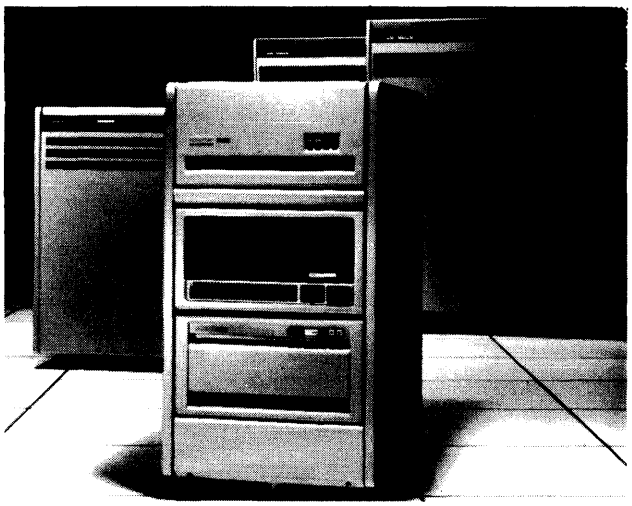
DEC VAX-11 Systems



The newest member of Digital Equipment Corporation's VAX family of virtual memory computers is the VAX-11/730, shown above in a single, 42-inch high cabinet with 131 megabytes of fixed and removable disk storage. Other VAX systems pictured are the mid-range VAX-11/750 (left), VAX-11/780 (right), and the VAX-11/782 attached processor system (rear). Prices range from $48,900 for an entry-level VAX-11/730 package to $445,000 for the top-of-the-line VAX-11/782 package.

MANAGEMENT SUMMARY

Digital's VAX (virtual address extension) family of 32-bit minicomputer systems includes the new VAX-11/730 and the VAX-11/782 attached processor system—as well as the earlier VAX-11/750 and VAX-11/780. All VAX processors implement 32-bit architecture, an extensive instruction set with numerous data types, and a 32-bit bus structure for high throughput. All VAX system hardware is complemented by the newly enhanced VAX/VMS operating system, a powerful multiprogramming operating system that handles multiuser, real-time and multistream batch applications, plus on-line program development.

The newest member of the VAX family, the VAX-11/730, incorporates bit-slice and Programmed Array Logic (PAL) technology. Like the other family members, the VAX-11/730 implements the VAX architecture and runs the VAX/VMS operating system and layered software. The VAX-11/730 can also be used as a powerful, remote DECnet data communications node, allowing its users access to higher performance members of the VAX family, when necessary. Connection to mass storage devices and other peripherals is provided through a UNIBUS adapter.

The VAX-11/750, the mid-range member of the VAX family, incorporates many innovations designed to increase performance and to reduce the overall cost of ownership. The VAX-11/750 is implemented primarily in custom bipolar LSI Schottky logic. One UNIBUS adapter ▷

The VAX-11 Series computers are 32-bit systems based on the PDP-11 family of 16-bit minicomputers. VAX provides 32-bit addressing for a 4-gigabyte program address space, and 32-bit arithmetic and data paths for processing speed and accuracy. The VAX/VMS virtual memory operating system features four billion bytes of virtual address space.

MAIN MEMORY: 1MB to 12MB (8MB local and 4MB shared).
DISK CAPACITY: 10MB to 256MB per drive.
WORKSTATIONS: Up to 384 (96 per UNIBUS).
PRINTERS: 30 cps to 180 cps; 210 lpm to 1200 lpm.
OTHER I/O: Magnetic tape, card readers, real-time I/O devices, console storage devices, and a color graphics terminal.

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 23,000 persons and maintains sales and service offices in all major U.S. cities and in major cities throughout Canada and the Western world.

MODELS: VAX-11/782, VAX-11/780, VAX-11/750, and VAX-11/730.

DATES ANNOUNCED: VAX-11/782, February 1982; VAX-11/780, October 1977; VAX-11/750, October 1980; VAX-11/730, April 1982.

DATES OF FIRST DELIVERIES: VAX-11/782, April 1982; VAX-11/780, January 1978; VAX-11/750, November 1980; VAX-11/730, May 1982.

NUMBER INSTALLED TO DATE: Over 2,000 VAX-11s.

DATA FORMATS

BASIC UNIT: 32-bit word.

FIXED-POINT OPERANDS: Integers can be 8-bit bytes, 16-bit words, 32-bit longwords, and 64-bit quadwords. All have the same general format, with the high-order bit used as the sign. Negative numbers are represented in two's complement form.

FLOATING-POINT OPERANDS: Two floating-point formats are available: single-precision (called floating) that uses a 4-byte format, and double-precision (called double floating) that uses an 8-byte format. In both formats, the high-order bit is used as a sign and the next seven bits for the exponent. Single-precision fractions are 24 bits long, while double-precision fractions are 56 bits long. The 4-byte format provides approximately seven decimal digits of precision, ▶

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VAX SYSTEM COMPARISON CHART

HARDWARE	VAX-11/730	VAX-11/750	VAX-11/780	VAX-11/782
Word Length:	32 bits	32 bits	32 bits	32 bits
Virtual Address Space:	4.3 gigabytes	4.3 gigabytes	4.3 gigabytes	4.3 gigabytes
Maximum Program Size:	2 gigabytes	2 gigabytes	2 gigabytes	2 gigabytes
Circuit Technology:	Programmed array logic	Low power bipolar Schottky	TTL Schottky	TTL Schottky
Implementation:	Integrated circuits (LSI)	Gate arrays (LSI)	Integrated circuits (MSI)	Integrated circuits (MSI)
Memory Type:	64K ECC MOS RAM	64K or 16K ECC MOS RAM	16K ECC MOS RAM	16K ECC MOS RAM
Memory Capacity:	5MB	8MB	8MB*	8MB
Cache Memory:	None	4KB bipolar	8KB bipolar	8KB bipolar each processor
User Control Store:	None	KU750, 20KB	KU780, 24KB	KU780, 24KB each processor
Buses:	UNIBUS (1 standard)	UNIBUS (1 standard, 1 optional) MASSBUS (3 optional)	UNIBUS (1 standard, 3 optional) MASSBUS (4 optional) DR780 parallel interface (1 optional)	UNIBUS (1 standard, 3 optional) MASSBUS (4 optional) DR780 parallel interface (1 optional)
Instruction Set:	244 instructions, 9 address modes, 6 data types	same as VAX-11/730	same as VAX-11/730	same as VAX-11/730
Access Control:	4 hierarchical protection modes	same as VAX-11/730	same as VAX-11/730	same as VAX-11/730

*12MB in multiprocessor configurations including two shared memory systems.

(integral to the processor) and up to three MASSBUS adapters or one additional UNIBUS and two MASSBUS adapters may be used for connection to mass storage devices and other peripherals.

The VAX-11/780 was designed for use with large databases and extensive processing needs. Central to its I/O system is a 32-bit wide data and control path that can move up to 13.3 million bytes of data per second among the system's major hardware components. Up to four UNIBUS and four MASSBUS adapters may be used for connection to mass storage devices and other peripherals.

The VAX-11/782 attached processor computer system is a tightly-coupled asymmetrical multiprocessor system that is said to provide up to 1.8 times the performance of a single VAX-11/780 system for compute-intensive applications. Consisting of two VAX-11/780 CPUs, the VAX-11/782 attached processor computer system can support up to eight million bytes of MA780 shared memory.

The interplay of the two processors is transparent to users. Only one copy of the VAX/VMS operating system is required, because the two processors share the same operating system code and data structures. The 11/782 is available in three packaged systems, or as an upgrade option to a single processor VAX-11/780 system.

Components of the attached processor system upgrade include the CPU, an LA120 console terminal, one million bytes of MA780 shared memory (maximum of eight million bytes) with battery backup, and the cache invalidate option. The attached processor does not support I/O peripherals. All I/O devices and peripherals

while the 8-byte format provides approximately 16 decimal digits of precision.

An optional high performance floating-point accelerator (FPA) can be added to the VAX-11 systems. The FPA is an independent processor that executes in parallel with the base CPU. The FPA takes advantage of the CPU's instruction buffer to prefetch instructions and memory cache to access main memory. Once the CPU has the required data, the FPA overrides the normal execution flow of the standard floating-point microcode and forces use of its own code. Then, while the FPA is executing, the CPU can be performing other operations in parallel.

In addition to executing standard floating-point instructions with substantial improvement, the FPA enhances the performance of a number of additional instructions including: extended multiply and integerize, polynomial evaluation, all floating-to-integer and integer-to-floating conversions, 8- and 16-bit integer multiply, and 32-bit integer multiply.

INSTRUCTIONS: The native instruction set is an extension of the PDP-11 instruction set that consists of 244 basic instructions, most of which can be applied to any one of several types of data, which can in turn be addressed in any one of nine ways. The native instruction set provides 32-bit addressing, 32-bit I/O operations, and 32-bit arithmetic. The instructions can be grouped into related classes based on their function and use: instructions to manipulate arithmetic and logical data types, instructions to manipulate special kinds of data, instructions to provide basic program flow control, instructions to perform special operating system functions, and instructions provided specifically for high-level language constructs.

Instructions and data need not be aligned on longword (32-bit) boundaries in physical memory, but may begin at any byte address (odd or even). Thus, instructions that do not require arguments use only one byte, while other instructions may be two, three, or up to 30 bytes in length, depending on the number of arguments and their addressing modes.

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PERIPHERALS/TERMINALS

DEVICE	DESCRIPTION	MANUFACTURER
MAGNETIC TAPE		
TEE16-AE (AJ)	Program-selectable 800 or 1600 bpi, 9-track, 45 ips transport and VAX-11/780 MASSBUS adapter; expandable to eight TE16 transports and seven MASSBUS disk drives	DEC
TEU77-AB (AD)	Program-selectable 800 or 1600 bpi, 9-track, 125 ips transport and VAX-11/780 MASSBUS adapter; expandable to four TU77 transports and seven MASSBUS disk drives	DEC
TEU78-AB (AD)	Single-access, program-selectable, 6250 or 1600 bpi, 9-track, 125 ips automatic loading magnetic tape transport, formatter, and VAX-11/780 MASSBUS adapter; expandable to four TU78 transports and seven MASSBUS disk drives/TU78 Masters	DEC
TEU78-BB (BD)	Dual-access, program-selectable, 6250 or 1600 bpi, 9-track, 125 ips automatic loading magnetic tape transport, formatter, and two VAX-11/780 MASSBUS adapters; expandable to four TU78 transports and a combined total of seven MASSBUS disk drives/TU78 Masters	DEC
TGE16-AE (AJ)	Program-selectable, 800 or 1600 bpi, 9-track, 45 ips magnetic tape transport and VAX-11/750 MASSBUS adapter; expandable to eight TE16 transports and seven MASSBUS disk drives	DEC
TGU77-AB (AD)	Program-selectable 800 or 1600 bpi, 9-track, 125 ips transport and VAX-11/750 MASSBUS adapter; expandable to four TU77 transports and seven MASSBUS disk drives	DEC
TS11-BA (BB)	1600 bpi, 9-track, 45 ips transport and control unit in a dedicated H9602 cabinet	DEC
TS11-CA (CB)	1600 bpi, 9-track, 45 ips transport and control unit in a dedicated H9646 cabinet; up to two TS11 subsystems per VAX-11/750 system, only one TS11 subsystem per VAX-11/730 system	DEC
PRINTERS/ PLOTTERS		
LP11-AA	132-column, 64-character band printer and control unit; 285 lpm	DEC
LP11-BA	132-column, 64- and 96-character band printer and control unit; 285 lpm when using 64-character set, 204 lpm when using 96-character set	DEC
LP11-CA (CD)	132-column, 64-character high speed printer and control unit; 900 lpm	DEC
LP11-DA (DD)	132-column, 96-character high speed printer and control unit; 660 lpm	DEC
LP11-YA (YD)	132-column, 64-character printer and control unit; 600 lpm	DEC
LP11-ZA (ZD)	132-column, 96-character printer and control unit; 436 lpm	DEC
LP32-AA	132-column, 64-character printer and universal power supply; 300 lpm	DEC
LP32-BA	132-column, 64- or 96-character printer and universal power supply; 300 or 210 lpm	DEC
LP32-EA	132-column, 64-character printer and universal power supply; 600 lpm	DEC
LP32-EB	132-column, 64- or 96-character printer and universal power supply; 600 or 450 lpm	DEC
LP32-GA (GB)	132-column, 64- or 96-character printer and universal power supply; 1200 or 880 lpm	DEC
LXY11-XX	132-column, 96-character dot matrix printer and plotter with control unit; 300 lpm print speed, 170 lpm plot speed	DEC
LXY21-XX	132-column, 96-character dot matrix printer and plotter with control unit; 600 lpm print speed, 320 lpm plot speed	DEC
CARD READERS		
CR11 (-A)	300 cpm reader and control unit; reads 80-column punched cards	DEC
CR11-BC (BD)	600 cpm reader and control unit; reads 80-column punched cards	DEC
CME11-KA (KB)	250 cpm reader and control unit; reads 40- and 80-column punched cards	DEC
TERMINALS		
LA34-DA	Table-top DECwriter IV printing terminal; can accommodate single sheets and roll paper; 30 cps print speed and up to 300 bps baud rate	DEC
LA38-GA	Table-top DECwriter IV printing terminal; can accommodate up to a 4-part computer form as well as single sheets and computer paper; 30 cps print speed and up to 300 bps baud rate	DEC
LA38-HA	Free-standing DECwriter IV printing terminal; can accommodate up to a 4-part computer form as well as single sheets and computer paper; 30 cps print speed and up to 300 bps baud rate	DEC
LA100-YA	Desktop, microprocessor-controlled hardcopy, receive-only terminal; used with video workstations and small business systems for word processing, graphics imaging, communications and electronic mail	DEC
LA120-DA	Free-standing DECwriter III high speed interactive hardcopy terminal; 180 cps bidirectional printing with up to 9600 bps baud rate	DEC
VT100-AA (AB)	High performance, table-top, hardcopy, receive-only terminal includes double-width/double-size characters, 80 columns x 24 lines or 132 columns x 14 lines, and 95-character detachable keyboard	DEC

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are connected to the primary processor. Both processors must be at the same revision level and the same version of microcode.

The major components of a VAX system are:

- Processor—the VAX-11/782 includes dual VAX-11/780 CPUs, while the VAX-11/780 includes one CPU. Each 11/780 CPU contains a bootstrap loader, standard instructions for packed decimal, floating- and fixed-point arithmetic, and character and string manipulations, bipolar cache memory with parity (8KB), a programmable real-time clock, a time-of-year clock with battery backup and writable diagnostic control store (2K words). In addition, one DZ11-A asynchronous multiplexer for connection to eight EIA communications lines, dual LA120 console terminals, and a diagnostic console subsystem are standard. The VAX-11/750 includes one 11/750 CPU with a bootstrap loader, standard instructions for floating- and fixed-point arithmetic, bipolar cache memory with parity (4KB), a programmable real-time clock, and a time-of-year clock with the battery backup. In addition, one DZ11-A asynchronous multiplexer for connection to eight EIA communications lines and a diagnostic console subsystem are standard. The VAX-11/730 includes one 11/730 CPU with a bootstrap loader, integral floating-point, packed decimal and character-string instructions, and interval time-of-year clock.

- Operating System—including a virtual memory manager, swapper, system services, device drivers, file system, record management services, command language, and operator's and systems manager's tools.

- Languages—including the native mode languages VAX-11 Macro and optionally, VAX-11 Fortran, VAX-11 Cobol, VAX-11 C, VAX-11 Basic, VAX-11 PL/1, VAX-11 Pascal, VAX-11 Bliss-32, VAX-11 Coral 66, and VAX-11 DSM. Also supported in compatibility mode are PDP-11 Basic-Plus-2/VAX, PDP-11 Fortran IV/VAX to RSX, and Macro-11. Development tools for both native and compatibility mode programs include editors, linkers, librarians, and debuggers.

- Peripherals—including a range of small- and large-capacity disk drives, magnetic tape systems, hardcopy and video terminals, line printers, card readers, and real-time I/O devices.

- Information Management Facilities—comprising a file system, volume structuring, and protection; Record Management Services (RMS), for record management, indexed and sequential file support; DATATRIEVE, for data inquiry, update, and application writing; DBMS, a database management system; CDD, a common data dictionary; and FMS, a forms management system.

- Data Communication Facilities—including the DECnet-VAX network software, Internet protocol emulators, and Packetnets.

In addition to its 32-bit native instruction set, the processors can concurrently execute a compatibility-mode instruction set, which is a subset of the DEC PDP-11 instruction set. This is not done by emulation or simulation; both instruction sets are built into the microcode and logic of the processor. The compatibility-mode instruction set contains all the PDP-11 instructions except those which perform the following functions:

- **Execution of floating-point instructions.**

- **Use of both instruction space and data space.**

- **Execution of privileged functions such as: 1) HALT, RESET and special instructions, such as traps and WAIT, which are normally reserved for operating system usage; 2) direct access to internal processor registers such as the Processor Status Word and the Console Switch Register; 3) direct access to the trap and interrupt vectors, which must be initialized for interrupt servicing; and 4) execution in any mode other than user-mode, along with the corresponding access to the alternate general register set.**

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

MAIN STORAGE

GENERAL: The main memory system is connected to the Synchronous Backplane Interconnect (SBI) via the memory controller. Physical memory is built using 16K MOS RAM chips. Memory types are organized in quadwords (64 bits) plus an 8-bit error-correcting code (ECC), which allows the correction of all single-bit errors and the detection of all double-bit errors and approximately 70 percent of errors which exceed two bits. On the 11/750 and 11/730, physical memory is organized into an array of 32-bit longwords plus an additional seven bits per longword dedicated to ECC. Interleaving is possible with two controllers and equal amounts of memory on each. Interleaving is enabled/disabled under program control. It is performed at the quadword level because of the memory organization. The memory controllers allow the writing of data in full 32- and 64-bit units. Also, upon command from an SBI device, individual bytes (or a single byte) may be written.

