of MOS memory, cabinet, 4 expansion slots, two RX02 floppy disk drives, LA38 console terminal, and RT-11 operating system	11,350	109
SR-VXSSA-BA	Same as SR-VXSSA-AA but with VT100 console terminal	11,350	113
SR-VXSSA-CA	Same as SR-VXSSA-AA but with LA120 console terminal	12,050	121
SR-VXSSB-AA	Includes 11/03L CPU with 64K bytes of MOS memory, cabinet, 4 expansion slots, two RX02 floppy disk drives, LA38 console terminal, and RT-11 operating system	12,350	121
SR-VXSSB-BA	Same as SR-VXSSB-AA but with VT100 console terminal	12,350	125
SR-VXSSB-CA	Same as SR-VXSSB-AA but with LA120 console terminal	13,050	130
SR-VXLLB-AA	Includes 11/03L CPU with 64K bytes of MOS memory, cabinet, 3 expansion slots, two RL01 cartridge disk drives, LA38 console terminal, and RT-11 operating system	19,350	184
SR-VXLLB-BA	Same as SR-VXLLB-BA but with VT100 console terminal	19,350	188
SR-VXLLB-CA	Same as SR-VXLLB-BA but with LA38 console terminal	20,050	193
PDP-11/23 PACKAGED SYSTEMS			
SR-WXSSA-AA	Includes 11/23 CPU with 128K bytes of MOS memory, 3 expansion slots, two RX02 floppy disk drives, LA38 console terminal, and RT-11 operating system	15,150	146
SR-WXSSA-BA	Same as SR-WXSSA-AA but with VT100 console terminal	15,350	150
SR-WXSSA-CA	Same as SR-WXSSA-AA but with LA120 console terminal	16,050	155
SR-WXLLA-AA	Includes 11/23 CPU with 128K bytes of MOS memory, 2 expansion slots, two RL01 cartridge disk drives, LA38 console terminal, and RT-11 operating system	20,750	209
SR-WXLLA-BA	Same as SR-WXLLA-AA but with VT100 console terminal	20,950	213
SR-WXLLA-CA	Same as SR-WXLLA-CA but with LA120 console terminal	21,650	218
SM-WXLLA-AA	Includes 11/23 CPU with 128K bytes of MOS memory, 2 expansion slots, two RL01 cartridge disk drives, LA38 console terminal, and RSX-11M operating system	24,000	209
SM-WXLLA-BA	Same as SM-WXLLA-AA but with VT100 console terminal	24,200	213
SM-WXLLA-CA	Same as SM-WXLLA-AA but with LA120 console terminal	24,900	218
PDP-11/04 PACKAGED SYSTEMS			
SR-20SSA-BA	Includes 11/04 CPU with 64K bytes of MOS memory, 4 expansion slots, two RX02 floppy disk drives, VT100 console terminal, and RT-11 operating system	13,350	152
SR-20SSA-CA	Same as SR-20SSA-BA but with LA120 console terminal	14,050	157
SR-20SSA-LA	Same as SR-20SSA-BA but with LA36 console terminal	13,350	151
SR-20LLA-BA	Includes 11/04 CPU with 64K bytes of MOS memory, 4 expansion slots, two RL01 cartridge disk drives, VT100 console terminal, and RT-11 operating system	20,350	215
SR-20LLA-CA	Same as SR-20LLA-BA but with LA120 console terminal	21,050	220
SR-20LLA-LA	Same as SR-20LLA-BA but with LA36 console terminal	20,350	214
CR-20SSA-LA	Includes 11/04 CPU with 64K bytes of core memory, 4 expansion slots, two RX02 floppy disk drives, LA36 console terminal, and RT-11 operating system	17,000	143
CR-20LLA-LA	Same as CR-20SSA-LA but two RL01 cartridge disk drives replace the RX02 drives	23,500	206
SM-20LLA-LA	Includes 11/04 CPU with 64K bytes of MOS memory, 4 expansion slots, two RL01 cartridge disk drives, LA36 console terminal, and RSX-11M operating system	25,050	214
CR-20LLA-LA	Same as 5M-20LLA-LA but with 64K bytes of core memory instead of MOS memory	26,750	206
PDP-11/34A PACKAGED SYSTEMS			
SR-3055B-AA	Includes 11/34A CPU with 128K bytes of MOS memory, 11 expansion slots, two RX02 floppy disk drives, LA38 console terminal, and RT-11 operating system	19,850	149
SR-3055B-BA	Same as SR-3055B-AA but with VT100 console terminal	19,850	153
SR-3055B-CA	Same as SR-3055B-AA but with LA120 console terminal	20,550	158

DEC PDP-11 Family

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
PDP-11/34A PACKAGED SYSTEMS (Continued)			
SR-30LLB-AA	Includes 11/34A CPU with 128K bytes of MOS memory, 10 expansion slots, two RL01 cartridge disk drives, LA38 console terminal, and RT-11 operating system	26,350	212
SR-30LLB-BA	Same as SR-30LLB-AA but with VT100 console terminal	26,350	216
SR-30LLB-CA	Same as SR-30LLB-AA but with LA120 console terminal	27,050	221
CR-3055A-LA	Includes 11/34A CPU with 64K bytes of core memory, 10 expansion slots, two RX02 floppy disk drives, LA36 console terminal, and RT-11 operating system	20,700	152
CR-30LLA-LA	Same as CR-3055A-LA but with two RL01 cartridge disk drives in place of RX02 drives	26,350	215
SM-30LLB-AA	Includes 11/34A CPU with 128K bytes of MOS memory, 10 expansion slots, two RL01 cartridge disk drives, LA38 console terminal, and RSX-11M operating system	29,550	212
SM-30LLB-BA	Same as SM-30LLB-AA but with VT100 console terminal	29,550	216
SM-30LLB-CA	Same as SM-30LLB-AA but with LA120 console terminal	30,250	221
SM-30MMA-AA	Includes 11/34A CPU with 256K bytes of MOS memory, 10 expansion slots, two RL02 cartridge disk drives, LA38 console terminal, and RSX-11M operating system	34,700	270
SM-30MMA-BA	Same as SM-30MMA-AA but with VT100 console terminal	34,900	274
SM-30MMA-CA	Same as SM-30MMA-AA but with LA120 console terminal	35,600	279
SM-30HHB-CA	Includes 11/34A CPU with 128K bytes of MOS memory, 3 expansion slots, two RK07 cartridge disk drives, LA120 console terminal, and RSX-11M operating system	49,250	373
SM-30UAA-CA	Includes 11/34A CPU with 256K bytes of MOS memory, 2 expansion slots, one RM02 disk pack drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSX-11M operating system	64,000	396
SM-30UVB-CA	Same as SM-30UAA—CA but with TJE 16 controller and TE16 magnetic tape transport in place of TS11	72,000	469
CM-30LLA-LA	Includes 11/34A CPU with 64K bytes of core memory, 10 expansion slots, two RL01 cartridge disk drives, LA36 console terminal, and RSX-11M operating system	29,550	215
CM-30HHA-LA	Includes 11/34A CPU with 128K bytes of core memory, 9 expansion slots, two RK07 cartridge disk drives, LA36 console terminal, and RSX-11M operating system	54,300	425
SE-30LLB-CA	Includes 11/34A CPU with 128K bytes of MOS memory, 11 expansion slots, two RL01 cartridge disk drives, LA120 console terminal, and RSTS/E operating system	37,900	221
SE-30MMA-CA	Includes 11/34A CPU with 256K bytes of MOS memory, 11 expansion slots, two RL02 cartridge disk drives, LA120 console terminal, and RSTS/E operating system	39,500	279
SE-30HHB-CA	Same as SE-30MMA-CA but with two RK07 cartridge disk drives in place of RL02 drives	57,700	411
SE-30UVB-CA	Same as SE-30MMA-CA but with one RM02 disk drive and a TJE16 controller and TE16 magnetic tape unit in place of RL02 drives	78,900	469
SP-30LLA-LA	Includes 11/34A CPU with 128K bytes of MOS memory, 11 expansion slots, two RL01 cartridge disk drives, LA36 console terminal, and DSM-11 operating system	40,000	215
SP-30HVA-LA	Includes 11/34A CPU with 256K bytes of MOS memory, 12 expansion slots, two RK07 cartridge disk drives, a TJE16 controller and TE16 magnetic tape unit, LA36 console terminal, and DSM-11 operating system	82,500	553
SP-30UVC-LA	Same as SP-30HVA-LA but with one RM02 disk pack drive in place of the two RK07 drives		
SP-30CVA-LA	Same as SP-30HVA-LA but with one RP06 cartridge disk drive in place of the two RK07 drives	101,800	513
PDP-11/44 PACKAGED SYSTEMS			
SM-40MMA-CA	Includes 11/44 CPU with 256K bytes of MOS memory, 4 expansion slots, two RL02 cartridge disk drives, LA120 console terminal, TU58 cartridge tape subsystem and RSX-11M operating system	44,900	293
SM-40HHA-CA	Includes 11/44 CPU with 256K bytes of MOS memory, 6 expansion slots, two RK07 cartridge disk drives, LA120 console terminal, TU58 cartridge tape subsystem and RSX-11M operating system	59,900	425
SM-40UAA-CA	Includes 11/44 CPU with 256K bytes of MOS memory, 2 expansion slots, one RM02 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSX-11M operating system	72,900	410
SM-40MMB-CA	Includes 11/44 CPU with 256K bytes of MOS memory, FORTRAN IV-PLUS compiler, 4 expansion slots, two RL02 cartridge disk drives, LA120 console terminal, TU58 cartridge tape subsystem and RSX-11M operating system	48,500	307
SN-40UAA-CA	Includes 11/44 CPU with 256K bytes of MOS memory, 2 expansion slots, one RM02 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSX-11M-PLUS operating system	76,400	410
SE-40MMA-CA	Includes 11/44 CPU with 256K bytes of MOS memory, 4 expansion slots, two RL02 cartridge disk drives, LA120 console terminal, TU58 cartridge tape subsystem and RSTS/E operating system	52,000	293
SE-40HHA-CA	Includes 11/44 CPU with 256K bytes of MOS memory, expansion slots, two RK07 cartridge disk drives, LA120 console terminal, TU58 cartridge tape subsystem and RSTS/E operating system	67,000	425
SE-40UAA-CA	Includes 11/44 CPU with 256K bytes of MOS memory, 2 expansion slots, one RM02 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSTS/E operating system	81,400	410
SE-40UAB-CA	Includes 11/44 CPU with 512K bytes of MOS memory, COBOL-11, 2 expansion slots, one RM02 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSTS/E operating system	97,400	471
PDP-11/60 PACKAGED SYSTEMS			
SR-60LLA-CA	Includes 11/60 CPU with 64K bytes of MOS memory, 3 expansion slots, two RL01 cartridge disk drives, LA120 console terminal, and RT-11 operating system	40,350	322
SM-60LLA-CA	Includes 11/60 CPU with 128K bytes of MOS memory, 3 expansion slots, two RL01 cartridge disk drives, LA120 console terminal, and RSX-11M operating system	45,550	337
SM-60MMA-CA	Includes 11/60 CPU with 256K bytes of MOS memory, 3 expansion slots, two RL02 cartridge disk drives, LA120 console terminal, and RSX-11M operating system	62,900	429
SM-60HHA-CA	Includes 11/60 CPU with 128K bytes of MOS memory, 3 expansion slots, two RK07 cartridge disk drives, LA120 console terminal, and RSX-11M operating system	57,300	489
SM-60WAA—CA	Includes 11/60 CPU with 256K bytes of MOS memory, 3 expansion slots, one RM02 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSX-11M operating system	79,000	504
SM-60UVB-CA	Includes 11/60 CPU with 256K bytes of MOS memory, 2 expansion slots, one RM02 disk drive, one TJE16 controller and TE16 magnetic tape transport, LA120 console terminal, and RSX-11M operating system	84,550	561