Each memory controller buffers up to four memory access requests. This "request buffer" substantially increases memory throughput and overall system throughput and decreases the need for interleaving for most configurations. With this buffer, memory bandwidth essentially matches that of the SBI—13.3 million bytes/second, including time for refresh cycles with interleaved memory. This is because a number of transactions can occur concurrently. For example, the memory controller can accept a WRITE command from a MASSBUS adapter while it is reading previously requested data by the processor for increased throughput. Were it not for the request buffer, there would be about a 50 percent degradation in memory bandwidth, making interleaving necessary to approach the bandwidth.

A shared MOS memory subsystem is optional for multiple VAX-11/780 systems, but is standard with the VAX-11/782 attached processor system.

Main memory for the VAX-11/730 consists of from one to five memory array modules that use 64K MOS RAM chips for data storage. The modules are connected to the CPU by the array bus. Memory data transfers over the array bus are 39 bits: one 32-bit longword (four bytes) of data and seven associated ECC (Error-Correcting Code) bits.

The memory controller (MCT) module contains the memory and UNIBUS control logic. The memory control logic controls data transfers to and from main memory array

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The VAX-11/780 and VAX-11/782 processors are basically the same, with these exceptions: the 11/780's Writable Control Store (WCS) option, the DR780 interface adapter, expansions to local memory, and the RP07 2.2-megabyte-per-second Winchester disk drive are not available with the 11/782. However, in all other aspects the following description applies to the 11/782.

The VAX-11/780 processor provides 32-bit addressing, 16 32-bit general registers, and 32 interrupt priority levels. The instruction set operates on integer and floating-point operands, character and packed decimal strings, and bit fields, and supports nine fundamental addressing modes. The processor includes an 8K-byte write-through cache memory that results in an effective 290-nanosecond memory access time, and also a 12K-byte Writable Diagnostic Control Store for diagnostic software. The processor's memory management includes four hierarchical processor access modes that are used by the operating system to provide read/write page protection between user software and system software.

Error-correcting code (ECC) MOS memory is connected to the main control and data transfer path (called the Synchronous Backplane Interconnect or SBI) via a memory controller. Physical memory is built using 16K-bit MOS RAM chips and is organized in 72-bit words (64 bits for data and eight for ECC). Each memory controller includes a request buffer that substantially increases overall system throughput and eliminates the need for interleaving in most applications.

The processor uses two standard clocks—a programmable real-time clock used by the operating system and diagnostics, and a time-of-year clock used for system operations. The time-of-year clock includes battery backup for automatic system restart operations.

The processor's console consists of an LSI-11 microcomputer with 16K bytes of read/write memory and 8K bytes of ROM, a floppy disk, and a terminal for local operations and an LSI-11 microcomputer for remote diagnosis. The console operator uses keyboard commands for diagnosis, bootstrapping, and incorporating software maintenance modifications.

Medium-capacity disk drives, unit record devices, terminals, interprocessor communications links, and user-specific devices are UNIBUS peripherals. The UNIBUS adapter provides the hardware pathways for data and control information to move between the UNIBUS and the SBI. The maximum aggregate throughput rate is 13.3 million bytes per second with interleaved memory.

High performance MASSBUS mass storage peripherals are connected to the SBI via a buffered MASSBUS adapter. The MASSBUS adapter provides the hardware path for data and control information to move between a MASSBUS peripheral controller and the SBI, and allows high speed data transfers at a maximum aggregate throughput rate of two million bytes per second for each adapter. The MASSBUS adapter performs parity checking on both data and control information.

modules over the array bus. The UNIBUS control logic controls transfers to and from the peripheral devices over the UNIBUS.

TYPE: ECC MOS RAM.

CYCLE TIME: The VAX-11/782 and 11/780 have an 800-nanosecond cycle time per 64-bit read, 1400 nanosecond cycle time per 64-bit write. The VAX-11/780 processor includes an 8K-byte write-through memory cache that results in an effective 290 nanosecond memory access time. On the VAX-11/750, effective memory access time is 400 nanoseconds. The read/write cycle time for the 11/730 is 810 nanoseconds.

CAPACITY: The minimum memory requirement on the VAX system is 1M-byte. Maximum memory capacity is 5M bytes on the 11/730, 8M bytes on the 11/750 and 11/780, and 8M bytes shared memory on the 11/782. By adding the MA780 shared memory option, memory on the 11/780 can be expanded to 12M bytes.

CONTROL STORAGE: The 11/782 and 11/780 have a control store size of 5K words (99-bit words), 4K words read-only memory and 1K words user control store.

On both of these systems, 12K bytes (plus parity) of Writable Diagnostic Control Store (WDCS) are provided to allow the Diagnostic Console Microcomputer to verify the integrity of crucial parts of the CPU, the intelligent console, the SBI, and the memory controller. In addition, the WDCS can be used to implement updates to the system microcode. The optional User Control Store (UCS) on the VAX-11/750 includes 10K bytes (1K bytes of 80-bit microwords) of writable storage. This allows users to augment the speed and power of the basic machine with customized microcode functions. Such customized functions include the loadable microcode package for extended precision floating-point arithmetic operations.

Control store on the 11/730 is a programmable read/write memory with a basic storage capacity of 16K 24-bit microwords. An additional 1K microwords of control store is available to support the integrated disk controller. Each microinstruction is 24 bits and contains several control fields for specific CPU functions.

STORAGE PROTECTION: The system's memory management logic divides memory into 512-byte pages. Each page is assigned a protection code specifying which, if any, access modes are to be permitted read or write access to the page. In addition, fault detection hardware causes a memory error-correcting code to detect all double-bit errors and correct all single-bit errors.

Battery backup support is included for the attached processor system configurations. Two backup units reside within the MA780 cabinet, and are capable of supporting 4M bytes of memory for a minimum of 10 minutes. Smaller amounts of memory are supported for longer periods of time. Optional battery backup is available on the VAX-11/780 to provide 10 minutes of power for up to 4M bytes of memory; a maximum of two backup batteries provide power for up to 8M bytes of memory.

CENTRAL PROCESSOR

GENERAL: The VAX-11/782 is a tightly-coupled asymmetric multiprocessor system based on the MA780 shared memory subsystem. It comprises two VAX-11/780 CPUs, and according to DEC, offers a performance improvement of 60 to 80 percent over a single VAX-11/780. The two processors communicate through the MA780 memory. All peripheral devices are connected to one of the CPUs that functions as the primary processor. The 11/782 is available as a complete packaged system or as an upgrade

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The processor includes 12K bytes of writable diagnostic control storage for updating the instruction set microcode. The control storage is also used for executing microcode diagnostics, which can be loaded from the console's floppy disk.

All VAX systems share such features as 16 32-bit general registers, 32 priority interrupt levels (16-hardware, 16-software), nine addressing modes, and four hierarchical protection modes, each with read/write access control. The VAX-11/750 and 11/730 use the same architecture, operating system, and language processors as the VAX-11/780 to offer additional setups in DEC's 32-bit virtual memory system progression.

The VAX-11/750 features a cartridge tape drive for software updates; a UNIBUS interface for terminals, serial devices and medium speed peripherals; and up to three optional MASSBUS adapters for up to 24 high speed disk and tape units. Users of the 11/750 can optionally substitute a second UNIBUS adapter in place of one MASSBUS adapter. A real-time clock is a standard feature, as is a time-of-year clock with battery backup to enable automatic restart even after extended power failures. Other options include an FP750 high performance floating-point accelerator and a writable control store of 1K 80-bit words for unique, user-defined code. A memory battery backup unit is available to sustain two megabytes of memory for 10 minutes.

Features of the VAX-11/730 include a cartridge tape drive for software updates, an LA120 console terminal, the UNIBUS interface, and a time-of-year clock. An optional FP730 high performance floating-point accelerator is available for the 11/730. Circuit technology is programmed array logic using integrated circuits (LSI). The 11/730 may function as an execute-only system for existing programs, and also be used to develop and run new programs.

The instruction set executed on the VAX processors is selected under operating system control as either the native-mode or compatibility-mode set. The native-mode instruction set includes over 200 different opcodes, which can be grouped into classes based on their function and use. Instructions used to manipulate the general data types include integer and floating-point instructions, packed decimal instructions, character-string instructions, and bit field instructions. Instructions used to manipulate special kinds of data include queue manipulation, address manipulation, and user-programmed general register control instructions. Instructions that provide basic program flow control and call procedures include branch, jump, and case instructions, subroutine call instructions, and procedure call instructions.

The compatibility-mode provides the PDP-11 instruction set, with the exception of privileged and floating-point instructions. Under control of the operating system, the processor can execute PDP-11 instruction streams within the context of any process. When executing in

option to a single processor VAX-11/780 system. Both VAX-11/780s must be at the same revision level and the same version of microcode. The VAX-11/780 processor has a 32-bit architecture based on the DEC PDP-11 family of 16-bit minicomputers. While using address modes and stack structures similar to those of the PDP-11, the VAX-11/780 provides 32-bit addressing for a large program address space, and 32-bit arithmetic and data paths for increased processing speed and accuracy. The processor includes the basic CPU, synchronous system bus, intelligent microcomputer console, interval and time-of-year clocks, and 8K bytes of cache memory. Up to 12 million bytes of memory, up to four MASSBUSES, a UNIBUS (1 standard, 3 optional), and a floating-point accelerator can be included with the processor. The processor provides 32-bit addressing, 16 32-bit general registers, and 32 interrupt priority levels. The instruction set operates on integer and floating-point operands, character and packed decimal strings, and bit field data. The instruction set supports nine fundamental addressing modes.

The VAX-11/750 processor also has a 32-bit architecture, and is the first 32-bit mini to employ gate array circuitry. The CPU performs the logical and arithmetic operation requested of the computer system. Its user-programmable registers include 16 32-bit general purpose registers for data manipulation, and the Processor Status Word for controlling the execution states of the CPU. The processor instruction set is defined by the microcode contained in its control store. The CPU also includes a 4K-byte bipolar cache memory, 10K-byte user control store, clocks and console. Up to 4M bytes of main memory can be added. Each VAX-11/750 system contains one UNIBUS adapter for standard peripherals and up to a maximum of three MASSBUS adapters for high speed peripherals. A second optional UNIBUS adapter is available for the 11/750.

The VAX-11/730 processor is implemented using bit-slice and Programmed Array Logic (PAL) technology. The standard components of the VAX-11/730 include the CPU with its DAP (data path) module, WCS (writable control store) module, MCTC (memory controller) module; 1M-byte memory module, clocks, console subsystem, and DMF32-AA combo board UNIBUS controller for peripheral devices. One additional UNIBUS controller may be configured with the 11/730. MASSBUS adapters are not available for the 11/730.

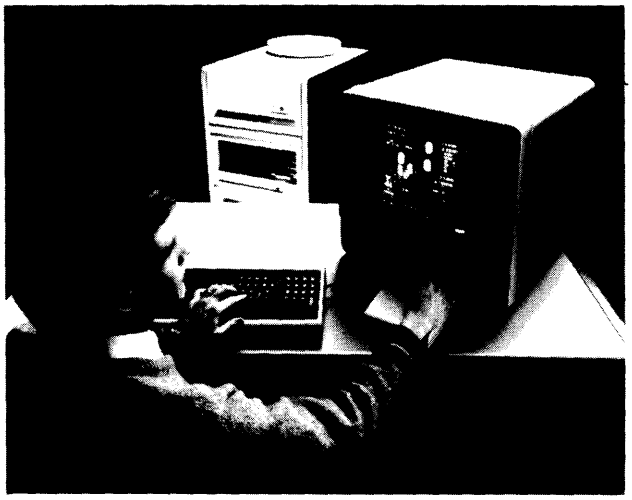
Memory management on VAX systems includes four hierarchical processor access modes that are used by the system to provide read/write page protection between user software and system software. Memory is connected to the main control and data transfer path (the SBI) via a memory controller. Each memory controller includes a request buffer that substantially increases overall system throughput and eliminates the need for interleaving in most applications.

The processors use two standard clocks: a programmable real-time clock used by the operating system and by diagnostics, and a time-of-year clock used for system operations. The time-of-year clock includes battery backup for automatic system restart operations.

The "intelligent" console on the 11/780 consists of an LSI-11 microcomputer with 16K bytes of read/write memory and 8K bytes of ROM, a floppy disk unit, a terminal for local operations, and an optional port for remote diagnosis. The console operator uses keyboard commands for diagnosis, bootstrapping, and incorporating software maintenance modifications.

The 11/750 and 11/730 consoles enable the computer system operator to control the processor operation directly. The console subsystem consists of the console terminal, the front panel, the user-oriented console command language, and a TU58 tape cartridge drive. Also optionally available for a console is the remote diagnosis interface.

DEC VAX-11 Systems



Digital Equipment Corporation's new VAX-11/730 32-bit minicomputer supports interactive graphics workstations using Digital's VS11 terminal for engineering design, educational, and commercial applications. The VAX-11/730 uses 64K-bit RAM chips for a maximum memory complement of five megabytes, and can be configured as a single cabinet system with prices beginning at less than $50,000.

compatibility-mode, the processor interprets the instruction stream as a subset of PDP-11 code that does not include floating-point hardware instructions or privileged instructions. The compatibility-mode enables the VAX/VMS operating system to provide an environment for executing most user-mode programs written for a PDP-11 (except standalone software). The processor expects all compatibility-mode software to rely on the services of the native operating system for I/O processing, interrupt and exception handling, and memory management. There are some restrictions, however, on the environment that the native operating system can provide for a PDP-11 program. For example, certain PDP-11 memory management instructions cannot be simulated by the operating system since they do not trap to native-mode software.

For compatibility with the PDP-11, the VAX systems use both the DCL and MCR command languages and implement upper compatible Fortran, Basic, and Cobol languages. Languages that produce native-mode code include Basic, Cobol, Fortran, Pascal, PL/1, DSM, Coral 66, Bliss-32, Macro, and C.

The VAX systems can also be used as host development systems for RSX-11M and RSX-11S operating systems running on PDP-11 minicomputers. Like the PDP-11, the systems use a UNIBUS for connecting peripherals; and like the PDP-11/70, they use integrated MASSBUS adapters for interfacing high speed peripherals. The disk structure is the same as that of the PDP-11, RSX-11 Real-Time Operating Systems and IAS (Interactive Application System). File inquiry methods using DATATRIEVE/VAX are the same as those available with DATATRIEVE-11, the PDP-11 inquiry and report writing system.

Medium-capacity disks, unit record devices, terminals, interprocessor communications links, and user-specified devices are UNIBUS peripherals. The maximum UNIBUS I/O throughput per UNIBUS is 1.5M bytes per second on all VAX systems.

High performance mass storage devices are connected to the VAX systems via up to three optional MASSBUS adapters on the 11/750, and up to four optional MASSBUS adapters on the 11/780 and 11/782. The 11/730 does not support VAX MASSBUS. Maximum MASSBUS I/O throughput is 2M bytes per second on VAX systems. The MASSBUS adapter does parity checking for both data and control information.

REGISTERS: The VAX systems provide 16 32-bit general registers that can be used for temporary storage, as accumulators, as index registers, and as base registers. The processor offers a variety of addressing modes that use the general registers to identify instruction operand locations, including an indexed addressing mode that provides a true post-indexing capability.

Four registers have special significance: the Program Counter contains the address of the next instruction to be executed; the Stack Pointer contains the address of the base (or top) of a stack maintained for subroutine and procedure calls; the Frame Pointer contains the address of the base of a software data structure stored on the stack and called the stack frame, which is maintained for procedure calls; and the Argument Pointer contains the address of the base of a software data structure called the argument list, which is maintained for procedure calls.

In addition, the first six registers have special significance for character and packed decimal string instructions and the Polynomial Evaluation instruction. These instructions use the first six registers to store temporary results and, upon completion, leave results in the registers that a program can use as the operands of subsequent instructions.

A register's special significance does not preclude its use for other purposes, except for the Program Counter. The Program Counter cannot be used as an accumulator, as a temporary register, or as an index register. In general, however, most users do not use the Stack Pointer, Argument Pointer, or Frame Pointer for purposes other than those designated.

Registers can be used for temporary storage, accumulators, base registers, and index registers. A base register contains the address of the base of a software data structure such as a table or queue, and an index register contains a logical offset into a data structure. Whenever a register is used to contain data, the data is stored in the register in the same format as it would appear in memory. If a quadword or double floating operand is stored in a register, it is actually stored in two adjacent registers.