DEC PDP-11 Family

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
PDP-11/60 PACKAGED SYSTEMS (Continued)			
SE-60HHA-CA	Includes 11/60 CPU with 192K bytes of MOS memory, 3 expansion slots, two RK07 cartridge disk drives, LA120 console terminal, and RSTS/E operating system	71,700	504
SE-60UVB-CA	Includes 11/60 CPU with 256K bytes of MOS memory, 2 expansion slots, one RM02 disk drive, one TJE16 controller and TE16 magnetic tape transport, LA120 console terminal, and RSTS/E operating system	91,900	561
SP-60UVB-LA	Includes 11/60 CPU with 256K bytes of MOS memory, 2 expansion slots, one RM02 disk drive, one TJE16 controller and TE16 magnetic tape transport, LA120 console terminal, and RSTS/E operating system	91,900	561
SP-60UVB-LA	Includes 11/60 CPU with 256K bytes of MOS memory, 4 expansion slots, one RM02 disk drive, one TJE16 controller and TE16 magnetic tape transport, LA36 console terminal, and DSM-11 operating system	91,900	555
SP-60HVA-LA	Includes 11/60 CPU with 256K bytes of MOS memory, 4 expansion slots, two RK07 disk drives, one TJE16 controller and TE16 magnetic tape transport, LA36 console terminal, and DSM-11 operating system	91,900	645
PDP-11/70 PACKAGED SYSTEMS			
SM-70TAA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSX-11M operating system	106,000	582
SM-70TVB-CA	Includes 11/70 CPU with 512 bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TWE16 controller and TE16 magnetic tape transport, LA120 console terminal, and RSX-11 operating system	114,000	639
SM-70TBA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, RM03 disk drive, one TWU77 controller and one TU77 magnetic tape transport, LA120 console terminal, and RSX-11 operating system	129,000	742
SM-70CAA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSX-11M operating system	131,000	632
SM-70CVA-LA	Includes 11/70 CPU with 256K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA36 console terminal, and RSX-11M operating system	132,650	623
SM-70CVB-CA	Includes 11/70 CPU and 1024K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA120 console terminal, and RSX-11M operating system	151,000	809
SM-70CBA-CA	Includes 11/70 CPU with 1024K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TWU77 controller and one TU77 magnetic tape transport, LA120 console terminal, and RSX-11M operating system	166,000	912
CM-70TVA-LA	Includes 11/70 CPU with 256K bytes of core memory, 6 expansion slots, one RM03 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA36 console terminal, and RSX-11M operating system	117,650	613
CM-70CVA-LA	Includes 11/70 CPU with 256K bytes of core memory, 6 expansion slots, one RP06 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA36 console terminal, and RSX-11M operating system	142,650	663
SN-70TAA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RP03 disk drive, one TS11 magnetic tape subsystem, LA12 console terminal, and RSX-11M-PLUS operating system	109,500	582
SN-70TVA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA120 console terminal, and RSX-11M-PLUS operating system	117,500	639
SN-70TBA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TWU77 controller and one TU77 magnetic tape transport, LA120 console terminal, and RSX-11M-PLUS operating system	132,500	742
SN-70CAA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSX-11M-PLUS operating system	134,500	632
SN-70CVA-CA	Includes 11/70 CPU with 1024K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA120 console terminal, and RSX-11M-PLUS operating system	154,500	809
SN-70CBA-CA	Includes 11/70 CPU with 1024K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TWU77 controller and one TU77 magnetic tape transport, LA120 console terminal, and RSX-11M-PLUS operating system	169,500	912
SE-70TAA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSTS/E operating system	114,600	582
SE-70TUB-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA120 console terminal, and RSTS/E operating system	122,600	639
SE-70TBA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TWU77 controller and one TU77 magnetic tape transport, LA120 console terminal, and RSTS/E operating system	137,600	742
SE-70CAA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TWU77 controller and one TU77 magnetic tape transport, LA120 console terminal, and RSTS/E operating system	137,600	742
SE-70CAA-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM06 disk drive, one TS11 magnetic tape subsystem, LA120 console terminal, and RSTS/E operating system	139,600	632
SE-70CUB-CA	Includes 11/70 CPU with 1024 bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TWE 16 controller and one TE16 magnetic tape transport, LA120 console terminal, and RSTS/E operating system	159,600	809
SE-70CBA-CA	Includes 11/70 CPU with 1024K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TWU77 controller and one TU77 magnetic tape transport, LA120 console terminal, and RSTS/E operating system	174,600	912
SP-70TVC-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA120 console terminal, and DSM-11 operating system	120,800	639

DEC PDP-11 Family

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
PDP-11/70 PACKAGED SYSTEMS (Continued)			
SP-70CVC-CA	Includes 11/70 CPU with 1024K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA120 console terminal, and DSM-11 operating system	157,800	809
SA-70TVC-CA	Includes 11/70 CPU with 512K bytes of MOS memory, 6 expansion slots, one RM03 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA120 console terminal, and IAS operating systems	120,800	639
SA-70CVC-CA	Includes 11/70 CPU with 1024K bytes of MOS memory, 6 expansion slots, one RP06 disk drive, one TWE16 controller and one TE16 magnetic tape transport, LA120 console terminal, and IAS operating system	157,800	809
TRAX PACKAGED SYSTEMS			
ST-30HVB	PDP-11/34 based TRAX system with RK07 disk drives	117,990	806
ST-30UVB	PDP-11/34 based TRAX system with RM02 disk drives	117,990	716
70TVA	PDP-11/70 based TRAX system with RM03 disk drives	141,620	856
70CWA	PDP-11/70 based TRAX system with RP06 disk drives	195,570	1,089
PROCESSOR OPTIONS			
For the 11/03 and 11/23			
KEF-11AA	Floating Point Processor; offers single and double precision; for the 11/23 only	390	NC
MRV11-BA	UV expandable PROM memory; 1K byte expandable to 8K bytes	325	NA
MRV11-BC	UV PROM chip; 1K x 8-bit; for use with MRV11-BA	100	NA
MRV11-AA	PROM/ROM memory unit; accepts 256 x 4 or 512 x 4 fusible link memory devices and masked ROM devices; 8K bytes maximum capacity; for the 11/03 only	175	NA
MRV11-AC	PROM chip; for use on MRV11-AA	40	NA
For the 11/04 and 11/34A			
FP11-A	Floating-Point Processor; offers 17-digit precision, 46 instruction set; operates on 32-bit and 64-bit floating point numbers as well as integer to floating point conversions; for the 11/34A only	2,900	21
KK11-A	Cache Memory: 2K-byte high-speed module; for the 11/34A only	3,900	17
M7850	Parity Control for memory; one per DD11 required	880	NC
H775-CA	Battery backup for MS11-J and MS11-L MOS memory; for the 11/34A only	1,300	7
For the 11/44			
KE44-A	Commercial Instruction Set (CIS) Processor	7,000	16
FP11-F	Floating-Point Processor; offers 17-digit precision, 46 instruction set; operates on 32-bit and 64-bit floating point numbers as well as integer to floating point conversions	2,900	14
H7750-BA	Battery backup for MS11-M ECC MOS memory	1,500	14
For the 11/60			
FP11-EA	Floating-Point Processor; offers 17-digit precision, 46 instruction set; operates on a 32-bit and 64-bit floating point numbers as well as integer to floating point conversions	5,600	42
KU116-AB	Extended Control Store (ECS) option; includes control circuitry and sockets for up to 1.5K x 48-bits of PROM or ROM	1,200	NA
KU116-AV	User Control Store (UCS) option; includes 1K x 48-bits (plus parity) of RAM software tools; minimum 128K bytes of memory required	5,325	NA
KU116-BB	Diagnostics Contorl Store (DCS) option; fault isolator; self-contained CPU diagnostics in ROM and fault directory	3,800	NC
For the 11/70			
FP11-C	Floating-Point Processor; offers 17-digit precision, 46 instruction set; operates of 32-bit and 64-bit floating point numbers as well as integer to floating point conversions	5,600	30
CORE MEMORY			
MM11-YP	64K-byte Module; for the 11/04 and 11/34A	6,300	42
MM11-DP	32K-byte Module; for the 11/04 and 11/34A		
MJ11-BA	128K-byte Module; includes parity, frame, power supply and control for up to 512K bytes; for the 11/70	18,590	70
MJ11-BE	128K-byte Module; includes parity; mounts for the MJ11-BA; for the 11/70	11,550	60
SEMICONDUCTOR MEMORY			
For the 11/03 and 11/23			
MSV11-DC	32K bytes of dynamic Random Access Memory	1,375	15
MSV11-DD	64K bytes of dynamic Random Access Memory	1,500	25
For the 11/04 and 11/34A			
MS11-JP	32K-byte Module	2,200	25
MS11-LB	128K bytes of parity MOS memory; for 11/34A only	4,000	40
MS11-LD	256K bytes of parity MOS memory; for 11/34A only	6,000	75
For the 11/44			
MS11-MB	256K-byte Module; with error checking and correction (ECC)	6,000	45
MS11-MC	512K-byte Module; with error checking and correction (ECC)	11,000	90
MS11-MD	768K-byte Module; with error checking and correction (ECC)	15,000	135