ADDRESSING: The processor's addressing modes allow almost any operand to be in a register or in memory, or used as an immediate constant. There are seven basic addressing modes that use the general registers to identify the operand location, including:

- **Register Mode, in which the register contains the operand.**
- **Register Deferred Mode, in which the register contains the address of the operand.**
- **Autodecrement Mode, in which the contents of the register are first decremented by the size of the operand, and then used as the address of the operand. The size of the operand (in bytes) is given by the data type of the instruction operand, and depends on the instruction.**

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The operating system for the VAX systems is VAX/VMS, a general purpose operating system that provides for the concurrent execution of multiuser time-sharing, batch, and time-critical applications. VAX/VMS provides: 1) virtual memory management for the execution of large programs; 2) event-driven priority scheduling; 3) shared memory, file, and interprocess communication data protection based on ownership and application groups; and 4) programmed system services for process and subprocess control and interprocess communication.

VAX/VMS performs process-oriented paging, which allows the execution of programs larger than the physical memory allocated to them. Four billion bytes of addressing space are provided. Paging is handled automatically by the system, freeing the user from any need to structure the program. In the VAX/VMS operating system, a process pages only against itself; thus, individual processes cannot significantly degrade the performance of other processes.

The memory management facilities provided by VAX/VMS can be controlled by the user. Any program, with sufficient privilege, can prevent pages from being swapped out, or prevent the entire working set from being swapped out, to optimize program performance in time-critical or interactive environments. Sharing and protection are provided for individual 512-byte pages. Four hierarchical modes (kernel, executive, supervisor, and user) provide page protection.

VAX/VMS schedules CPU time and memory residency on a preemptive priority basis. Thus, time-critical processes do not have to compete with lower-priority processes. The scheduler adjusts the priorities of processes assigned one of the low 16 priorities to overlap I/O and computation. Time-critical processes can be placed in one of the top 16 scheduling priorities, in which case the scheduler does not alter their priorities, but they can still be altered by the system manager or an appropriately privileged user.

The operating system also includes system services to control processes and process execution, control time-critical response, control scheduling, and obtain information. Process control services allow the creation of subprocesses as well as independent detached processes. Processes can communicate and synchronize using mailboxes, shared areas of memory, or shared files. A group of processes can also communicate and synchronize using multiple common-event flag clusters.

VAX/VMS provides a program development capability that includes editors, language processors, and a symbolic debugger. The Bliss-32 implementation language was designed for the development of operating systems, database file systems, communications software, and utilities. All VAX languages are native-mode.

The VAX-VMS operating system provides a file and record management facility that allows the user to create,

- **Autoincrement Mode, in which the contents of the register are used as the address of the operand, and then incremented by the size of the operand. If the Program Counter is the specified register, the mode is called the Immediate mode.**
- **Autoincrement Deferred Mode, in which the contents of the register are used as the address of a location in memory containing the address of the operand, and then are incremented by four (the size of an address). If the Program Counter is the specified register, the mode is called the Absolute mode.**
- **Displacement Mode, in which the value stored in the register is used as a base address. A byte, word, or longword signed constant is added to the base address, and the resulting sum is the effective address of the operand.**
- **Displacement Deferred Mode, in which the value stored in the register is used as the base address of a table of addresses. A byte, word, or longword signed constant is added to the base address, and the resulting sum is the address of the location that contains the actual address of the operand.**

Of these seven basic modes, all except Register Mode can be modified by an index register. When an index register is used with a basic mode to identify an operand, the addressing mode is the name of the basic mode with the suffix "Indexed." Therefore, in addition to the seven basic addressing modes that use registers, the processor recognizes six indexed addressing modes.

The processor also provides Literal Mode addressing, in which an unsigned 6-bit field in the instruction is interpreted as an integer or floating-point constant.

INSTRUCTION REPERTOIRE: At any one time, the processor's instruction interpretation hardware can be set to either of two modes: native-mode or compatibility-mode. In native-mode, the processor executes a large set of variable-length instructions, recognizes a variety of data types, and uses 16 32-bit general purpose registers. In compatibility-mode, the processor executes a set of PDP-11 instructions, recognizes integer data, and uses eight 16-bit general purpose registers. While native-mode is the primary instruction execution state of the machine and compatibility-mode the secondary state, their instruction sets are closely related, and their programming characteristics are similar. A user process can execute both native-mode images and compatibility-mode images. The native-mode instruction set that the processor executes is based on over 200 different opcodes. The opcodes can be grouped into classes based on their function and use. Instructions used to manipulate the general data types include:

- **Integer and floating-point instructions.**
- **Packed decimal instructions.**
- **Character-string instructions.**
- **Bit field instructions.**

Instructions that are used to manipulate special kinds of data include:

- **Queue manipulation instructions.**
- **Address manipulation instructions.**
- **User-programmed general register control instructions.**

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access, and maintain data files and records within the files with full protection. The record management services handle sequential, relative file and indexed sequential organizations, sequential and random record access, and fixed- and variable-length records.

VAX/VMS Version 3 was introduced concurrently with the VAX-11/730. VMS Version 3 supports all VAX family processors, as well as the new VAX-11C and VAX-11 PSI (Packetnet System Interface) software. Enhancements have been added to the operating system for terminal and file handling capabilities, communications and layered software support, and management tools for system maintenance and tuning.

Data communications capabilities for the VAX systems are provided by DECnet, a family of network products developed by DEC that add networking capabilities to all of the company's computer families and operating systems. Using DECnet, various kinds of computer networks can be constructed to facilitate remote communications, resource sharing, and distributed computation.

DECnet/VAX is designed to:

- Provide an interprocess communication facility that is highly transparent and easy to use.
- Provide a high-level language programming interface.
- Allow programs to access files at other systems.
- Allow users and programs to transfer files between systems.
- Allow users to transmit command files to be executed in other systems.
- Allow an operator to down-line load RSX-11S system images into other systems.

DEC continues to compete with an ever-expanding arena of 32-bit systems including Perkin-Elmer's 3200 Series systems, Gould-S.E.L. 32 Series computers, and Data General's MV family.

USER REACTION

Fifty-four users of the VAX systems replied to Datapro's 1982 Computer Users' Survey, reporting on a total of 80 installed systems. Average time of installation was one year and five months.

The majority of the users were from the engineering/scientific field (13), and manufacturing, (nine). Other users represented government (four), education (four), and banking/finance/securities (four).

The average VAX configuration included from 2048K to less than 4096K bytes of memory, from 200M to less than 600M bytes of disk storage, from 16 to 60 local

Instructions that provide basic program flow control and permit the calling of procedures are:

- **Branch, jump, and case instructions. (The processor provides a branch instruction, CASE, that implements higher-level language computed GO TO statements. For CASE, the user supplies a list of displacements that generate different branch addresses indexed by the value obtained as a selector. The branch falls through if the selector does not fall within the limits of the list.)**
- **Subroutine call instructions.**
- **Procedure call instructions.**

INSTRUCTION TIMINGS: All times shown are for longword (32-bit) operands, in microseconds. Floating-point instruction times are for systems that include the Floating-Point Accelerator:

	Fixed-Point	Floating-Point
Add/Subtract	0.4	0.8
Multiply	1.6	1.2
Divide	9.8	4.2

The above instruction timings are the same for all VAX-11s, however, performance variants between VAXs are in memory access and instruction decoding.

INTERRUPTS: The processor recognizes 32 interrupt priority levels. The highest 16 interrupt priority levels are reserved for interrupts generated by hardware, and the lowest 16 levels are reserved for interrupts requested by software. Normal user software runs at the process level, which is interrupt priority level zero.

To handle interrupt requests, the processor enters a special system-wide context. In the system-wide context, the processor executes in kernel mode, using a special stack called the interrupt stack. The interrupt stack cannot be referenced by any user-mode software because the processor selects the interrupt stack only after an interrupt, and all interrupts are trapped through system vectors.

The interrupt service routine executes at the interrupt priority level of the interrupt request. When the processor receives an interrupt request at a level higher than that of the currently executing software, the processor honors the request and services the new interrupt at its priority level. When the interrupt service routine issues the REI (Return from Exception or Interrupt) instruction, the processor returns control to the previous level.

PHYSICAL SPECIFICATIONS: Nominal operating environment for the VAX-11 processors is 70 degrees F. ± 5 degrees F. (21 degrees C. ± 3 degrees C.) at 50 percent relative humidity (±10 percent).

A VAX-11/780 processor (for either a 11/780 or 11/782 system) is 60.5 inches (153.7 cm) high, 46.5 inches (118.1 cm) wide, 30 inches (76.2 cm) deep, and weighs 1,100 pounds (498 kg). Power requirements are 120/280 volts. Maximum AC power consumption is 6,225 watts, and maximum heat dissipation is 21,230 BTU/hour.

The VAX-11/750 is 42 x 29 x 30 inches in size (106 x 74 x 76 cm), approximately one-third the size of a VAX-11/780. Maximum weight is 400 pounds. Power requirements are 120 volts at 30 amps, and 240 volts at 15 amps, single phase. Maximum power consumption is 1,700 watts, and maximum heat dissipation is 5,800 BTU/hour.

The VAX-11/730 is 41.8 inches high, 21.3 inches wide and 31.5 inches deep (106.2 cm x 54.1 cm x 80 cm).

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workstations, and from six to 15 remote workstations. Both word processing and database management were being used with 24 VAX systems.

The following table shows the users' ratings:

	Excellent	Good	Fair	Poor	WA*
Ease of operation	38	16	0	0	3.7
Reliability of mainframe	38	14	1	1	3.7
Reliability of peripherals	20	23	10	1	3.2
Maintenance service:					
Responsiveness	17	28	6	3	3.1
Effectiveness	13	28	11	0	3.0
Technical support:					
Trouble-shooting	7	27	15	2	2.8
Education	5	32	13	2	2.8
Documentation	13	31	6	2	3.1
Manufacturer's software:					
Operating system	27	24	0	0	3.5
Compilers & assemblers	24	24	2	0	3.4
Applications programs	8	24	4	1	3.1
Ease of programming	27	24	0	1	3.5
Ease of conversion	18	25	1	1	3.3
Overall satisfaction	23	29	2	0	3.4

*Weighted Average on a scale of 4.0 for Excellent.

Users were generally happy with their VAX systems as indicated by the ratings. Specifically, 44 users felt the system was easy to expand/reconfigure; 43 users were happy with response time; 25 mentioned that productivity aids kept programming costs down; 23 noted that terminals/peripherals carried over from other systems were compatible (as the vendor had promised); and 22 added that the programs/data carried over from other systems were compatible (as the vendor had promised).

Although the users mentioned more advantages than disadvantages, the following are comments on the negative side: 10 users stated that the installation of the equipment was late; seven said the equipment was noisy; and five mentioned that the delivery of the required software was late.

An overwhelming majority of 50 VAX respondents would recommend their systems to other users, only one would not recommend the system, and three were undecided.

A final positive comment was added by one VAX user. This user represents a software house which develops and markets database systems software. His comment was, "We have recommended VAX to a number of our DBMS customers . . . with older, smaller machines. Many have switched and been very happy." Asked then about his satisfaction with an in-house VAX system, he replied, "I'm very pleased with it."□

INPUT/OUTPUT CONTROL

UNIBUS: All devices other than the high speed disk drives and magnetic tape transports are connected to the UNIBUS, an asynchronous bidirectional bus. These include all Digital- and user-developed real-time peripherals. The UNIBUS is connected to the memory interconnect through the UNIBUS adapter. The UNIBUS adapter does priority arbitration among devices on the UNIBUS. UNIBUS adapters may be placed on the memory interconnect as follows: up to four on the VAX-11/782 and 11/780, up to two on the 11/750, and up to two UNIBUS controller boards on the 11/730.

The UNIBUS adapter provides access from the VAX processors to the UNIBUS peripheral device registers by translating UNIBUS addresses, data transfer requests, and interrupt requests to their memory interconnect equivalents, and vice versa. The UNIBUS adapter address translation map translates an 18-bit UNIBUS address to a 30-bit memory interconnect address on the 11/782 and 11/780 and to 24 bits on the 11/750 and 11/730.

On the 11/782 and the 11/780, the UNIBUS adapter provides buffered DMA (NPR) devices. Each of these channels has a 64-bit buffer (plus byte parity) for holding four 16-bit transfers to and from UNIBUS devices. The result is that only one memory interconnect transfer (64 bits) is required for every four UNIBUS transfers. On the 11/750 and 11/730, the UNIBUS adapter facilitates high speed DMA transfers by providing buffered DMA data paths for up to three high speed devices at one time. Each of these channels has a 32-bit buffer (plus byte parity) for holding two 16-bit transfers to or from UNIBUS devices. The result is that only one memory transfer (32 bits) is required for every two UNIBUS transfers. The maximum aggregate transfer rate through the buffered data path is 1.5M bytes per second.

Any number of unbuffered direct memory access transfers are handled by one direct DMA data path. Every 8- or 16-bit transfer requires one 32-bit transfer on the memory interconnect. The maximum transfer rate through the direct data path is 500,000 bytes per second on the 11/780 and 11/782, and 1M bytes per second on the 11/750 and 11/730. The UNIBUS adapter permits program interrupts, unbuffered and buffered data transfers to occur concurrently.

MASSBUS: Used to attach high speed disk or magnetic tape devices, the MASSBUS adapter performs control, arbitration, and buffering functions. Up to four MASSBUS adapters can be connected to the memory interconnect on the 11/782 and 11/780, and up to three adapters on the 11/750. VAX MASSBUS is not available for the 11/730.

Each MASSBUS adapter includes its own address translation map that permits scatter/gather disk transfers. In scatter/gather transfers, physically contiguous disk blocks can be read into or written from discontiguous blocks of memory. The translation map contains the addresses of the pages, which may be scattered throughout memory, from or to which the contiguous disk transfer takes place.

Each VAX MASSBUS adapter includes a 32-bit silo (first in/first out) data buffer. Data is assembled in 32-bit longwords plus parity (64-bit quadwords plus parity on the 11/780) to make efficient use of the system bus. On transfers from memory to a MASSBUS peripheral, the MASSBUS adapter anticipates upcoming MASSBUS data transfers by fetching the next 32 bits (64 bits on the 11/780) from memory before all of the previous data are transferred to the peripheral. The maximum MASSBUS I/O throughput on the VAX processors is 2M bytes per second. On-line diagnostics and loopback enable adapter fault isolation without requiring the use of a drive on the MASSBUS.

CONFIGURATION RULES

Both the VAX-11/782 and VAX-11/780 contain the CPU, with virtual memory management, bootstrap loader, standard instructions for floating- and fixed-point arithmetic, 8K-byte parity bipolar cache memory, programmable real-time clock, time-of-year clock (with battery backup), and 2K words of writable diagnostic control store.

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Both systems also include as standard equipment, an integral diagnostic console subsystem, for use in both local and remote operations. This subsystem consists of an LSI-11 microcomputer to which an RX01 floppy disk unit and an LA120 console terminal are connected.

Optional expansions of the 11/782 and 11/780 can be made through the use of the CPU, CPU expansion and the UNIBUS cabinets. The following options are available for the 11/782 CPU cabinet: high performance floating-point accelerator with power supply, 2K words of user control store, the shared memory option, and a serial line unit for remote diagnosis.

Options mounted in the CPU cabinet include the Multiport Memory Option, a high performance Floating-Point Accelerator with power supply, 2K words of user control store, an additional 3M bytes of error-correcting memory, memory battery backup for up to 4M bytes of memory, a serial line unit for remote diagnosis, and up to two MASSBUS adapters. The VAX-11/780 expansion cabinet offers expansion for up to four MASSBUS adapters.

The basic equipment for the VAX-11/750 system includes the CPU, virtual memory management, bootstrap loader, standard instructions for floating- and fixed-point arithmetic, 4K-byte bipolar cache memory with parity, high precision programmable real-time clock, and time-of-year clock with battery backup. Also included as standard equipment is the console subsystem made up of an integral TU58 tape cartridge unit and an LA38 terminal.

Expansion space for packaged 11/750s is available in both the CPU backplane and the UNIBUS expansion backplane within the CPU cabinet. The optional VAX-11/750 general purpose expansion cabinet is used for expansion beyond the packaged system. The CPU backplane accepts the following options: a second UNIBUS adapter, a high performance floating-point accelerator, 1K words user writable control store, an additional 1.5M bytes of ECC MOS memory, a remote diagnosis module, and up to three MASSBUS adapters.

On VAX systems, the DMR11 series synchronous communications line provides high performance point-to-point interprocessor connection using the Digital Data Communications Message Protocol (DDCMP). For very high performance interprocessor communications, the 11/780 offers both multiport memory (MA780) and a high speed channel interface (DR780). For real-time applications, VAX supports the LPA11-K and DR11-13 Direct Memory Access (DMA) interfaces. The LPA11-K is an intelligent (dual microprocessor) controller that provides high speed data sampling, operates in both dedicated and multi-request mode, and supports a number of peripheral devices. The DR11-W is a general purpose interface that performs high speed block data transfers between the VAX memory and user peripheral devices.

UNIBUS ADAPTERS/CONTROLLERS: The 11/782 and 11/780 support up to four UNIBUS adapters, the 11/750 supports up to two UNIBUS adapters, and the 11/730 supports up to two VAX DMF32 combo board UNIBUS controllers.

WORKSTATIONS: Up to 384 terminals may be configured with the 11/782 or 11/780 (96 per each UNIBUS adapter); up to 128 terminals may be configured with the 11/750 (64 per each UNIBUS adapter); and up to eight terminals may be configured with a single cabinet packaged 11/730 (eight per each UNIBUS controller). With the 11/730 expander cabinet, the recommended maximum number of terminals is from 24 to 36.