DEC PDP-11 Family

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
SEMICONDUCTOR MEMORY (Continued)			
For the 11/60			
MS11-KE	64K-byte Module; with error checking and correction (ECC)	4,500	15
MS11-KF	128K-byte Module; with error checking and correction (ECC)	7,400	30
MS11-KG	192K-byte Module; with error checking and correction (ECC)	10,000	45
For the 11/70			
MK11-CA	512K byte Module; includes error checking and correction (ECC), frame, power supply, battery backup, and control; expandable to 3.5M bytes	31,700	160
MK11-CE	512K byte Module; mounts in MK11-CA	20,000	120
MK11-CF	1024K byte Module; mounts in MK11-CA	32,000	240
MK11-BA	128K-byte Module; includes error checking and correction (ECC), frame, power supply, battery backup, and control; expandable to 1024K bytes	22,500	70
MK11-BE	128K-byte Module; mounts in MK11-BA	10,800	30
MK11-BF	512K-byte Module; mounts in MK11-BA	20,000	120
MASS STORAGE			
RXV21-BA	Floppy Disk Subsystem; includes controller and two 512K-byte RX02 drives; for 11/03L and 11/23 only	3,900	45
RX211-BA	Same as RSV21-BA except for use with UNIBUS PDP-11	3,900	45
RLV11-AK	Cartridge Disk Subsystem; includes controller and 5-megabyte RL01 removable cartridge disk drive; for 11/03L and 11/23	5,100	58
RLV21-AK	Same as RLV11-AK except 10.4 megabyte RL02 in place of RL01	6,900	68
RL11-AK	Cartridge Disk Subsystem; includes controller and 5-megabyte RL01 removable cartridge disk drive; expandable to four RL01 drives; for use with UNIBUS PDP-11	5,100	58
RL211-AK	Same as RL11-AK except 10.4-megabyte RL02 drives in place of RL01	6,900	68
RK-711-EA	Cartridge Disk Subsystem; includes controller and 28-megabyte RK07 cartridge disk drive; expandable to eight RK07 drive; for use with UNIBUS PDP-11	14,500	145
RK-711-PA	Same as RK711-EA except for 11/44 only	14,500	145
RL01-AK	5-megabyte removable cartridge disk drive	3,800	50
RL02-AK	10.4-megabyte removable cartridge disk drive	5,600	60
RK07-EA	28-megabyte removable cartridge disk drive	10,500	115
RK07-PA	28-megabyte removable cartridge disk drive; for 11/44 only	10,500	115
RJM02-AA	Pack Disk Subsystem; includes controller and 67-megabyte disk pack drive; expandable to eight RM02 disk drive; for 11/34A, 11/44, and 11/60	24,000	170
RJP06-AA	Disk Subsystem; includes controller and 176-megabyte disk drive; expandable to eight RP06 drives; for 11/34A, 11/44, 11/60	44,000	220
RWM03-AA	Pack Disk Subsystem; includes controller and 67-megabyte disk pack drive; expandable to eight RM03 drives; for 11/70 only	25,000	170
RWM03-BA	Same as RWM03-AA except dual-access	33,000	215
RWM03-C	RM03 Dual-Access kit; contains drive logic, cables, and second controller to convert RWM03-A to RWM03-8	8,000	45
RWP06-AA	Same as RJP06-AA except for 11/70 only	44,000	220
RWP06-BA	Dual-Access Disk Subsystem; includes two PDP-11/70 controls and dual-access 176-megabyte disk drive; expandable to eight RP06 drives; for two 11/70's with RW06-A subsystem	56,000	270
RWP06-C	RP06 Dual Access Kit; contains drive logic, cables, and second controller to convert RWP06-A to RWP06-B; for two 11/70's with RWP06-A subsystem	14,700	50
RM02-AA	Single-access 67-megabyte disk pack drive	8,000	140
RM03-AA	Single-access 67-megabyte disk pack drive	19,000	140
RM03-BA	Dual-access 67-megabyte disk pack drive	21,000	155
RP06-AA	Single-access 176-megabyte disk pack drive	34,000	190
RP06-BA	Dual-access 176-megabyte disk pack	39,140	210
RP06-C	RP06 Dual-Access Kit; converts RP06-A to RP06-B	5,150	20
RP06-P	176-megabyte disk pack for RP06	750	NA
RM03-C	RM03 Dual-Access Kit; converts RM03-A to RM03-B	2,000	15
RM03-P	67-megabyte disk pack for RM02 or RM03	595	NA
MAGNETIC TAPE SUBSYSTEMS			
TS11-BA	Magnetic Tape Subsystem; includes controller, transport, and cabinet; 9-track, 45 ips, 1600 bpi, expandable to four TS11 subsystems; for use with UNIBUS PDP-11	14,350	75
TJE16-AA	Magnetic Tape Subsystem; includes controller, transport, and cabinet; 9-track, 45 ips, 800 and 1600 bpi, expandable to eight TE16 transports; for use with UNIBUS PDP-11	18,850	132
TWE16-AA	Same as TJE16-AA (for use with 11/70 only)	18,850	132
TJU77-AB	Same as TJE16-AA except 125 ips; expandable to four TU77 transports	28,000	235
TWU77-AB	Same as TJU77-AB (for use with 11/70 only)	28,000	235
TME11-EA	Magnetic Tape Subsystem; includes controller, transport, and cabinet; 9-track, 45 ips, 800 bpi; expandable to eight TE10W transports; for use with UNIBUS PDP-11	15,000	27
TE16-AE	Magnetic Tape Transport; for use with TJE16-A and TWE16-A subsystem	12,000	72
TU77-AF	Magnetic Tape Transport; for use with TJU77-A or TWU77-A subsystem	19,500	175
TE10W-EE	Magnetic Tape Transport; for use with TME11-EA subsystem	12,000	89