UNIBUS DISK SYSTEMS: Up to eight disk drives may be configured per UNIBUS. Up to two dual-drive subsystems may be configured per system.

UNIBUS MAGNETIC TAPE: Maximum of two TS11 subsystems on the 11/750 and one TS11 subsystem on the 11/730.

MASSBUS ADAPTERS: The 11/782 and 11/780 support up to four MASSBUS adapters; the 11/750 supports up to three adapters. VAX MASSBUS is not available for the 11/730.

MASSBUS DISK STORAGE: Each MASSBUS adapter can run either eight disk drives or eight tape formatters or any combination totaling eight on its MASSBUS.

MASSBUS MAGNETIC TAPE: See MASSBUS disk storage. Included with each TE16, TU77, and TU78 tape transport is a different formatter. The TE16 magnetic tape subsystem supports up to eight TE16 add-on magnetic tape drives, while the TU77 and TU78 magnetic tape subsystems support up to four TU77 and four TU78 add-on magnetic tape drives, respectively. According to the vendor, the maximum number of tape drives supported by the VAX is dependent on the user's application and configuration, with no physical limit within reason.

MASS STORAGE

RP06 DISK DRIVES: A single- or dual-access, free-standing 176M-byte removable disk pack drive including one or two MASSBUS adapters, respectively. One RP06-P disk pack is included. Peak transfer rate is 806K bytes per second, average access time is 38.3 milliseconds, and average rotational latency is six milliseconds.

RP07 DISK DRIVES: A single- or dual-access, 516M-byte fixed disk drive. Peak transfer rate is 1.3 or 2.2M bytes per second, average access time is 31.3 milliseconds. An RP07-D option upgrades the interleaved transfer rate from 1.3 to 2.2M bytes per second.

RM05 DISK DRIVES: A single- or dual-access, 256M-byte removable disk pack drive including one or two MASSBUS adapters, respectively. Packaged in one free-standing disk drive cabinet plus one utility cabinet which houses the RM05 drive adapter and contains space for one additional RM05 drive adapter. One RM05-P disk pack is included. Peak transfer rate is 1.2M bytes per second, average access time is 38.3 milliseconds. For VAX-11/780 only.

RM03 DISK DRIVES: A single- or dual-access, free-standing 67M-byte removable disk pack drive including one or two MASSBUS adapters, respectively. One RM03-P disk pack is included. Peak transfer rate is 1.2M bytes per second, average access time is 38.3 milliseconds.

RL02/211 CARTRIDGE DISK DRIVE: A 10.4M-byte disk drive. One RL02K-DC data cartridge is included. Average access time is 67.5 milliseconds, peak transfer rate is 512K bytes per second. The RL02/211 disk drive is used only as a data disk, not a system disk. For VAX-11/750 and VAX-11/730 only.

RK07/711 CARTRIDGE DISK DRIVES: A single- or dual-access, free-standing 28M-byte disk drive. One RK07K-DC data cartridge is included. Average access time is 49.0 milliseconds, peak transfer rate is 538K bytes per second.

RX211 FLOPPY DISK SUBSYSTEM: A 1M-byte RX02 floppy disk subsystem for VAX-11/730 systems only. The peak transfer rate is 61K bytes per second; average seek time is 263 milliseconds. The RX02 subsystem is used only as a data disk.

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RM80 FIXED MEDIA DISK DRIVES: A single- or dual-access, free-standing 124M-byte fixed media disk drive. Peak transfer rate is 1.2M bytes per second, and average access time is 33.3 milliseconds.

CONSOLE STORAGE

RX01 FLOPPY DISK CARTRIDGE: An integral part of the VAX-11/782 and VAX-11/780 console subsystems, the RX01 is a random access mass memory subsystem that stores data in fixed length blocks on a flexible diskette with preformatted, industry standard headers. The RX01 is a single drive floppy capable of storing 256K bytes of data. The RX02 floppy disk system can also read/write data formatted for the RX01 floppy disk.

TU58 TAPE CARTRIDGE DRIVE: As part of the VAX-11/750 and VAX-11/730 console subsystems, the TU58 connects directly to the CPU and maintains the capability to administer diagnostics even with some system components inoperative. The tape cartridge is preformatted to store 2,048 records, each containing 128 bytes. The controller provides random access to any record. The TU58 searches at 60 ips to find the file requested, then reads at 30 ips. Data read from the tape is verified through checksums at the end of each record or header. All data transfers between the TU58 and the host are in 512-byte blocks, with the TU58 concatenating four 128-byte records to accomplish this. Data is transferred to the CPU at approximately 2K bytes per second.

INPUT/OUTPUT UNITS

Please refer to the Peripherals/Terminals table.

COMMUNICATIONS CONTROL

The variety of communications interfaces supported by the VAX/VMS operating system allows VAX systems to be connected to other VAX systems, other Digital systems, and to other manufacturers' computer systems. Synchronous, point-to-point, and multipoint connections are supported for interprocessor communication. For terminal to host communications, asynchronous connections are supported.

Six variations of the *DZ11 Asynchronous Multiplexer* are available with VAX systems. Three variations are designed for EIA/CCITT terminals or lines, and the other three are for 20mA current loop terminals or lines. The DZ11 provides control for up to 16 asynchronous terminal devices or 16 full-duplex lines. Each line can be individually programmed for one of 15 line speeds up to 9600 bps. The DZ11 includes modem controls to operate a Bell 103, 113, or equivalent 300 bps data set, or a Bell 212 at up to 1200 bps.

The DZ11 optionally generates parity on output and checks parity on input. Input characters are buffered with identification hardware in a first-in/first-out (FIFO) buffer, or "silo" (in DEC terms). Up to eight or 16 asynchronous serial lines per UNIBUS can be used in a system.

The *DMP11 Single Line Synchronous Controller* permits high speed Direct Memory Access (DMA) data transfers between computer systems in distributed networks. Parallel data is converted to serial data for line transmission and vice-versa for the UNIBUS via the controller. The microcode which is stored in ROM and executed by the microprocessor implements the Digital Data Communications Message Protocol (DDCMP) protocol. Multipoint or point-to-point operations are allowed over common carrier on private lines, or through shielded cables. The DMP11 can be configured for half-duplex operation at transfer rates of up to one million bps or for full-duplex at 500K bps. An integral modem is included for connection to shielded cables. For remote applications to common carrier lines, the DMP11 can be connected to synchronous modems conforming to EIA or CCITT standards. The DMP11 interfaces to Bell 200 series modems or equivalent at speeds up to 9600 bps and includes modem cable and data set control.

The *DMR11 Network Links* are single line synchronous interfaces for local and remote support, operating in full- or half-duplex. The Network Link for local support provides high speed connection to another DMR11 or DMC11 using twinaxial, coaxial, or triaxial cable up to 18,000 feet, and includes an integral modem. Switch-selectable speeds are 56,000 bps, 250,000 bps, 500,000 bps, and one million bps.

The remote DMR11 has speeds up to 19,200 bps, includes data set control for switched network operations, and can be used to communicate over common carrier facilities to another DMR11, DMC11, or to a synchronous interface with software implementation of DDCMP version 3.1 or 4.0. The remote Network Link interfaces to EIA RS-232-C/CCITT V.10 synchronous modems (Bell series 200-compatible) and to EIA RS-423/CCITT V.10 synchronous modems.

The *DUP11 Single Line Synchronous Interface* is full-/half-duplex and can be programmed to handle 8-bit character-oriented protocols such as DDPMP and BISYNC, and bit-oriented protocols such as SDLC and HDLC. The hardware calculates CRC-16 when using DDCMP protocol (not BISYNC) and CRC/CCITT when using bit-oriented protocols. The DUP11 interfaces to Bell 200 series modems or equivalent at speeds up to 9600 bps.

The *KMS11 Multiple Line Synchronous Interface* is an intelligent, full-duplex, eight line synchronous communications front-end for the VAX-11/780 only. The KMS11 supports concurrent data transfers over eight lines with full synchronous modem control, at speeds up to 56K bps. Maximum throughput is achieved by DMA from the multiplexer to the processor under control of the microprogram loaded into the WCS of the device. The KMS11 multiplexer is microprogrammed to off-load link and packet-level functions from the host for ADCCP, HDLC, and 3271 Bisynchronous Communications protocols. Hardware calculates CRC-16 when using byte-oriented protocols, and CRC/CCITT when bit-oriented protocols are implemented. Electrical interfaces supported are RS-232-C, MIL-188-114 (unbalanced), and V.24.

The *MA780 Multiport Memory* is a bank of MOS semiconductor memory with error-correcting code (ECC) that can be shared by up to four VAX-11/780 systems. Each system can randomly access all of the shared memory in exactly the same way it accesses its local memory.

Each MA780 can be expanded from a minimum of 256K bytes to a maximum of 2M bytes. This storage is in addition to each system's local memory, which can be as large as 8M bytes. Since there can be up to two MA780s connected to a CPU, a VAX-11/780 system can now directly address up to 12M bytes of physical memory.

Using VAX/VMS, the MA780 can be used to configure multiple computer systems for very high throughput. Depending on the application, the CPUs can be arranged in either a parallel or pipeline manner. In parallel systems, two or more appropriately programmed CPUs can divide a task. This allows the CPUs to pool their power to finish the job quickly. Pipeline systems can increase throughput by allowing instantaneous data exchange between CPUs that are handling sequential parts of an application.

DECnet is a family of network products that add networking capability to all of DEC's computer families, including the VAX systems. Using DECnet, various kinds of computer system networks can be constructed to facilitate remote communications, resource sharing, and distributed computation. DECnet is highly modular and flexible, and

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enables the user to select the appropriate hardware and software to build a network that satisfies a particular application's requirements.

Digital Network Architecture (DNA) is a set of protocols governing the format, control, and sequencing of message exchange for all DECnet implementation. DNA controls all data that travels through a DECnet network and provides a modular design for DECnet.

DNA consists of the following functional layers:

- The User Layer, which includes user-written programs and services that access the network. It is the highest layer in the architecture.
- The Network Management Layer, which defines the functions that allow the system manager to oversee, control, maintain, and test all major facets of a network node. Unlike most other layers, it has interfaces defined not only for adjacent layers, but also for every other layer in the architecture. The multiple interfaces meet the special requirements of network system management.
- The Network Application Layer, which defines network functions used by the two higher layers. The most important DECnet functions currently operating within this layer are remote file access, file transfer, and the remote terminal capability.
- The Session Control Layer and Network Service Layer, which together allow a program in one node to communicate with a program in another node, via a logical link regardless of either program's location within the network. Modules in the User Layer, Network Management Layer, and the Network Application Layer can use all the mechanisms provided by the Session Control and Network Service Layer.
- The Transport Layer, which defines an adaptive-path-routing mechanism for transporting data from one node to a specific node elsewhere in the network over the least costly path, as defined by the user.
- The Data Link Layer, which defines a mechanism for error-free communication between nodes. The layer is independent of communication device characteristics.
- The Physical Link Layer, which encompasses the software device driver for each communications device plus the communications hardware. The hardware includes interface devices, modems, and communication lines.

DNA specifies the interface by which DECnet software modules in the same system interact with one another. Reflecting the structure of DNA, DECnet modules are like building blocks. Within each node, a layer contains only those modules required to support modules in higher layers.

In addition to defining vertical interfaces, DNA also defines the protocols governing interaction between modules in different nodes. A module in one node communicates only with a module in the same layer that is servicing the same function in another node.

The protocols define the form and content of messages to be exchanged by modules.

Some of the DNA protocols and their functions are as follow:

- Network Information and Control Exchange protocol (NICE) defines mechanisms for exchanging network, node, and configuration data and for servicing requests from modules residing in the Network Management Layer.
- The Data Access Protocol (DAP) defines mechanisms for performing remote file access and remote file transfer on behalf of software modules residing in the Network Management Layer.
- The Network Services Protocol (NSP) defines a mechanism for creating and maintaining logical links between modules of higher level that reside in the same or different nodes.
- The transport protocol (Transport) defines a mechanism for dispatching data to any node in the network via the best possible route.
- The Maintenance Operation Protocol (MOP) defines mechanisms for transmitting data over a communications channel for down-line loading of a remote node, upline dumping from a remote node, testing a node and network connections, and starting up an unattended remote node.
- The Digital Data Communications Message Protocol (DDCMP) defines a mechanism for ensuring the integrity and sequentiality of data transmitted over a communications channel.

DNA does not define protocols for all functional layers. For example, User Layer programs communicate over the network according to the rules defined by the programmer. More than one protocol can be defined for the same layer because some layers support more than one function. For instance, the Network Applications Layer can include modules that use the Data Access Protocol (DAP) as well as modules that use a protocol defined by users for a specific application.

COMMUNICATIONS SOFTWARE

DECnet-VAX offers Phase III networking capabilities that provide alternatives for configuration flexibility and communications cost saving, in addition to Phase II networking features like file transfer and task-to-task communication. Adaptive routing reduces the need for direct links between every pair of communicating computers in a network. True network support tools in the form of Network Management are also available with DECnet Phase III. Network Command Terminals enable users at terminals to access to remote homogenous systems as if they were local.

DECnet-VAX interfaces are standard with VAX/VMS. To program task-to-task communication or file access, programmers use identical calls whether or not the tasks or data are on the same or different systems. The logical link between two programs is like an I/O channel over which programs can send and receive data. Using DECnet for task-to-task communication is like doing I/O with an existing driver.

Task-to-Task Communication—DECnet-VAX provides task-to-task communication, enabling cooperating programs to exchange data. Task-to-task communication is a method of creating a logical link between two tasks, exchanging data between the tasks, and disconnecting the link when the communication is complete. Any VAX language programmer can write programs that perform task-to-task communication.

Intertask communication routines can be coded using one of two methods: transparent calls or non-transparent calls. The process can send optional data along with the connect request. The receiving process or task can accept or reject the connect initiate. A process can access multiple connect requests and can send or receive mailbox messages to or from another process or task.

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In a DECnet-VAX network, a program using non-transparent access normally opens a control path directly to the Network Ancillary Control Process (NETACP) and designates one or more mailboxes for receiving information from the NETACP about the logical or physical links over which the process is communicating.

Access Control—Access control is the method by which network users are screened before gaining access to network facilities. With the appropriate access control information, a user program can log into a remote system and access any of the remote system's resources. The accessing program must have either an account or access to a guest account on the remote system, to log in successfully.

Remote File Access—All DECnet systems support exchange of sequential ASCII or binary files. The DECnet software handles compatibility issues among operating systems by translating the file syntax of the sending node into a common network syntax and then retranslating at the receiving end appropriately for that node. The transfer of file types other than ASCII can also be supported between particular operating systems.

DECnet-VAX supports file transfers between locally supported File Control Services (FCS) devices and the file system of other DECnet nodes. Wildcards can be used for the user identification code, file name, file type, and version number for local-to-remote file transfers. Directory listings are also a supported feature.

Additional facilities available on DECnet-VAX software allow system command files to be submitted to a remote node. The list of commands must be in a format acceptable to the node responsible for the execution. Similarly, command files can be received from other systems and then executed.

Down-line loading of tasks (programs) and systems is another useful tool provided by some DECnet products. Down-line system loading and it converse, upline system dumping, is particularly useful for small memory-based RSX-11S systems or for systems in hostile environments.

For terminal-to-terminal communication, a DECnet-VAX utility enables a user to send messages to any VAX system. Messages can be directed to any specific terminal or to the operator's console at the destination node. The messages can be exchanged in a dialog.

Network Command Terminals—With the Network Command Terminal facility, local users can log onto and use remote VAX systems as though they were local. Network Command Terminals, which are a software capability, require no special hardware. They provide virtual terminal communication between VAX/VMS systems. Intermediate nodes can be running DECnet-VAX or other DECnet Phase III software.

Network Management—The Network Control Program (NCP) performs three primary functions: displaying statistical and error information, controlling network components, and testing network operation. These functions can be performed locally or executed at remote Phase III nodes that support these functions.

Nodes communicate based on some combination of physical and logical capabilities. The physical capabilities for DECnet-VAX are point-to-point, multipoint, and adaptive routing.

A point-to-point node communicates only with adjacent nodes to which it is directly connected. A multipoint network party line shares time on one line with several nodes. This type of multipoint topology can reduce line costs. Multipoint configurations include a control station and tributaries. The control station controls network traffic by polling; it queries the tributary computer stations to determine if they have messages to send.

Routing is a method for sending messages from source to destination through intermediate nodes. DECnet Phase III provides adaptive routing wherein messages are routed through the network over the least-cost-path, as defined by the user. If either a line or a node in this preferred path goes down, the network will automatically reroute over the next least-cost-path.

Digital's Internet family of products supports the interconnection of Digital computers and Digital networks to systems built by other manufacturers. Members of the Internet family are the VAX-11 2780/3780 Protocol Emulator, VAX-11 3271 Protocol Emulator, and MUX200/VAX.

The *VAX-11 2780/3780 Protocol Emulator* allows data files to be transferred between VAX systems and other host computer systems capable of using 2780 or 3780 communications protocol. VAX-11 2780/3780 emulates binary synchronous communications (BSC) protocol, appearing to be an actual IBM 2780 or 3780 remote batch terminal on a point-to-point line. The product can run concurrently on up to four lines, each with a different set of attributes at speeds up to 9600 bps per line. Minimum system requirements include any valid VAX/VMS system with 512K bytes of memory and a DUP11 synchronous communication interface.