DEC PDP-11 Family

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
PRINTERS			
LA11-PA	Serial Printer Subsystem; includes 132-position, 96-character set, 180-cps dot matrix printer and control unit	3,770	55
LP11-CA	Line printer Subsystem; includes 132-position, 64-character set, 900-lpm printer and control unit	24,000	185
LP11-DA	Line printer Subsystem; includes 132-position, 96-character set, 660-lpm printer and control unit	25,700	185
LP11-AA	Line Printer Subsystem; includes 132-position, 64-character set, 285-lpm printer and control unit	7,250	90
LP11-VA	Line Printer Subsystem; includes 132-position, 64-character set, 300-lpm printer and control unit	11,800	127
LP11-WA	Line Printer Subsystem; includes 132-position, 96-character set, 240-lpm printer and control unit	14,050	127
LP11-YA	Line Printer Subsystem; includes 132-position, 64-character set, 600-lpm printer and control unit	18,900	150
LP11-ZA	Line Printer Subsystem; includes 132-position, 96-character set, 436-lpm printer and control unit	20,500	150
LP11-BA	Line Printer Subsystem; includes 132-position, 64- and 96-character set, 285- and 204-lpm printer and control unit	7,850	90
PUNCHED CARD EQUIPMENT			
CR11-A	Reader Subsystem; includes 80-column, 300-cpm, card reader and control unit	7,000	6
TERMINALS			
VT100-AA	Video Display Terminal; features double-width/double size characters, 80 columns x 24 lines or 132 columns x 14 lines, detached keyboard, line-drawing characters, smooth scrolling, reverse video or underline character attribute and composite video input/output; operates on full-duplex async. lines and includes a standard EIA interface	1,900	17
VT1XX-AB	Advanced Video Option; provides four character attributes, and adds 10 additional lines; for use with VT 100	270	3
VT1XX-AA	20-mA Current Loop Adapter; for VT100	120	3
VT55-EE	EIA Version CRT; provides graphics and alphanumeric capability; DL11-WB required	3,025	25
VT55-EA	Same as VT55-EE except 20mA version	3,025	25
VT55-FE	Same as VT55-EE except integral hard copy device	4,395	60
VT55-FA	Same as VT55-EA except integral hard copy device	4,395	60
LA37-CE	DECwriter II Hardcopy Terminal; includes APL-11 character set and 20-ma interface	3,350	22
LA37-PE	With EIA interface	3,450	22
LA36-CE	DECwriter II Hardcopy Terminal with 20-ma interface	2,500	19
LA36-HE	With EIA interface	2,600	19
LA35-CE	DECwriter II Hardcopy Terminal; without keyboard; includes 20-ma interface	2,100	19
LA38-GA	Tabletop DECwriter IV printing terminal, includes EIA interface	1,600	16
LA38-HA	Free-Standing DECwriter IV printing terminal, includes EIA interface	1,700	16
LA120-DA	EIA version high speed interactive hardcopy terminal	2,600	25
COMMUNICATIONS EQUIPMENT			
KMC11-A	High-Speed General-Purpose MSI Microprocessor for interface to PDP-11 Unibus	2,200	21
Single-Line Asynchronous Interfaces:			
DL11-F	20-ma Current or EIA/CCITT Loop Asynchronous Line Interface	290	7
DL11-FA	20-ma Current Loop Asynchronous Line Interface; jumper-selectable character size	340	7
DL11-FB	EIA/CCITT Asynchronous Line Interface; jumper-selectable character size	340	7
DL11-E	Modem-Controlling EIA/CCITT Interface; includes 25 feet of cable, customer specifications	770	6
DL11-WA	Serial Line Interface and Real-Time Clock; 20-ma interface	770	5
DL11-WB	Serial Line Interface and Real-Time Clock; EIA/CCITT interface	770	5
DLV11	Serial Interface Unit; optically isolated 20-ma or EIA/CCITT interface levels	300	5
DLV11-E	Modem-Controlling EIA/CCITT Serial Line Unit; with programmable speed, character size, parity, and stop bit	300	7
DLV11-EB	With BC01-25 25-foot cable	400	7
DLV11-J	Four independently programmable serial line units; supports RS-422 and RS-423 (compatible with RS-232C); selectable parity data and stop bits; rates from 150 to 38400 bps	465	9
DLV11-KA	EIA to 20-ma In-Line Converter; support for 110 bps; for use with the DLV11-J	150	NA
Asynchronous Multiplexers (Programmed I/O):			
DZ11-A	EIA/CCITT Asynchronous 8-Line Multiplexer; speeds and formats are programmable on a per-line basis; expandable to 16 lines	2,310	25
DZ11-B	EIA/CCITT 8-Line Multiplexer Expansion Unit for DZ11-A	1,800	21
DZ11-C	20-ma Asynchronous 8-Line Multiplexer; speeds and formats are programmable on a per-line basis; expandable to 16 lines	2,360	25
DZ11-D	20-ma 8-Line Multiplexer Expansion Unit for DZ11-C	1,850	21
DZ11-E	EIA/CCITT Asynchronous 16-Line Multiplexer; speeds and formats are programmable on a per-line basis	3,850	46
DZ11-F	20-ma Asynchronous 16-line Multiplexer; speeds and formats are programmable on a per-line basis	3,950	46
DZV11-B	EIA/CCITT Asynchronous 4-Line Multiplexer; speeds and formats are programmable on a per-line basis	935	9
Asynchronous Multiplexers (NPR Output):			
DH11-AD	Programmable Asynchronous 16-line Multiplexer; EIA/CCITT interface and modem controls; cables not included	7,600	56
DH11-AE	Same as DH11-AD above without modem controls	6,700	46

DEC PDP-11 Family

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
COMMUNICATIONS EQUIPMENT (Continued)			
Single-Line Synchronous Interfaces:			
DUP11-DA	Synchronous Line Interface; programmable characteristics; speed to 9600 bps; double-buffered	1,380	9
DUV11-DA	Synchronous Line Interface; full-duplex transmission at speeds up to 9600 bps; interfaces to Bell Series 200 modems	750	7
DFC11-A	Clock option for DU11-DA; used in local PDP-11 to PDP-11 connections without modems	310	4
DMC11-AL	Network Link Microprocessor Module for local applications; data rates to 1 million bps, full- or half-duplex; includes firmware for unattended operation; requires DMC11-MA or DMC11-MD line unit module; requires one hex SPC slot	1,600	13
DMC11-AR	Network Line Microprocessor Module for remote applications; data rates to 19,200 bps, full- or half-duplex; includes full data set controls, and firmware for unattended operation; requires DMC11-AD line unit module; requires one hex SPC slot	1,600	13
DMC11-DA	Network Line Remote Line Unit Module; interfaces to EIA/CCITT	1,100	6
DMC11-FA	Network Line Remote Line Unit Module; interfaces to CCITT V.35/DDS synchronous modems (Bell 500A L 1/5 or equivalent)	1,100	6
DMC11-MA	Network Line; local line unit module; 1,000,000 bps	1,100	6
DMC11-MD	Network Link; local line unit module; 56,000 bps	1,100	6
DQ11-DA	Full/Half-Duplex Synchronous Interface; programmble characteristics; speed to 10K bps; interfaces Bell 201, 208, 209, or equivalent modems; data set controls included	3,570	24
DQ11-EA	Same as DQ11-DA above except for Bell 303 or equivalent modems; speed to 1M bps	5,450	25
Multiple-Line Synchronous/Asynchronous Interfaces:			
DV11-AA	EIA/CCITT Synchronous 16-Line Multiplexer with internal CRC hardware; speed to 9600 bps; full duplex; uses DV11-BA adapters	4,840	29
DV11-BA	8-Line Synchronous Adapter for DV11-AA; maximum of 2	3,960	15
DV11-BB	8-Line Asynchronous Adapter for DV11-AA	3,860	15
DV11-BC	8-Line Synchronous/Asynchronous (4 lines each) Adapter for DV11-AA	4,160	15
Miscellaneous Communications Equipment:			
DN11-AA	Auto-dial system for 4 data sets; uses DN11-DA interfaces; includes wired cabinet	675	5
DN11-DA	Auto-dial interface for Bell 801 ACU; used with DN11-AA, maximum of 4	640	5
H312-A	Null modem; allows direct connection of peripheral having an EIA interface	140	2
KG11-A	Check character option; computes LRC, CRC, and BCC characters; used with DU11 synchronous interface	1,270	6
DR11-B	DMA interface for customer devices; includes registers for word count, current address, and data	1,620	13
DR11-C	16-bit parallel General-Purpose Bidirectional Unibus Interface for customer devices; includes interrupt, address, and control signals	540	5
DR11-K	16-bit parallel General-Purpose Bidirectional Unibus Interface for customer devices; each line can generate an interrupt, address, and control signals	770	6
DR11-KT	Packaged Unit; includes DR11-K, two BC08R cables, and H322 Distribution Panel	1,100	6
DRV11	Parallel Line Interface Unit; 16-bit diode-clamped input; 16-bit latched-drive output; protocol and control signals	250	5
DRV11-B	Parallel Line DMA Interface Unit; single-cycle rate of 250K words per second; protocol and control signals	580	8
DRV11-P	LSI-11 Bus Interface Foundation Module; preassembled bus interface logic and wire-wrapped area for custom interfaces; capacity up to 60 14-pin IC's	275	NA
KWV11-A	Programmable Crystal Clock with frequencies from 100 Hz to 1 MHz plus 60-cycle and external input	800	5
HARDWARE			
BA11-KE	Rack-Mountable Extension Mounting Box; provides space for five systems units; not for 11/03 or 11/60	3,000	16
BA11-LE	For two systems units; not for 11/03 or 11/60	2,200	10
BA11-PE	For six systems units; for 11/60 only	3,900	15
BA11-ME	Expander Box; includes H9270 backplane and power supply	1,000	7
BA11-NE	Expander Box; includes backplane for LSI-11	1,720	NA
KY11-LB	Programmer's Octal Keyboard Console; for 11/04 and 11/34A	660	—
H9600-AA	Double-Width High-Boy Expansion Cabinet; includes three-phase power control	3,090	—
H9601-AA	Double-Width, Low-Boy Expansion Cabinet; includes three-phase power control	3,090	—
H9602-BA	Single-Width, High-Boy Expansion Cabinet; includes single-phase power control	1,995	—
H9603-BA	Single-Width, Low-Boy Expansion Cabinet; includes single-phase power control	1,995	—
H960-DH	Free-Standing Equipment Mounting Cabinet; provides a single sliding extension mounting chassis with space for up to nine system units; includes fans, power supplies, power distribution panel, extension feet, and front bezel panels	5,695	16
H960-CA	Free-Standing Standard PDP-11 Equipment Cabinet; 72 inches high; includes fans, power distribution panel, extension feet, front bezel panels, and end panels	1,695	—
DD11-CK	Backpanel Mounting Unit for BA11-KE, BA11-LE, or 11/34A; accommodates 2 hex and 2 quad slot modules	330	—
DD11-CF	Backpanel Mounting Unit for BA11-FD, BA11-PE, or H960-DH; accommodates 2 hex and 2 quad slot modules	400	—
DD11-DK	Backpanel Mounting Unit for BA11- KE or 11/34A; accommodates 7 hex and 2 quad slot modules	800	—
DD11-DF	Backpanel Mounting Unit for BA11-FD, BA11-PE, or H960-DH; accommodates 7 hex and 2 quad slot modules	800	—