The *VAX-11 3271 Protocol Emulator* permits user programs running on VAX systems to communicate interactively with user tasks running on an IBM System/370 (including 303X processor systems). The IBM application program may run under either the IMS/VS or CICS/VS DB/DC systems. The VAX-11 3271 package makes it possible for VAX users to have on-line access to IBM databases for the purpose of information entry, retrieval, and update. The communications discipline used by the VAX-11 3271 Protocol Emulator is the 3271 subset of IBM's binary synchronous communications (BSC) protocol using EBCDIC code. Minimum system requirements include any valid VAX/VMS system with 512K bytes of memory and a DUP11 synchronous communications interface.

MUX200/VAX is a VAX-based software package that allows communication with a CDC 6000, CYBER series, or other host computer systems capable of using 200UT mode 4A communication protocol. It can be configured to support either the ASCII or the extended BCD versions of the protocol. MUX200/VAX provides for one synchronous communication circuit to a host computer system and allows several users to communicate simultaneously with the host computer over a single line. Minimum system requirements include any valid VAX/VMS system with 512K bytes of memory and a DUP11 synchronous communication interface.

VAX-11 PSI (Packetnet System Interface) allows a suitably configured VAX/VAX system to connect to Public-Packet Switched Networks (PPSNs) conforming to the CCITT recommendation X.25. Access to VAX-11 PSI is supported for VAX/VMS user programs written in VAX-11 Macro and native-mode high-level languages—for example, VAX-11 Fortran. VAX-11 PSI supports process-to-process and remote terminal communications via the network. Minimum system requirements include any valid VAX/VMS system with 512K bytes of memory and a DUP11 synchronous communication interface. (VAX-11 PSI is the prerequisite software to operate the KMS11 multiple line communication interface.)

SOFTWARE

OPERATING SYSTEM: The operating system for VAX computers is *VAX/VMS*, a general purpose operating system that provides the environment for the concurrent execution of

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multiuser time-sharing, batch and time-critical applications. Applications can be divided into several independent subsystems whose data and code are protected from one another but which have general communication and data sharing facilities. Jobs can communicate using general, group, or local communication facilities.

Jobs can be scheduled as time-critical jobs that have strict priorities of execution. When a time-critical job is ready to execute, it executes until it becomes blocked or until another time-critical job of higher-priority needs the resources of the processor. Normal jobs can be scheduled using a modified preemptive algorithm that ensures that they receive processor and peripheral resources at regular intervals commensurate with their processing needs.

If insufficient memory is available for keeping concurrently executing jobs resident, the operating system will swap jobs in and out of memory to allocate each its share of processor time. Time-critical jobs can be locked in memory to ensure that they can be started up rapidly when they need to execute.

The operating system provides a dynamic virtual memory programming environment. Large programs can be executed in a portion of physical memory that is considerably smaller than the program's memory requirements, without requiring the programmer to define overlays. The operating system optimizes its virtual memory system for program locality and provides tools that support optimization. It makes program performance predictable and controllable by restricting paging to the process program, and by allowing the user to cause large amounts of a program to be brought in at one time.

The operating system provides sophisticated peripheral device management for sharing, protection, and throughput. Devices can be shared among all jobs or reserved for exclusive use by particular jobs. Input and output for low speed devices is spooled to high speed devices to increase throughput. Files on mass storage devices can be protected from unauthorized access on an individual, group, or volume basis.

The I/O request processing system is optimized for throughput and interrupt response. The operating system provides the user with several data accessing methods, from logical record accessing for device-independent programming to direct I/O accessing for rapid data processing. Files can be stored in any of several ways to optimize subsequent processing.

VAX/VMS provides the programming tools, scheduling services, and protection mechanisms for multiuser program development. Programmers can write, execute, and debug programs interactively, and can also create batch command files that perform repetitive program development operations without requiring their attention.

The VAX/VMS operating system's own jobs run as independent activities. They include the Job Controller, which initiates and terminates user processes and manages spooling; the Operator Communications Manager, which handles messages queued to the system operators; and the Error Logger, which collects all hardware and software errors detected by the processor and the operating system.

A command interpreter executes as a service for interactive and batch jobs. It enables the general user to request the basic functions that the operating system provides, such as program development, file management, and system information services.

Both hardware-detected and software-detected exception conditions are tracked through the exception dispatcher. The exception dispatcher passes control to user-programmed condition handlers or, in the case of system-wide exception conditions or the absence of user routines, to operating system condition handlers.

The operating system's memory management routines include the virtual activator, which controls the mapping of virtual memory to system and user jobs, and the pager, which moves portions of a process in and out of memory as required. They respond to a program's dynamic memory requirements and enable programs to control their allocated memory, share data and code, and protect themselves from one another.

The scheduler controls the allocation of processor time to system and user jobs. The scheduler always ensures that the ready-to-execute time-critical job of highest-priority receives control of the processor until it relinquishes it. When no time-critical jobs are ready to execute, the scheduler dynamically allocates processor time to all other jobs according to their resource requirements. The swapper works in conjunction with the scheduler to move entire jobs into and out of memory when memory requirements exceed memory resources. The swapper ensures that the jobs most likely to execute are kept in memory.

The operating system's I/O processing software includes interrupt service routines, device-dependent I/O drivers, device-independent control routines, and user-programmed record processing services. The I/O system ensures rapid interrupt response and processing throughput, and provides programming interfaces for both special purpose and general purpose I/O processing.

DATABASE MANAGEMENT: The components of the VAX database management or information management architecture are arranged in layers above the operating system.

On the top layer, the VAX languages and VAX-11 FMS (Forms Management System) provide a user interface for interactive and language-callable video forms. VAX-11 DATATRIEVE supports English-like queries, hardcopy reports, and graphics.

On the next level, the VAX-11 Common Data Dictionary (CDD) integrates the other components of the architecture. The CDD provides a facility for storing logical data definitions.

Also on this level are the VAX-11 DATATRIEVE high-level and distributed data access facilities. High-level access provides the capability to access data without having to specify the means to access it, without specifying the file type, keys, etc. DATATRIEVE handles this by using definitions in the CDD that contain information about the data characteristics and user needs. The high-level data access facility also supports a 'relational join' capability that can be used to dynamically link related records. Users do not have to determine in advance the records they want to link. Using a relational join, the high-level access facility is capable of making these associations dynamically.

The distributed data access facility retrieves data from remote VAX-11 nodes running VAX-11 DATATRIEVE. The process is totally transparent to the user. A remote query looks just like a local query as far as the results of a DATATRIEVE request are concerned.

The lowest-level consists of two on-line multiuser data management facilities: VAX-11 RMS (Record Management Services) and VAX-11 DBMS (Database Management System).

The VAX programming languages which are a basic part of the VAX system architecture, are integrated into the information architecture. Language support for high-level access and direct access to VAX-11 RMS files and VAX-11

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DBMS databases is provided through the VAX standard calling interface to VAX-11 DATATRIEVE. Programmers can concentrate on coding the procedural part of the application and call DATATRIEVE to supply a high-level conditional value-based data access.

VAX-11 RMS is a file access method with an extended syntax interface to all high-level languages. It supports sequential, relative, and multikey indexed sequential file organizations, as well as concurrent file access with record-level locking. VAX-11 RMS also supports transparent file access to and from remote DECnet systems.

VAX-11 DATATRIEVE is a complete data management facility that provides both interactive and program-callable access to data in RMS file organizations or in more complex interrelated DBMS database structures. It is a comprehensive query and report writer with full update capabilities. It also includes an integrated graphics capability and forms support through FMS.

The *VAX-11 Common Data Dictionary* is the keystone of the architecture. The CDD is prerequisite to the operation of VAX-11 DATATRIEVE and VAX-11 DBMS. VAX-11 DATATRIEVE statements refer to data definitions in the Common Data Dictionary. The CDD is also used to store sequences of VAX-11 DATATRIEVE statements as procedures that can be invoked interactively or from application programs, as well as to store database definitions that VAX-11 DBMS needs to create, access, and maintain databases.

VAX-11 DBMS is a full-scale CODASYL-compliant database management system based on the March 1981 Working Document of the ANSI Data Definition Committee. It is a new implementation with many special ease-of-use and performance features. The VAX information architecture allows DBMS data to be accessed directly from programming languages, through VAX-11 DATATRIEVE, or through special DBMS utilities.

VAX-11 FMS provides a forms management capability for programming languages and VAX-11 DATATRIEVE. It provides video form support for applications on VT100, VT125, and VT52 video terminals. FMS forms are defined interactively and then stored in a FMS forms library. At run-time, VAX-11 FMS works as a forms management software front-end. It passes data between user programs and a video terminal on a per-field or per-form basis.

The process works exactly the same way when FMS forms are used with VAX-11 DATATRIEVE. If a form name is used as part of a DATATRIEVE definition, the VAX-11 DATATRIEVE facility will automatically use the form to collect, display, or modify the associated data.

WORD PROCESSING: *DX/VMS* is a VAX-11 Fortran software package that executes on a VAX/VMS operating system. It enables a WPS-8 word processing system running WPS-8, WPS-8/78, or WPS-8/MTS software to communicate with the VAX/VMS host over an asynchronous terminal interface. DX/VMS enables distributed standalone WPS-8 systems and the host VAX system to be linked together for better system utilization and data sharing.

VAX-11 DECmail is a standalone, single node mail and filing system that runs under the VAX/VMS operating system. DECmail can create, edit, send, and process messages on a single VAX computer system. DECmail has the ability to store, search, and retrieve messages held in system-provided or user-created folders. DECmail can also be used to store documents created on Digital's word processing systems which use the CX (Character Transmission) option that allows document transfer (text only) to and from VAX-11 DECmail.

LANGUAGES: VAX/VMS provides a native programming environment. The native programming environment consists of the language processors that produce native object code and the program development tools that support native program development. VAX-11 Fortran, Cobol, Basic, PL/1, Pascal, Coral 66, Bliss-32, DSM, and C are native-mode language processors that produce native object code, and take advantage of the native instruction set and 32-bit architecture of the VAX hardware.

VAX offers many PDP-11 compatibility features:

- The VAX processor can execute a subset of PDP-11 16-bit instructions in compatibility-mode.
- The VAX/VMS operating system provides functionally equivalent system services for many RSX-11M executive directives.
- The VAX/VMS high-level language compiler accepts source languages that are upwardly compatible with the same PDP-11 compilers.
- The VAX/VMS file system can read and write disk volumes and magnetic tapes written under RSX-11 and IAS operating systems.
- The VAX/VMS record management services provide record processing methods that are upwardly compatible with RMS-11 record management services.
- The VAX/VMS operating system provides an RSX-11 MCR command language, as well as DCL.
- The DECnet-VAX package supports RSX-11S system image down-line loading.

VAX-11 Fortran is an optimizing Fortran compiler designed to achieve high execution speed. It is an implementation of full language Fortran-77 which is based on ANSI Fortran X3.9-1978. The shareable, re-entrant compiler operates under the VAX/VMS operating system to take full advantage of the VAX floating-point and character instruction set and the VAX/VMS virtual memory operating system. It includes switch-selectable support for programs conforming to the previous standard, ANSI X3.9-1966.

VAX-11 Fortran also provides a number of extensions beyond the current ANSI standard, including language elements for keyed and sequential access to VAX-11 RMS multikey ISAM files and a set of data types beyond those specified for full language Fortran-77.

VAX-11 Cobol is a high performance, interactive language processor-based on the ANSI X3.S3-1974 standard. VAX-11 Cobol also incorporates many features planned for the upcoming ANSI standard, including more structured programming to allow simplification of complex coding procedures.

VAX-11 Cobol takes full advantage of the VAX hardware, generating in-line instructions for high speed compilation and program execution and support of larger programs. It includes full implementations of nine ANSI modules, including SORT/MERGE. Utilities are included to aid users in migrating other Cobol programs to VAX-11 Cobol.

VAX-11 Basic is a native-mode language processing system. It is an excellent instructional language as well as a general purpose programming language with a variety of industrial, technical, and commercial applications. VAX-11 Basic is a superset of PDP-11 Basic-PLUS-2/VAX, which is itself a highly extended superset of standard Basic language developed at Dartmouth College. VAX-11 Basic produces shareable native objective code, makes full use of the VAX

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floating-point and character-string instructions, and is itself shareable.

VAX-11 Pascal is a re-entrant, native-mode compiler particularly suited to instructional use. Pascal is a structured, high-level programming language that provides a modular systematic approach to computerized problem solving. VAX-11 Pascal takes full advantage of the VAX hardware floating-point and character instruction sets and the virtual memory capabilities of the VAX/VMS operating system.

VAX-11 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 applications and system implementation. VAX-11 Coral 66 is designed to replace assembly level programming in a number of commercial, process control, research and military applications. It is particularly adapted to long-life products requiring flexibility and ease of maintenance.

VAX-11 PL/1 is a comprehensive and powerful language that supports scientific computation, commercial data handling and data organization, and extensive string manipulation capabilities. Block structuring provides for programs which are easier to understand and less error prone.

VAX-11 PL/1 is an extended implementation of the proposed ANSI X3.74 PL/1 General Purpose Subset. Extensions to the subset language are either full language PL/1 features, or system-specific features that provide more complete access to VAX/VMS features. The VAX-11 PL/1 compiler generates optimized, shareable, native object code.

VAX-11 Bliss-32 is a high-level systems implementation language for VAX systems. Bliss-32 supports development of modular software according to structured programming concepts by providing an advanced set of language features for VAX systems to facilitate programming of real-time and/or hardware-independent applications. VAX-11 Bliss-32 is especially intended for the development of operating systems, compilers, run-time system components, database file systems, communications software and utilities.

VAX-11 DSM is a multiuser data management system and a high-level interpretive language. The Digital Standard Mumps (DSM) language conforms to the ANSI Mumps specification X11.1-1977 with several extensions to this specification. The DSM language is directed primarily toward the processing of variable-length string data, making interactive database systems easier to implement and maintain.

VAX-11C is a general purpose programming language featuring control and data structures with concise operations. Based on "The C Programming Language," VAX-11C is an integrated VAX/VMS layered language product, allowing programmers to use all of the services and program development aids that the VAX/VMS system provides. Also featured with VAX-11C is run-time support to aid UNIX to VAX/VMS migration including emulation of many of the UNIX-specific routines.

PDP-11 Basic-PLUS-2/VAX is a superset of the RSTS/E Basic-PLUS, Basic-11 IAS-RSX, and Dartmouth Basic languages. It includes CALL statements, COMMON statements, and record I/O. The Basic-PLUS-2/VAX compiler generates code for compatibility-mode.

Fortran IV/VAX-to-RSX Cross Compiler is a software tool for the development and execution of RSX-11M or RSX-11S Fortran programs. It is based on ANSI Fortran, X3.9-1966. The compiler operates in compatibility-mode under the RSX-11M Application Migration Executive (AME) or VAX/VMS systems. Programs compiled and tasks built can be transported to remote RSX-11M or RSX-11S target systems or executed on VAX/VMS in compatibility-mode.

The *VAX-11 Macro* assembler accepts one or more source modules written in Macro assembly language and produces a relocatable object module and optional assembly listing. VAX-11 Macro is similar to PDP-11 Macro, but its instruction mnemonics correspond to the VAX native instructions.

UTILITIES: The VAX utility programs (or, as DEC categorizes them, program development tools) include several text editors, a linker, a librarian, a common run-time procedure library, a symbolic debugger, and a code management system. These tools are available to the programmer through the VAX/VMS command language.

The text editors can be used to create memos, documentation, and data files, as well as source program modules for any language processor. The linker, librarian, debugger, and run-time procedure library described below are used only in conjunction with the language processors that produce native code. The language processors that produce compatibility-mode code offer their own task building, library, and debugging facilities and include their own object time system libraries.

SOS is an interactive text editor that enables the programmer to create and modify text files using commands entered from either a hardcopy or video terminal. The user can insert, delete, and replace lines, find and substitute strings, or modify the text a character at a time. Lines can be identified by line number, by relative position, or by content. An adjacent group of lines can be copied or transferred from one place to another. Editing can be done in any order in the file. Editor parameters can be set to user-specified values, and the current values can be shown. User-specific parameters can be set automatically at editor start-up.

SLP is a programmed text editor that enables the user to modify an existing file by supplying a command file containing a list of the modifications to be made. The command file provides a reliable way to duplicate the changes made to a file at a later time or on another system. SLP provides a formal record of changes made to files, both in the source file and in an audit-trail listing.

The *EDT* editor lets users enter and manipulate text and programs. EDT, with its extensive HELP facility, is designed to be learned easily by novices. EDT features line and character editing facilities, screen editing and keypad editing on the VT52 and VT100 video terminals, a start-up command file, a journaling facility, and the ability to work on multiple files simultaneously. It is shipped as part of VAX/VMS.

VAX-11 RUNOFF is a document formatter. A RUNOFF-processed document can be updated without extensive retyping because text changes, via the text editors, do not affect the basic design. The input to RUNOFF is a file containing the text of the document and the RUNOFF instructions. It is shipped as part of VAX/VMS.