DEC PDP-11 Family

SOFTWARE PRICES

		Purchase Price
QJ830-A	RT-11 BASIC and extensions; with support services	830
QJ913-A	BASIC/RT-11; with support services	830
QJ913-C	BASIC/RT-11; without support services	550
QJ913-D	BASIC/RT-11; single use license only	440
QJ916/19-A	BASIC-PLUS-2 under RSTS/E or IAS/RSX-11M; with support services	4,400
QJ921-AE	MU BASIC/RT-11; with support services	1,000
QP554	RSX-11M RGP II	5,500
QJV40-C	LSI-11 Microprogramming Tools; without support services	1,500
QJV40-XY	WCS Software Development Tools/RT-11	1,500
ZJV01-RB	LSI-11 Basic Diagnostics	126
ZJ215-RY	LSI-11 System Diagnostics	330
QF703-A	SX/RSTS; with support services	NA
QF703-C	DX/RSTS; without support services	NA
QF703-D	DX/RSTS; single use license only	NA
QF704-A	DX/11M; with support services	NA
QF704-C	DX/11M; without support services	NA
QF704-D	DX/11M; single use license only	NA
QP900-A	RSTS/E RMS-11K; with support services	2,750
QP900-C	RSTS/E RMS-11K; without support services	1,650
QP900-D	RSTS/E RMS-11K; single use license only	1,320
QP901-A	RSX-11M RMS-11K; with support services	2,750
QP901-C	RSX-11M RMS-11K; without support services	1,650
QP902-A	IAS RMS-11K; with support services	2,750
QP902-C	IAS RMS-11K; without support services	1,650
QP601-A	IAS/RSTS/E Sort-11; with support services	370
QP602-A	IAS/RSX-11M Sort-11; with support services	370
QP240-A	IAS/RSX-11M BASIC-11; with support services	830
QP240-C	IAS/RSX-11M BASIC-11; without support services	550
QP010-A	RSX-11D COBOL; with support services	7,700
QP010-C	RSX-11D COBOL: without support services	4,730
QP011-A	RSX-11M/RSTS-E/IAS COBOL-11	7,700
QP066-A	IAS/RSX-11M CORAL-66; with support services	6,600
QP066-C	IAS/RSX-11M CORAL-66; without support services	4,400
QP523-A	DIBOL-11/DECFORM; with support services	NA
QP523-C	DIBOL-11/DECFORM; without support services	NA
QP523-D	DIBOL-11/DECFORM; single use license only	NA
QJ922-A	FOCAL RT-11; with support services	370
QJ922-C	FOCAL RT-11; without support services	185
QJ922-D	FOCAL RT-11; single use license only	150
QJ813-A	FORTRAN/RT-11; with support services	880
QJ813-C	FORTRAN/RT-11; without support services	NA
QJ813-D	FORTRAN/RT-11; single use license only	490
QJ960-A	Scientific Subroutine Package for RT-11 FORTRAN; with support services	370
QJ960-C	Scientific Subroutine Package for RT-11 FORTRAN; without support services	185
QJ960-D	Scientific Subroutine Package for RT-11 FORTRAN; single use license only	150
QJ980-A	FORTRAN/RT-11 Extensions; with support services	880
QJE02-A	MSB/FORTRAN IV; with support services	NA
QJE02-C	MSB/FORTRAN IV; without support services	NA
QJE02-D	MSB/FORTRAN IV; single use license only	NA
QP100-A	IAS/RSX-11M FORTRAN IV-Plus; with support	5,000
QP100-C	IAS/RSX-11M FORTRAN IV-Plus; without support services	1,750
QP230-A	IAS/RSX-11M FORTRAN IV; with support services	880
QP230-C	IAS/RSX-11M FORTRAN IV; without support services	610
QR435-A	RSTS/E FORTRAN IV; with support services	1,820
QJ906-C	RSTS/E APL-11	825
QJD58-A	RT11/LSI-11 2780 Emulation Software; with support services	2,500
QJD58-C	RT11/LSI-11 2780 Emulation Software; without support services	NA
QJD58-D	RT11/LSI-11 2780 Emulation Software; single use license only	NA
QJD63/8-A	2780 Emulation Software; with support services	3,030
QJD63-D	RT-11 2780 Emulation Software; single use license only	1,100
QJD76-A	RSX-11M 2780 Emulation Software; with support services	4,500
QJD68-D	RSX-11M 2780 Emulation Software; single use license only	2,420
QPD10-A	RSTS/E 2780 Emulation Software; with support services	4,400
QPD10-D	RSTS/E 2780 Emulation Software; single use license only	3,300
QPD70-A	RSX-11D 2780 Emulation Software; with support services	3,030
QPD70-D	RSX-11D 2780 Emulation Software; single use license only	2,420
QRD03-A	IAS/2780; with support services	3,030
QRD03-C	IAS/2780; without support services	NA
QRD03-D	IAS/2780; single use license only	NA

DEC PDP-11 Family

SOFTWARE PRICES

		Purchase Price
QJS60-X	RSX-11M RJE/HASP	7,500
QJ070-A	MUX200/RSX-IAS; with support services	6,600
QJ070-C	MUX200/RSX-IAS; without support services	4,950
QJ070-D	MUX200/RSX-IAS; single use license only	3,960
QJ170-A	UN1004/RSX-IAS; with support services	5,500
QJ170-C	UN1004/RSX-IAS; without support services	3,850
QJ681-A	DECnet-11M; runs under RSX-11M; with support services	2,700
QJ681-C	DECnet-11M; runs under RSX-11M; without support services	1,100
QJ685-A	DECnet/RT; with support services	1,500
QJ685-C	DECnet/RT; without support services	NA
QJ685-D	DECnet/RT; single use license only	NA
QJ691-A	DECnet-11S; runs under RSX-11S; with support services	1,100
QJ691-C	DECnet-11S; runs under RSX-11S; without support services	500
QP680-A	DECnet RSX-11D; with support services	2,750
QP680-C	DECnet RSX-11D; without support services	2,200
QP680-D	DECnet RSX-11D; single use license only	1,760
QP690-A	DECnet/E; with support services	2,700
QP690-C	DECnet/E; without support services	NA
QP690-D	DECnet/E; single use license only	NA
QR680-A	DECnet-IAS; with support services	3,500
QR680-C	DECnet-IAS; without support services	2,200
—	DECnet-11M-PLUS	5,000
—	DECnet-11M	3,500
—	DECnet-11S	1,500
—	RSX-11M/SNA Protocol Emulator	7,000
QP300-A	DATATRIEVE-11; with support services	4,500
QP300-C	DATATRIEVE-11; without support services	NA
QP300-D	DATATRIEVE-11; single use license only	NA
QP375-A	IAS DBMS-11; with support services	16,500
QP375-C	IAS DBMS-11; without support services	8,250
QP376-A	RSX-11M DBMS-11; with support services	NA
QP376-C	RSX-11M DBMS-11; without support services	NA
QP376-D	RSX-11M DBMS-11; single use license only	NA