The *VAX/VMS Linker* accepts one or more native object modules produced by an assembler or compiler, resolves the symbols and procedure references between them, and produces an executable program image. The linker also enables a programmer to create shareable images that can be linked subsequently with other modules to produce an executable image. Furthermore, the linker not only accepts object modules to produce executable or shareable images, but can also accept object module libraries, shareable images, and shareable image libraries.

The *Librarian* enables a programmer to create, update, modify, list, and maintain library files. A library file can be a

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collection of object modules or shareable images. A programmer can request the linker to use one or more library files from which the linker can obtain modules to resolve references during linking.

The *Run-Time Procedure Library (RTL)* is a collection of general purpose and language-specific libraries available to any native program, regardless of the source language in which the program was written. The run-time library is a shareable program that allows the choice of either incorporating procedures from the library into an executable image or mapping the global sections into a process virtual address space at run-time. A single copy of the library can be shared by all processes, and a new library can be installed without the need to relink existing programs. The run-time library includes a mathematical library, a general utility library, a condition-handling facilities library, a language-independent support library, and a Fortran IV-PLUS language-specific support library.

The *Symbolic Debugger* can be linked with a native program image to control program execution during development. The debugger can be used interactively or controlled from a command procedure file. The debugging language is similar to the VAX/VMS command language. Expressions and data references are similar to those of the source language used to create the image being debugged. Debugging commands include the ability to start and interrupt program execution, to step through instruction sequences, to call routines, to set break or trace points, to set default modes, to define symbols, and to deposit, examine, or evaluate virtual memory locations.

DEC/CMS (Code Management System) is a set of commands to help software developers manage the files of an on-going project. CMS enables users to keep ASCII text files in a project library, retrieve previous file generations, get reports of modified files, learn the origin of each line of a file manage and merge concurrent or separately developed modifications, and keep related files together as a single element.

VAX/VMS supports an *RSX-11M program development package* that enables users to write, assemble or compile, and link RSX-11M task images. The task images can be written to execute on a PDP-11 under RSX-11M or RSX-11S; or, if properly coded, they can be written to execute in the VAX compatibility-mode environment.

The RSX-11M development package includes both the PDP-11 Macro assembler and the PDP-11 Fortran IV compiler, plus RSX-11M program development utilities. Programmers can use the VAX/VMS command language to edit, copy, or back up their files. They can also use the RSX-11M MCR command interface on the VAX-11/780 system. MCR enables the programmer to run the standard RSX-11M utilities such as the EDI and SLP editors, the PIP and FLX file transfer utilities, and the Task Builder, Librarian, and patch utilities.

GRAPHICS UTILITIES: The *VAX-11 Pen Plotter Utilities* is a library of Fortran subroutines used to produce graphical output on most of the CALCOMP range of Pen Plotters. Included are all the standard CALCOMP calls (LINE, SYMBOL, WHERE, ETC.) and a handler for the CALCOMP 906 controller which connects to the VAX system via an EIA asynchronous line (DZ11).

The *VAX-11 Digitizer Utilities* is a library of Fortran subroutines for acquiring data from the TALOS range of digitizer tablets. The TALOS digitizers provide a means of accurately capturing graphic information through the position of either a hand-held pen or a tracking "mouse." VAX-11 Digitizer Utilities includes such single calls as fetch AREA, LENGTH, etc., in any scale of units specified by the user, and allow flexible creation of MENU areas on the digitizer surface.

VAX-11 Engineering Drawing Utilities is a library of Fortran callable subroutines used to provide high-level control plotting devices. Single calls are included to produce complex output with the minimum of applications programming effort, including routines to create circles, arcs, graph axes with labeling, dimension lines, arrowheads, etc., as well as a library of over 60 standard mathematical, logic and electronic symbols. Users may define their own symbols within 100 x 100 matrix and reference them with a unique calling number.

The *VAX-11 ReGIS Grahics Library (RGL)* is a collection of subroutines conforming to the standard VAX/VMS calling interface and designed to support the graphics capabilities of the UT125. RGL is written in Fortran and executes under the VAX/VMS operating system.

APPLICATIONS SOFTWARE: *Digital's External Applications Software (EAS) Library* service acquires software from third parties and makes it available through the company's software distribution channels. Software is tested by Digital for operation, documentation, and ease of installation prior to being included in the EAS Library. Software products from the EAS Library are sold on an "as is" unsupported basis, although the author of the software may offer a separate maintenance agreement.

PRICING

POLICY: DEC provides VAX systems on a purchase basis, with separately priced maintenance agreements. Leasing arrangements are available through DEC's joint venture with U.S. Leasing Corporation at a monthly charge of 2.4 percent of the purchase price. DEC software is licensed rather than sold. Users purchase licenses and distribution rights separately.

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
STANDARD SYSTEMS			
VAX-11/782 SYSTEMS			
All basic VAX-11/782s include the VAX/VMS operating system and two VAX-11/780 CPUs, each with virtual memory management, a bootstrap loader, standard instructions for packed decimal, floating- and fixed-point arithmetic, and character and string manipulations, bipolar cache memory with parity (8KB), a programmable real-time clock, a time-of-year clock with battery back-up, and writable diagnostic control store (2K words). In addition, one TEU78 magnetic tape transport with MASSBUS adapter, one DZ11-A asynchronous multiplexer for connection to eight EIA communications lines, dual LA120 console terminals, and a diagnostic console subsystem are standard.			
SV-AADCA-CA (CD)	With 2MB shared ECC MOS memory, one REM05 single-access 256MB disk drive with MASSBUS adapter	$430,000	$2,354

DEC VAX-11 Systems

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
VAX-11/782 SYSTEMS (Continued)			
SV-AAWCA-CA (CD)	With 2MB shared ECC MOS memory, and REM80 single-access 124MB fixed-disk drive with MASSBUS adapter	395,000	2,126
SV-AAVCA-CA (CD)	With 3MB shared ECC MOS memory, and RP07 single-access 516MB fixed-disk drive with MASSBUS adapter	445,000	2,394
VAX-11/780 SYSTEMS			
All basic VAX-11/780s include the VAX/VMS operating system, one VAX-11/780 CPU with virtual memory management, a bootstrap loader, standard instructions for packed decimal, floating- and fixed-point arithmetic, and character and string manipulation, bipolar cache memory with parity (8KB), a programmable real-time clock, a time-of-year clock with battery backup, and writable diagnostic control store (2K words). In addition, one DZ11-A asynchronous multiplexer for connection to eight EIA communications lines, an LA120 console terminal, and a diagnostic console subsystem are standard.			
SV-AXTVC-CA (CD)	With a TEE16 magnetic tape transport, 1MB ECC MOS memory, an REM03 single-access 67MB disk drive with MASSBUS adapter	219,100	955
SV-AXTBB-CA (CD)	With a TEU77 magnetic tape transport, 1MB ECC MOS memory, an REM03 single-access 67MB disk drive with MASSBUS adapter	239,200	1,099
SV-AXDBC-CA (CD)	With a TEU77 magnetic tape transport, 2MB ECC MOS memory, an REM05 single-access 256MB disk drive with MASSBUS adapter	274,900	1,349
SV-AXDCA-CA (CD)	With a TEU78 magnetic tape transport, 2MB ECC MOS memory, an REM05 single-access 256MB disk drive with MASSBUS adapter	296,700	1,514
SV-AXWBB-CA (CD)	With a TEU77 magnetic tape transport, 2MB ECC MOS memory, an REM80 single-access 124MB disk drive with MASSBUS adapter	243,900	1,121
SV-AXCBC-CA (CD)	With a TEU77 magnetic tape transport, 2MB ECC MOS memory, an REP06 single-access 176MB disk drive with MASSBUS adapter	274,900	1,270
SV-AXVCA-CA (CD)	With a TEU78 magnetic tape transport, 2MB ECC MOS memory, an REP07 single-access 516MB fixed Winchester disk drive with MASSBUS adapter	300,000	1,441
SV-AXVCB-CA (CD)	With a TEU78 magnetic tape transport, 3MB of interleaved ECC MOS memory, an REP07 single-access 516MB fixed Winchester disk drive with MASSBUS adapter	341,600	1,556
VAX-11/750 SYSTEMS			
All basic VAX-11/750s include the VAX/VMS operating system, one VAX-11/750 CPU with virtual memory management, a bootstrap loader, standard instructions for floating- and fixed-point arithmetic, bipolar cache memory with parity (4KB), a programmable real-time clock, and a time-of-year clock with battery backup. In addition, one DZ11-A asynchronous multiplexer for connection to eight EIA communications lines, and a diagnostic console subsystem are standard.			
SV-BXHHB-AA (AD)	With an RA80 fixed media disk drive and RL02 removable cartridge disk for a total of 131MB storage, 1MB ECC MOS memory, an RK711 UNIBUS controller, and an LA120 console terminal	84,900	N/A
SV-BXTAB-AA (AD)	With an RGM03 single-access 67MB disk drive with MASSBUS adapter and a TS11 magnetic tape subsystem with UNIBUS controller, 1MB ECC MOS memory, and an LA38 console terminal with stand	128,800	674
SV-BXDBB-CA (CD)	With a TGU77 magnetic tape transport, 3MB ECC MOS memory, one RGM05 single-access 256MB disk drive with MASSBUS adapter, and an LA120 console terminal	160,000	872
SV-BXWAB-AA (AD)	With an RGM80 single-access 124MB fixed media disk drive with MASSBUS adapter and a TS11 magnetic tape subsystem with UNIBUS controller, 1MB ECC MOS memory, and an LA38 console terminal with stand	123,600	627
SV-BXWVB-CA (CD)	With an RGM80 single-access fixed media disk drive with MASSBUS adapter and a TGE16 magnetic tape subsystem, 1MB ECC MOS memory, and one LA120 console terminal	130,000	728
SV-BXWBB-CA (CD)	With a TGU77 magnetic tape transport with MASSBUS adapter, an RGM80 single-access 124MB fixed media disk drive with MASSBUS adapter, 1MB ECC MOS memory, and an LA120 console terminal	140,000	785
VAX-11/730 SYSTEMS			
All basic VAX-11/730s include the VAX/VMS operating system, one VAX-11/730 CPU with virtual memory management, a bootstrap loader, integral floating-point, packed decimal and character-string instructions, and interval time-of-year clock. In addition, a console subsystem is included, with dual redundant TU58 tape cartridges, and an LA120 console terminal.			
SV-CXMMA-CA (CD)	With VAX-11/730-ZA CPU box, 1MB ECC MOS memory, dual RL02 disk storage devices for 20MB of on-line storage, an integrated disk controller (IDC), DMF32-AA combo board and distribution panel, and an H9642-type cabinet with 874 B/D power controller	48,900	342
SV-CXWMA-CA (CD)	With VAX-11/730-ZA CPU box, 1MB ECC MOS memory, an RL02 10MB dedicated disk drive, R80 single-access fixed media disk drive, DMF32-AA combo board and distribution panel, and an H9642-type cabinet with 874 B/D power controller	59,400	363

DEC VAX-11 Systems

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
VAX-11/782 PROCESSOR OPTIONS			
FP782-AA (AB)	Two FP780 high performance floating-point accelerators for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL; power supply included	22,400	96
VAX-11/780 PROCESSOR OPTIONS (also for VAX-11/782)			
FP780-AA (AB)	High performance floating-point accelerator for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL; power supply included	11,200	50
DR780-AA (AB)	Intelligent, high performance general purpose interface to connect customer designed devices to the VAX-11/780, or to connect two VAX-11/780 systems	18,700	88
DW780-AA (AB)	UNIBUS adapter	12,900	39
KE780-A	Extended range G&H floating-point data type option; includes microcode, single user license and support hardware; two required on VAX-11/782 systems (one per CPU), prerequisite, KU780-A	1,500	N/C
KU780-A	2K words (99-bit words) User Control Store, not supported on VAX-11/782 systems	11,000	53
VAX-11/750 PROCESSOR OPTIONS			
KU750-YG	1K words (88-bit words) User Writable Control Store	6,000	47
FP750	High performance floating-point accelerator for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL	8,500	45
VAX-11/730 PROCESSOR OPTION			
FP730	High performance floating-point accelerator for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL	3,995	25
VAX-11/782 EXPANSION MEMORY OPTION			
MA780-HA (HB)	1M-byte ECC MOS expansion memory subsystem for expansion from 4MB to 8MB, includes dual memory controllers, battery backup, cache invalidate option, cabinet and power supplies	70,000	594
VAX-11/782 AND VAX-11/780 EXPANSION MEMORY			
MS780-CC (CD)	512K-byte ECC MOS 16K-chip memory with controller for VAX-11/780 only	26,600	166
MS780-DA	256K-byte ECC MOS expansion memory	2,400	61
MS780-DB	512K-byte ECC MOS expansion memory	4,000	103
MS780-DC	1M-byte ECC MOS expansion memory	7,000	179
MS780-DD	2M-byte ECC MOS expansion memory	13,000	294
MS780-DE	4M-byte ECC MOS expansion memory	22,000	380
VAX-11/750 EXPANSION MEMORY			
MS750-AA	256K-byte ECC MOS expansion memory	2,400	61
MS750-AB	512K-byte ECC MOS expansion memory	4,000	103
MS750-AC	1M-byte ECC MOS expansion memory	7,000	179
MS750-CA*	1MB ECC 64K MOS expansion memory	9,000	29
MS750-CB*	2MB ECC 64K MOS expansion memory	16,000	58
MS750-CC*	3MB ECC 64K MOS expansion memory	21,000	87
MS750-CD*	4MB ECC 64K MOS expansion memory	24,000	116
MS750-CF*	10MB ECC 64K MOS expansion memory	50,000	290
MS750-DA	11/750 64K upgrade, 1M-byte, no BP (battery pack)	13,000	29
MS750-DC	11/750 64K upgrade, 1M-byte with BP (battery pack)	13,000	29
VAX-11/730 EXPANSION MEMORY			
MS730-CA	1MB ECC MOS expansion memory	9,000	29
MS730-CB	2MB ECC MOS expansion memory	16,000	58
MS730-CC	3MB ECC MOS expansion memory	21,000	116
MS730-CD	4MB ECC MOS expansion memory	24,000	232
VAX-11/782, VAX-11/780 AND VAX-11/750 MEMORY OPTION			
H7112-A (B)	MOS memory battery backup	1,800	12
VAX-11/782 SYSTEM UPGRADE PACKAGE			
782UP-AA (AD)	Field-installed system upgrade option to upgrade a VAX-11/780 packaged system to a VAX-11/782 system; includes a VAX-11/780 processor, battery backup, cache invalidate, a shared memory subsystem with 1MB of memory and an LA120-DA console terminal	1,450	8

*Requires VAX-11/750-CA CPU or MS750-D upgrade.

DEC VAX-11 Systems

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
VAX-11/780 SYSTEM UPGRADE OPTION			
H9604-BA (BB)	System upgrade option for dual RK07-based VAX-11/780 packaged system	25,750	N/C
VAX-11/780 MULTIPORT MEMORY OPTIONS (not for VAX-11/782)			
MA780-AA (AB)	256K-byte ECC MOS multiport memory subsystem	39,500	188
MA780-BA (BB)	Additional 256K-byte MA780 multiport memory subsystem	34,600	188
MA780-D	VAX-11/780 multiport memory selective cache invalidate option	9,900	61
MA780-EA (EB)	MA780 multiport memory port interface	39,500	188
MA780-F	Filler cab assembly kit	39,500	188
MASSBUS PERIPHERALS			
VAX-11/780 DISK DRIVE SYSTEMS (also for VAX-11/782)**			
REM03-AA (AD)	Single-access, free-standing 67MB removable disk pack drive and VAX-11/780 MASSBUS adapter	32,300	188
REM03-BA (BD)	Dual-access, free-standing 67MB removable disk pack and two VAX-11/780 MASSBUS adapters	43,900	237
REM05-AA (AB)	Single-access, 256MB removable disk pack drive and VAX-11/780 MASSBUS adapter	46,000	326
REM05-BA (BB)	Dual-access, 256MB removable disk pack drive and two VAX-11/780 MASSBUS adapters	60,600	415
REM80-AA (AD)	Single-access, free-standing 124MB fixed media disk drive and VAX-11/780 MASSBUS adapter	31,900	131
REM80-BA (BD)	Dual-access, free-standing 124MB fixed media disk drive and two VAX-11/780 MASSBUS adapters	43,500	179
REP06-AA (AB)	Single-access, free-standing 176MB removable disk pack drive and VAX-11/780 MASSBUS adapter	46,000	243
REP06-BA (BB)	Dual-access, free-standing 176MB removable disk pack drive and two VAX-11/780 MASSBUS adapters	60,600	298
REP07-AA (AB)	Single-access, free-standing 516MB fixed Winchester disk drive and VAX-11/780 MASSBUS adapter, 1.3- or 2.2-megabyte-per-second peak transfer rate**	50,000	240
REP07-BA (BB)	Dual-access, free-standing 516MB fixed Winchester disk drive and two VAX-11/780 MASSBUS adapters, 1.3- or 2.2-megabyte-per-second peak transfer rate**	64,600	320

**REP07 drives with 2.2-megabyte-per-second transfer rates are for VAX-11/780s only.

VAX-11/750 DISK DRIVE SYSTEMS			
RGM03-AA (AD)	Single-access, free-standing 67MB removable disk pack drive and VAX-11/750 MASSBUS adapter	32,300	188
RGM03-BA (BD)	Dual-access, free-standing 67MB removable disk pack drive and two VAX-11/750 MASSBUS adapters	43,900	237
RGP07	Single-access, free-standing, 516MB fixed Winchester disk drive and VAX-11/750 MASSBUS adapter, 1.3 megabytes per second peak transfer rate	50,000	N/A
RGM05-AA (AB)	Single-access, free-standing 256MB removable disk pack drive and VAX-11/750 MASSBUS adapter, packaged in one free-standing disk drive cabinet plus one utility cabinet which houses the RM05 drive adapter and contains space for one additional RM05 drive adapter	46,000	310
RGM05-BA (BB)	Dual-access, free-standing 256MB removable disk pack drive and two VAX-11/750 MASSBUS adapters, packaged in one free-standing disk drive cabinet plus one utility cabinet which houses the RM05 drive adapter and contains space for one additional RM05 drive adapter	46,000	310
RGM80-AA (AD)	Single-access, free-standing 124MB fixed media disk drive and VAX-11/750 MASSBUS adapter	31,900	131
RGM80-BA (BD)	Dual-access, free-standing 124MB fixed media disk drive and two VAX-11/750 MASSBUS adapters	43,500	179
RGP06-AA (AB)	Single-access, free-standing 176MB removable disk pack drive and VAX-11/750 MASSBUS adapter	46,000	243
RGP06-BA (BB)	Dual-access, free-standing 176MB removable disk pack drive and two VAX-11/750 MASSBUS adapters	60,600	298
ADD-ON DISK DRIVES			
RM03-AA (AD)***	Single-access, free-standing 67MB removable disk pack drive	20,300	154
RM03-BA (BD)***	Dual-access, free-standing 67MB removable disk pack drive	22,500	171
RM05-AA (AB)***	Single-access 256MB removable disk pack drive packaged in one free-standing disk drive cabinet plus one utility cabinet which houses the RM05 drive adapter and contains space for one additional RM05 drive adapter	34,000	252
RM05-AC (AD)***	Single-access 256MB removable disk pack drive packaged in free-standing disk drive cabinet only; one RM05-P disk pack is included	34,000	252
RM05-BA (BB)***	Dual-access 256MB removable disk pack drive packaged in one free-standing disk drive cabinet plus one utility cabinet which houses the RM05 drive adapter and contains space for one additional RM05 drive adapter	39,140	268
RM05-BC (BD)***	Dual-access 256MB removable disk pack drive packaged in free-standing disk drive cabinet only; one RM05-P disk pack is included	39,140	268
RM80-AA (AD)***	Single-access, free-standing 124MB fixed media disk drive	19,900	100
RM80-BA (BD)***	Dual-access, free-standing 124MB fixed media disk drive	22,000	116
RP06-AA (AB)***	Single-access, free-standing 176MB removable disk pack drive; one RP06-P disk pack is included	34,000	210
RP06-BA (BB)***	Dual-access, free-standing 176MB removable disk pack drive; one RP06-P disk pack is included	39,140	232

***Requires VAX-11/780 or VAX-11/750 MBA.

DEC VAX-11 Systems

EQUIPMENT PRICES

ADD-ON DISK DRIVES (Continued)

		Purchase Price	Monthly Maint.
RP07-AA (AB)	Single-access, free-standing 516MB fixed Winchester disk drive, requires RP07-D for 2.2MB transfer rate with interleaved memory, VAX-11/780 MBA	38,000	180
RP07-BA (BB)	Dual-access, free-standing 516MB fixed Winchester disk drive, requires RP07-D for 2.2MB transfer rate with interleaved memory, VAX-11/780 MBA	43,140	200

***Requires VAX-11/780 or VAX-11/750 MBA.

DUAL ACCESS AND UPGRADE OPTIONS

REM80-DA (DB)	RM80 dual-access conversion kit contains RM80-C, VAX-11/780 MASSBUS adapter with power supply to convert REM80-A to REM80-B	13,700	47
REP06-DA (DB)	RP06 dual-access conversion kit contains RP06-C, VAX-11/780 MASSBUS adapter with power supply to convert REP06-A to REP06-B	16,700	56
REP07-CA (CB)	RP07 dual-access conversion kit contains RP07-C, VAX-11/780 MASSBUS adapter with power supply to convert REP07-A to REP07-B	16,700	80
RGM03-C	RM03 dual-access conversion kit contains RM03-C and VAX-11/750 MASSBUS adapter to convert RGM03-A to RGM03-B	13,700	50
RGM05-C	RM05 dual-access conversion kit contains RM05-C and VAX-11/750 MASSBUS adapter to convert RGM05-A to RGM05-B	46,000	310
RGM80-C	RM80 dual-access conversion kit contains RM80-C and VAX-11/750 MASSBUS adapter to convert RGM80-A to RGM80-B	13,700	47
RGP06-C	RP06 dual-access conversion kit contains RP06-C and VAX-11/750 MASSBUS adapter to convert RGP06-A to RGP06-B	16,700	56
RM03-C	RM03 dual-access kit containing drive logic and cables to convert RM03-A to RM03-B	2,150	17
RM05-C	RM05 dual-access kit containing drive logic and cables to convert RM05-A to RM05-B	5,150	16
RM80-C	RM80 dual-access kit containing drive logic and cables to convert RM80-A to RM80-B	2,150	16
RP06-C	RP06 dual-access kit containing drive logic and cables to convert RP06-A to RP06-B	5,150	22
RP06-U	RP05 to RP06 upgrade kit includes drive upgrade parts and RP06-P disk pack	10,500	N/A
RP07-C	RP07 dual-access kit containing drive logic and cables to convert RP07-A to RP07-B	5,150	20
RP07-D	1.3 to 2.2MB transfer rate upgrade kit, requires interleaved memory	†	N/A
RM03-P	67MB removable disk pack for RM03	635	N/A
RM05-P	256KB removable disk pack for RM05	1,500	N/A
RM05-PX	RM05 disk pack, hard error (flag) free	1,650	N/A
RP06-P	176MB removable disk pack for RP06	950	N/A
RP06-PX	RP06 disk pack, hard error (flag) free	1,100	N/A

†Contact Digital or the Accessories and Supplies Group for pricing.

MAGNETIC TAPE EQUIPMENT

TEE16-AE (AJ)	Program-selectable 800 or 1600 bpi, 9-track, 45 ips magnetic tape transport and VAX-11/780 MASSBUS adapter; prerequisite, VAX-11/780 or VAX-11/782	27,000	163
TEU77-AB (AD)	Program-selectable 800 or 1600 bpi, 9-track, 125 ips magnetic tape transport and VAX-11/780 MASSBUS adapter; prerequisite, VAX-11/780 or VAX-11/782	36,800	259
TEU78-AB (AD)	Single-access, program-selectable, 6250 or 1600 bpi, 9-track, 125 ips, automatic loading magnetic tape transport, formatter, and VAX-11/780 MASSBUS adapter; prerequisite, VAX-11/780 or VAX-11/782	54,000	340
TEU78-BB (BD)	Dual-access, program-selectable, 6250 or 1600 bpi, 9-track, 125 ips, automatic loading magnetic tape transport, formatter, and two VAX-11/780 MASSBUS adapters; prerequisite, VAX-11/780 or VAX-11/782	68,600	420
TGE16-AE (AJ)	Program-selectable 800 or 1600 bpi, 9-track, 45 ips magnetic tape transport and VAX-11/750 MASSBUS adapter; prerequisite, VAX-11/750	15,900	97
TGU77-AB (AD)	Program-selectable 800 or 1600 bpi, 9-track, 125 ips magnetic tape transport and VAX-11/750 MASSBUS adapter; prerequisite, VAX-11/750	36,800	259

ADD-ON MAGNETIC TAPE DRIVES

TE16-AE (AJ)	Program-selectable 800 or 1600 bpi, 9-track, 45 ips magnetic tape transport unit in dedicated cabinet; prerequisite, TEE16 or TGE16 magnetic tape subsystem	15,900	97
TU77-AF (AJ)	Program-selectable 800 or 1600 bpi, 9-track, 125 ips automatic loading magnetic tape transport unit in dedicated cabinet; prerequisite, TEU77 or TGU77 magnetic tape subsystem	23,800	193
TU78-AB (AD)	Master drive, program-selectable, 6250/1600 bpi, 9-track, 125 ips automatic loading magnetic tape transport and formatter in a single dedicated cabinet; prerequisite, VAX-11/780, MBA	48,000	280
TU78-AF (AJ)	Program-selectable, 6250/1600 bpi, 9-track, 125 ips automatic loading magnetic tape transport and formatter in a single dedicated cabinet; prerequisite, TEU78 magnetic tape subsystem or TU78 master drive	25,500	170

DEC VAX-11 Systems

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
UNIBUS OPTIONS			
DW780-AA (AB)	UNIBUS adapter for VAX-11/780 and VAX-11/782	12,900	39
DW750-AA (AB)	UNIBUS adapter; requires a BA11-KW (KX) expansion box; for VAX-11/750	12,900	39
DMF32-AB	DMA UNIBUS controller; requires H9544-SJ picture frame mounting panel; for VAX-11/730	3,995	55
H9602-MB (MH)	Single-width, high-boy general purpose UNIBUS expansion cabinet with single-phase power control; for VAX-11/780 or VAX-11/782	5,000	N/C
BA11-KE (KF)	Rack-mountable expansion box with bezel and slides for UNIBUS expansion cabinet H9602-MF (MH); for VAX-11/780 or VAX-11/782	3,500	20
DB11-A	UNIBUS repeater allows an additional 19 unit loads and an additional 50 ft. of UNIBUS cable to be added; for VAX-11/780 or VAX-11/782	2,240	7
H9642-DB (DC)	High front loading expander cabinet and power control; bolts to VAX-11/750 CPU cabinet or to the VAX-11/730 H9642-type system cabinet	1,490	N/C
BA11-KW (KX)	Rack-mountable expansion box with bezel and slides; for the VAX-11/730 or VAX-11/750 general purpose expansion cabinet H9642-DB (DC)	1,490	N/C
FLOPPY DISK SUBSYSTEM			
RX211-BA (BD)	1.0MB RX02 floppy disk subsystem includes controller and two 0.5MB RX02 drives; prerequisite, VAX-11/730	4,150	50
CARTRIDGE DISK SUBSYSTEMS			
RL211-AK	10.4MB disk drive and control unit; one RL02K-DC data cartridge is included; expandable to a total of four RL02 drives; prerequisite, VAX-11/730	6,900	71
RK711-EA (ED)	Single-access, free-standing 28MB disk drive and control unit expandable to a total of eight RK06 or RK07 drives; one RK07K-DC data cartridge is included; prerequisite, VAX-11/780 or VAX-11/782	18,500	161
RK711-FA (FD)	Dual-access, free-standing 28MB disk drive and two control units expandable to a total of eight RK06 or RK07 drives; one RK07K-DC data cartridge is included; prerequisite, VAX-11/780 or VAX-11/782	25,500	210
ADD-ON CARTRIDGE DISK DRIVES			
RK07-EA (ED)	Single-access, free-standing 28MB disk drive; one RK07K-DC data cartridge is included; prerequisite, VAX-11/780 or VAX-11/782	13,000	127
RK07-FA (FD)	Dual-access, free-standing 28MB disk drive; one RK07K-DC data cartridge is included; prerequisite, VAX-11/780 or VAX-11/782	16,800	144
RK07-PA (PD)	Single-access, free-standing 28MB disk drive; one RK07K-DC data cartridge is included; prerequisite, VAX-11/730 or VAX-11/750	13,000	127
RL02-AK	10.4MB disk drive; one RL02K-DC data cartridge is included; prerequisite, VAX-11/730 or VAX-11/750	3,000	63
DUAL ACCESS OPTIONS			
RK711-C	Dual-access kit containing drive logic and hardware, one controller and cables to convert an RK711-E to an RK711-F; prerequisite, VAX-11/780 or VAX-11/782	11,700	50
RK07-C	Dual-access kit containing drive logic, hardware and cables to convert an RK07-E to an RK07-F; prerequisite, VAX-11/780 or VAX-11/782	4,100	17
CARTRIDGE DISKS AND ACCESSORIES			
RK07K-AA (AB)	Disk cleaner/115 VAC	1,395	N/A
RK07K-EF	Error free 28MB disk cartridge for RK07	650	N/C
RK07K-AC	28MB alignment cartridge for RK07	1,483	N/C
RK07K-DC	28MB disk cartridge for RK07	430	N/C
RL02K-DC	10.4MB disk cartridge for RL02	199	N/A
MAGNETIC TAPE SUBSYSTEMS			
TS11-BA (BB)	1600 bpi, 9-track, 45 ips magnetic tape transport and control unit in a dedicated 60-inch H9602 cabinet; prerequisite, VAX-11/780 or VAX-11/782	16,400	79
TS11-CA (CB)	1600 bpi, 9-track, 45 ips magnetic tape transport and control unit in a dedicated 60-inch H9646 cabinet; prerequisite, VAX-11/730 or VAX-11/750	16,400	79
ASYNCHRONOUS MULTIPLEXERS			
DZ11-A	Asynchronous 8-line multiplexer for connection of eight EIA/CCITT terminals or lines	2,700	33
DZ11-B	Eight-line EIA/CCITT expansion multiplexer	2,150	28
DZ11-C	Asynchronous 8-line multiplexer for connection of 20mA current loop terminals	3,000	33
DZ11-D	Eight-line 20mA current loop expansion multiplexer	2,310	28
DZ11-E	Asynchronous 16-line multiplexer for connection of EIA/CCITT terminals or lines	4,350	56
DZ11-F	Asynchronous 16-line multiplexer for connection of 20mA current loop terminals	5,000	56

DEC VAX-11 Systems

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
SINGLE LINE SYNCHRONOUS INTERFACES			
DMP11-AA	Microprocessor-controlled communications controller that permits high speed DMA data transfers between computer systems in distributed networks	†	†
DMR11-AA	Network link DDCMP microprocessor and line unit modules for remote support; speeds up to 19,200 bpi	4,400	39
DMR11-AC	Network link DDCMP microprocessor and line unit modules for local support; provides high speed connection to another DMR11 or DMC11	4,400	39
DUP11-DA	Full/half-duplex synchronous interface	1,575	12
†Contact Digital or the Accessories and Supplies Group for pricing.			
MULTIPLE LINE SYNCHRONOUS INTERFACES			
KMS11-BD	Intelligent, full-duplex, 8-line, synchronous, communications, front-end interface with concurrent data transfers over eight lines; includes 9-slot backplane and cable to connect modems; prerequisite, VAX-11 PSI (QE071-AY), for VAX-11/780 only	12,500	97
KMS11-BE	Same functions as KMS11-BD, except without 9-slot backplane and cable to connect modems; prerequisite, VAX-11 PSI (QE071-AY), for VAX-11/780 only	12,200	97
GENERAL PURPOSE UNIBUS INTERFACES			
DR11-W	General purpose DMA controller, interfaces to VAX UNIBUX	1,650	11
PCL11-B	High speed multiple computer link (500 bytes per inch); prerequisite, VAX-11/780 or VAX-11/782	7,750	66
LPA11-K	High speed DMA controller for laboratory I/O devices, allows concurrent multiuser control of analog-to-digital converters, digital-to-analog converters, and parallel digital I/O devices, a library of Fortran callable support subroutines is provided; prerequisite, VAX-11/750, VAX-11/780, or VAX-11/782	5,600	48
LPA11-KK	Package; includes LPA11-K DMA controller, ADK11-KT analog-to-digital converter package, and DD11-CK backplane; prerequisite, VAX-11/750, VAX-11/780, or VAX-11/782	8,600	102
PACKAGED LABORATORY PERIPHERAL OPTIONS			
The following options are supported only with the LPA11-K bus.			
AA11-KT	Digital-to-analog converter with distribution panel, and cable; prerequisite, KW11-K real-time clock	1,650	8
ADK11-KT	Analog-to-digital converter with KW11-K real-time clock, distribution panel, and cables	3,950	56
DR11-KT	General purpose digital interface with distribution panel and cables; prerequisite, KW11-K real-time clock	1,360	8
AA11-K	4-channel, 12-bit, digital-to-analog converter; prerequisite, KW11-K real-time clock	1,450	8
AD11-K	12-bit, 16-channel, single-ended 8-channel true differential 12-bit analog-to-digital converter with self-test and software-controlled vernier offset; prerequisite, KW11-K real-time clock	2,850	37
AM11-K	48-channel, single-ended (24-channel differential), expander or switch gain multiplexer), six gain levels per 16 channels; prerequisite, AD11-K and KW11-K or ADK11-KT	1,550	17
DR11-K	General purpose digital interface	940	8
H3220	Low profile, 1.75-inch (4.44 cm) high distribution panel used to interconnect LPA11-K options	1,820	12
KW11-K	Dual programmable real-time clock	1,150	20
LINE PRINTERS			
LP11-AA	132-column, 64-character band printer and control unit; 285 lpm	8,350	100
LP11-BA	132-column, 64- and 94-character band printer and control unit; 285 lpm when using 64-character set and 204 lpm when using 96-character set	8,950	100
LP11-CA (CD)	132-column, 64-character high speed printer and control unit; 900 lpm	32,500	205
LP11-DA (DD)	132-column, 96-character high speed printer and control unit; 600 lpm	34,500	205
LP11-YA (YD)	132-column, 64-character printer and control unit; 600 lpm	24,240	166
LP11-ZA (ZD)	132-column, 96-character printer and control unit; 436 lpm	26,280	166
LP32-AA	132-column, 64-character printer and universal power supply, 300 lpm; prerequisite, DMF32 UNIBUS controller	26,280	166
LP32-BA	132-column, 64-/96-character printer and universal power supply, 300/210 lpm; prerequisite, DMF32 UNIBUS controller	26,280	166
LP32-EA	132-column, 64-character printer and universal power supply, 600 lpm; prerequisite, DMF32 UNIBUS controller	26,280	166
LP32-EB	132-column, 64-/96-character printer and universal power supply, 600/450 lpm; prerequisite, DMF32 UNIBUS controller	26,280	166
LP32-GA (GB)	132-column, 64-/96-character printer and universal power supply, 1200/880 lpm; prerequisite, DMF32 UNIBUS controller	26,280	166

DEC VAX-11 Systems

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.
PRINTERS/PLOTTERS			
LXY11-XX	132-column, 96-character dot matrix printer and plotter with control unit, 300 lpm print speed, 170 lpm plot speed, including PLXY-11/VAX plot software package	11,250	141
LXY21-XX	132-column, 96-character dot matrix printer and plotter with control unit, 600 lpm print speed, 320 lpm plot speed, including PLXY-11/VAX plot software package	15,800	163
CARD READERS			
CR11 (-A)	300 cpm reader and control unit; reads 80-column punched cards	8,250	74
CR11-BC (BD)	600 cpm reader and control unit; reads 80-column punched cards	11,700	76
CME11-KA (KB)	250 cpm reader and control unit; reads 40- and 80-column punched cards	4,950	74
TERMINALS			
LA34-DA	Table-top DECwriter IV printing terminal; includes universal power supply, standard EIA interface and EIA null modem cable; 30-character per second print speed and baud rates up to 300 bps, for single sheets and computer paper	1,450	18
LA38-GA	Same as LA34-DA except can accommodate up to 4-part computer form as well as single sheets and computer paper	1,750	18
LA38-HA	Free-standing DECwriter IV printing terminal; includes stand, universal power supply, standard EIA interface and EIA null modem cable; 18-button numeric keypad, 30 cps print speed and baud rates up to 300 bps, accommodates up to 4-part computer form as well as single sheets and computer paper	1,850	18
LA100-YA	Table-top, microprocessor-controlled hardcopy, receive-only terminal used with video workstations and small business systems; operates on full-duplex (or full-duplex with local echo) asynchronous communications lines and includes universal power supply, standard EIA interface, tractors, BC22A-10 cable, ribbon cartridge, and one roll of paper	2,800	25
LA120-DA	Free-standing DECwriter III high speed interactive hardcopy terminal; 180 cps bidirectional printing with baud rates up to 9600	2,800	32
VT100-AA (AB)	High performance, table-top, hardcopy, receive-only terminal, includes double-width/double-size characters, 80 columns x 24 lines or 132 columns x 14 lines, 95-character detachable keyboard	2,150	18
VT100-WA (WB)	Video display terminal for DECmail applications, includes word processing features, double-width/double-size characters, 80 columns x 24 lines or 132 columns x 14 lines, 95-character detachable keyboard; operates on full-duplex asynchronous communications lines, with a standard interface	2,345	21
VT101-AA (AB)	Video display terminal, totally self-contained with no functional upgrade options, offers basic VT100 functions and full VAX/VMS support plus local echo (which allows connection to non-Digital computer systems); features double-width/double-size characters, 80 columns x 24 lines or 132 columns x 14 lines, 95-character detachable keyboard; operates on full-duplex asynchronous communications lines with a standard EIA interface; same software support as VT100	2,150	15
VT102-AA (AB)	Video display terminal of the VT100 family, fully optioned and functional communicates with both Digital and non-Digital systems, for data processing or word processing on models with DECWORD word processing keycaps; features advanced video and built-in printer port characteristics, and the U.S. and European half- and full-duplex communications and modem controls, plus local echo; same software support as VT100	2,400	22
VT125-AA (AB)	An enhanced VT100 alphanumeric video terminal with data plotting extensions, automatic vector and curve generation	3,800	29
278-AA	Intelligent video display terminal for DECmate word processing systems, supports word processing in standalone mode and data processing in terminal mode; offers a display rate of 960 characters per second on 80 columns x 24 lines (in word processing operation), an 83-key detachable keyboard, 254-character set and 7 x 9 dot matrix printing; prerequisite, DMF32, DZ11-A, DZ11-B, or DZ11-E	6,595	48
VT1XX-AB	Advanced video option; adds 10 additional lines of 132-column data for a total of 132 columns x 24 lines	180	4
VT1XX-AA	20mA current loop adapter for VT100	140	4
VT1XX-CA	20mA current loop adapter for VT125	140	4
VT1XX-CB	Upgrade/conversion kit to convert VT100 to VT125	2,000	11
COLOR GRAPHICS SYSTEM			
VS11-AA (AB)	High performance, 16 color and monochrome raster graphics system; features graphics instruction set, bit-slice architecture, switch-selectable resolution and intensity for interlaced (512 x 512 x 2 bits) or non-interlaced (512 x 256 x 4 bits) image memory operation; prerequisite VAX/VMS system configuration and VAX/VMS driver	6,480	62

DEC VAX-11 Systems

SOFTWARE PRICES

		License Fee
QE001-AM	VAX/VMS operating system for VAX-11/780 and VAX-11/782 on 9-track magtape	$20,000
QE001-AV	VAX/VMS for VAX-11/780 and VAX-11/782 on RK07 disk cartridge	20,000
QD001-AM	VAX/VMS for VAX-11/750 on 9-track magtape	20,000
QD001-AV	VAX/VMS for VAX-11/750 on RK07 disk cartridge	20,000
QC001-AH	VAX/VMS for VAX-11/730 on 9-track magtape	20,000
QC001-AV	VAX/VMS for VAX-11/730 on RL02 disk cartridge	20,000
QE100-AY	VAX-11 Fortran on floppy disk (VAX-11/780 and VAX-11/782)	8,700
QD100-AG	VAX-11 Fortran on TU58 tape cartridge (VAX-11/750)	8,700
QC100-AG	VAX-11 Fortran on TU58 tape cartridge (VAX-11/730)	8,700
QE099-AY	VAX-11 Cobol on floppy disk (VAX-11/780 and VAX-11/782)	13,800
QD099-AG	VAX-11 Cobol on TU58 tape cartridge (VAX-11/750)	13,800
QC099-AG	VAX-11 Cobol on TU58 tape cartridge (VAX-11/730)	13,800
QE101-AY	VAX-11 Cobol-74 on floppy disk (VAX-11/780 and VAX-11/782)	13,800
QD101-AG	VAX-11 Cobol-74 on TU58 tape cartridge (VAX-11/750)	13,800
QC101-AG	VAX-11 Cobol-74 on TU58 tape cartridge (VAX-11/730)	13,800
QE095-AY	VAX-11 Basic on floppy disk (VAX-11/780 and VAX-11/782))	9,200
QD095-AG	VAX-11 Basic on TU58 tape cartridge (VAX-11/750)	9,200
QC095-AG	VAX-11 Basic on TU58 tape cartridge (VAX-11/730)	9,200
QE110-AY	VAX-11 Pascal on floppy disk (VAX-11/780 and VAX-11/782)	5,500
QD110-AG	VAX-11 Pascal on TU58 tape cartridge (VAX-11/750)	5,500
QC110-AG	VAX-11 Pascal on TU58 tape cartridge (VAX-11/730)	5,500
QE067-AY	VAX-11 Coral 66 on floppy disk (VAX-11/780 and VAX-11/782)	10,000
QD067-AG	VAX-11 Coral 66 on TU58 tape cartridge (VAX-11/750)	10,000
QC067-AG	VAX-11 Coral 66 on TU58 tape cartridge (VAX-11/730)	10,000
QE114-AY	VAX-11 PL/1 on floppy disk (VAX-11/780 and VAX-11/782)	13,800
QD114-AG	VAX-11 PL/1 on TU58 tape cartridge (VAX-11/750)	13,800
QC114-AG	VAX-11 PL/1 on TU58 tape cartridge (VAX-11/730)	13,800
QE106-AY	VAX-11 Bliss-32 on floppy disk (VAX-11/780 and VAX-11/782)	13,800
QD106-AG	VAX-11 Bliss-32 on TU58 tape cartridge (VAX-11/750)	13,800
QC106-AG	VAX-11 Bliss-32 on TU58 tape cartridge (VAX-11/730)	13,800
QE107-AY	Fortran IV/VAX-to-RSX Cross Compiler on floppy disk (VAX-11/780 and VAX-11/782)	1,150
QD107-AG	Fortran IV/VAX-to-RSX Cross Compiler on TU58 tape cartridge (VAX-11/750)	1,850
QC107-AG	Fortran IV/VAX-to-RSX Cross Compiler on TU58 tape cartridge (VAX-11/730)	1,850
QE014-AY	VAX-11 Bliss-16 on floppy disk (VAX-11/780 and VAX-11/782)	13,800
QD014-AG	VAX-11 Bliss-16 on TU58 tape cartridge (VAX-11/750)	13,800
QC014-AG	VAX-11 Bliss-16 on TU58 tape cartridge (VAX-11/730)	13,800
QE015-AY	VAX-11C on floppy disk (VAX-11/780 and VAX-11/782)	7,500
QD015-AG	VAX-11C on TU58 tape cartridge (VAX-11/750)	7,500
QC015-AG	VAX-11C on TU58 tape cartridge (VAX-11/730)	7,500

COMMUNICATIONS

QED03-AY	DECnet-VAX on floppy disk (VAX-11/780 and VAX-11/782)	6,000
QDD03-AG	DECnet-VAX on TU58 tape cartridge (VAX-11/750)	6,000
QCD03-AG	DECnet-VAX on TU58 tape cartridge (VAX-11/730)	6,000
QE111-AY	VAX-11 2780/3780 Protocol Emulator on floppy disk (VAX-11/780 and VAX-11/782)	6,400
QD111-AG	VAX-11 2780/3780 Protocol Emulator on TU58 tape cartridge (VAX-11/750)	6,400
QC111-AG	VAX-11 2780/3780 Protocol Emulator on TU58 tape cartridge (VAX-11/730)	6,400
QE070-AY	MUX200/VAX on floppy disk (VAX-11/780 and VAX-11/782)	8,100
QD070-AG	MUX200/VAX on TU58 tape cartridge (VAX-11/750)	8,100
QC070-AG	MUX200/VAX on TU58 tape cartridge (VAX-11/730)	8,100
QE071-AY	VAX-11 PSI (Packetnet System Interface) on floppy disk (VAX-11/780 and VAX-11/782)	5,000
QD071-AG	VAX-11 PSI (Packetnet System Interface) on TU58 tape cartridge (VAX-11/750)	5,000
QC071-AG	VAX-11 PSI (Packetnet System Interface) on TU58 tape cartridge (VAX-11/730)	5,000
QE112-AY	VAX-11 3271 Procotol Emulator on floppy disk (VAX-11/780 and VAX-11/782)	7,500
QD112-AG	VAX-11 3271 Procotol Emulator on TU58 tape cartridge (VAX-11/750)	7,500
QC112-AG	VAX-11 3271 Procotol Emulator on TU58 tape cartridge (VAX-11/730)	7,500

DEC VAX-11 Systems

SOFTWARE PRICES

DATA MANAGEMENT

		License Fee
QE898-AM	VAX-11 DATATRIEVE on 9-track magtape (VAX-11/780 and VAX-11/782)	15,000
QD898-AV	VAX-11 DATATRIEVE on RK07 disk cartridge (VAX-11/750)	15,000
QC898-AH	VAX-11 DATATRIEVE on RL02 disk cartridge (VAX-11/730)	15,000
QE701-AY	VAX-11 FMS Forms Management System on floppy disk (VAX-11/780 and VAX-11/782)	5,180
QD701-AG	VAX-11 FMS on TU58 tape cartridge (VAX-11/750)	5,180
QC701-AG	VAX-11 FMS on TU58 tape cartridge (VAX-11/730)	5,180
QE897-AY	Common Data Dictionary on floppy disk (VAX-11/780 and VAX-11/782)	3,000
QD897-AG	Common Data Dictionary on TU58 tape cartridge (VAX-11/750)	3,000
QC897-AG	Common Data Dictionary on TU58 tape cartridge (VAX-11/730)	3,000
QE899-AM	VAX-11 DBMS on 9-track magtape (VAX-11/780 and VAX-11/782)	30,000
QD899-AV	VAX-11 DBMS on RK07 disk cartridge (VAX-11/750)	30,000
QC899-AH	VAX-11 DBMS on RL02 disk cartridge (VAX-11/730)	30,000
QE900-AM	VAX-11 DATATRIEVE upgrade on 9-track magtape (VAX-11/780 and VAX-11/782)	11,800
QD900-AV	VAX-11 DATATRIEVE upgrade on RK07 disk cartridge (VAX-11/750)	11,800
QE072-AM	VAX-11 DATATRIEVE and VAX-11 CDD on 9-track magtape (VAX-11/780 and VAX-11/782)	17,000
QD072-AV	VAX-11 DATATRIEVE and VAX-11 CDD on RK07 disk cartridge (VAX-11/750)	17,000
QC072-AH	VAX-11 DATATRIEVE and VAX-11 CDD on RL02 disk cartridge (VAX-11/730)	17,000
QE073-AM	VAX-11 DBMS and VAX-11 CDD on 9-track magtape (VAX-11/780 and VAX-11/782)	32,000
QD073-AV	VAX-11 DBMS and VAX-11 CDD on RK07 disk cartridge (VAX-11/750)	32,000
QC073-AH	VAX-11 DBMS and VAX-11 CDD on RL02 disk cartridge (VAX-11/730)	32,000
QE074-AM	VAX-11 DATATRIEVE, VAX-11 DBMS, and VAX-11 CDD on 9-track magtape (VAX-11/780 and VAX-11/782)	42,000
QD074-AV	VAX-11 DATATRIEVE, VAX-11 DBMS, and VAX-11 CDD on RK07 disk cartridge (VAX-11/750)	42,000
QC074-AH	VAX-11 DATATRIEVE, VAX-11 DBMS, and VAX-11 CDD on RL02 disk cartridge (VAX-11/730)	42,000
QE130-AY	VAX-11 DSM on floppy disk (VAX-11/780 and VAX-11/782)	12,000
QD130-AG	VAX-11 DSM on TU58 tape cartridge (VAX-11/750)	12,000
QC130-AG	VAX-11 DSM on TU58 tape cartridge (VAX-11/730)	12,000
QE007-AY	DEC/CMS code management system on floppy disk (VAX-11/780 and VAX-11/782)	15,000
QD007-AG	DEC/CMS code management system on TU58 tape cartridge (VAX-11/750)	15,000
QC007-AG	DEC/CMS code management system on TU58 tape cartridge (VAX-11/730)	15,000

ELECTRONIC MAIL AND WORD PROCESSING

QE400-AY	VAX-11 DECmail on floppy disk (VAX-11/780 and VAX-11/782)	20,000
QD400-AG	VAX-11 DECmail on TU58 tape cartridge (VAX-11/750)	20,000
QC400-AG	VAX-11 DECmail on TU58 tape cartridge (VAX-11/730)	20,000
QE707-YY	DX/VMS on floppy disk (VAX-11/780 and VAX-11/782)	2,900
QD707-YG	DX/VMS on TU58 tape cartridge (VAX-11/750)	2,900
QC707-YG	DX/VMS word processing utility on TU58 tape cartridge (VAX-11/730)	2,900

ENGINEERING GRAPHICS UTILITIES

QE051-YY	VAX-11 Pen Plotter Utilities on floppy disk (VAX-11/780 and VAX-11/782)	2,500
QD051-YG	VAX-11 Pen Plotter Utilities on TU58 tape cartridge (VAX-11/750)	2,500
QC051-YG	VAX-11 Pen Plotter Utilities on TU58 tape cartridge (VAX-11/730)	2,500
QE055-YY	VAX-11 Digitizer Utilities on floppy disk (VAX-11/780 and VAX-11/782)	2,500
QD055-YG	VAX-11 Digitizer Utilities on TU58 tape cartridge (VAX-11/750)	2,500
QC055-YG	VAX-11 Digitizer Utilities on TU58 tape cartridge (VAX-11/730)	2,500
QE053-YY	VAX-11/Engineering Drawing Utilities on floppy disk (VAX-11/780 and VAX-11/782)	2,750
QD053-YG	VAX-11/Engineering Drawing Utilities on TU58 tape cartridge (VAX-11/750)	2,750
QC053-YG	VAX-11/Engineering Drawing Utilities on TU58 tape cartridge (VAX-11/730)	2,750
QE118-AY	VAX-11 ReGIS Graphics Library (RGL) on floppy disks (VAX-11/780 and VAX-11/782)	6,000
QD118-AG	VAX-11 ReGIS Graphics Library (RGL) on TU58 tape cartridge (VAX-11/750)	6,000
QC118-AG	VAX-11 ReGIS Graphics Library (RGL) on TU58 tape cartridge (VAX-11/730)	6,000■