# DEC VAX-11 Systems

## MANAGEMENT SUMMARY

With the introduction of the MicroVAX I and the VAX-11/725 computers, Digital's VAX (virtual address extension) family of 32-bit minicomputer systems now comprises six basic central processor units including the VAX-11/730, mid-range VAX-11/750, and two high-end systems—the VAX-11/780 and the VAX-11/782. All VAX processors implement an extensive instruction set with numerous data types, and a 32-bit bus structure for high throughput. In addition, all VAX systems run VAX/VMS, a multiprogramming operating system that handles multiuser, real-time and multistream batch applications, plus on-line program development.

The MicroVAX I is a two-board microcomputer contained in a small, floor-standing or rack-mountable package. With CPU performance averaging 35 percent that of the VAX-11/780, the MicroVAX I is intended for machine and process control applications in industry, for OEM systems, and for single-user and small, multiuser computing requirements in business and scientific fields. The MicroVAX I system implements a subset of the VAX architecture that retains all key elements of the family. These include: full virtual memory management with address capability of more than four billion bytes; sixteen 32-bit general registers; 32 hardware and software interrupt priority levels; and all native-mode instructions for byte, word, longword, quadword, and single- and double-precision floating point data types. Main memory availability includes a 256KB dual-size board and a 512KB quad-size board, both based on 64KB RAM chips.

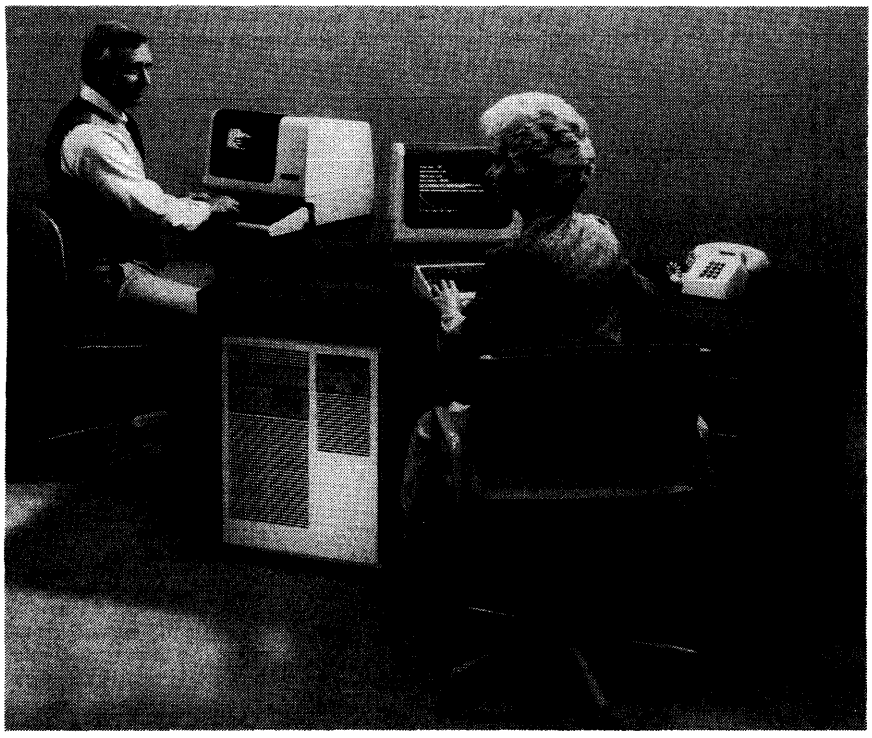
**The VAX-11 Series 32-bit computer systems are an upward extension of the PDP-11 family of 16-bit minicomputers but also comprise a significant new architecture of their own. VAX provides 32-bit addressing for a 4-gigabyte program address space, and 32-bit arithmetic and data paths for processing speed and accuracy. The VAX/VMS virtual memory operating system features four billion bytes of virtual address space.**

**MODELS: MicroVAX I, VAX-11/725, VAX-11/730, VAX-11/750, VAX-11/780, and VAX-11/782.**
**MAIN MEMORY: 256KB to 12MB (8MB local and 4MB shared).**
**DISK CAPACITY: 800KB to 456MB per drive.**
**WORKSTATIONS: Up to 384 (96 per Unibus).**
**PRINTERS: 30 cps to 1200 lpm.**
**PRICE: $9,995 to $370,000.**

## CHARACTERISTICS

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

**CANADIAN ADDRESS: Digital Equipment of Canada, Ltd., P.O. Box 13000, 100 Herzberg Road, Kanata, Ontario, K2K 2A6, Canada.**



*The new VAX-11/725 superminicomputer is Digital Equipment Corporation's smallest, least expensive Unibus-based VAX system, featuring quiet operation and low heat generation for open-office environments. With a VAX-11/730 processor and the new, high-capacity RC25 52MB fixed and removable 8-inch Winchester disk subsystem, the VAX-11/725 serves as a low-cost, multiuser system for general-purpose applications or as a computing "engine" for high-performance graphics workstations.*

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**CHART A. SYSTEM COMPARISON CHART**

| MODEL | MicroVax I | 11/725 | 11/370 | 11/750 | 11/780 | 11/782 |
|---|---|---|---|---|---|---|
| SYSTEM CHARACTERISTICS | | | | | | |
| Date of Introduction | Oct. 1983 | Oct. 1983 | April 1982 | Oct. 1980 | Oct. 1977 | Feb. 1982 |
| Date of First Delivery | March 1984 | Nov. 1983 | May 1982 | Nov. 1980 | Jan. 1978 | April 1982 |
| Operating Systems | MicroVMS, ULTRIX | VAX/VMS | VAX/VMS | VAX/VMS | VAX/VMS | VAX/VMS |
| Upgradable From | — | — | — | — | — | VAX-11/780 |
| Upgradable To | — | — | — | — | VAX-11/782 | — |
| MIPS | — | — | 0.36 | .72 | 1.06 | — |
| Relative Performance (based on a rating of the 11/780 at 1.0) | 0.3 | 0.3 | 0.3 | .65 | 1.0 | 1.8 |
| MEMORY | | | | | | |
| Minimum Capacity (bytes) | 256K | 1M | 1M | 2M | 2M | 2M |
| Maximum Capacity (bytes) | 2.5M | 3M | 5M | 8M | 32M | 8M |
| Type | 64K RAM | 64K ECC MOS RAM | 64K ECC MOS RAM | 64K ECC MOS RAM | 64K ECC MOS RAM | 16K ECC MOS RAM |
| Cache Memory | 8K | None | None | 4K | 8K | 8K |
| Cycle Time, Nanoseconds | 500 | 810 | 810 | 400 | 290 | 290 |
| Bytes Fetched Per Cycle | 4 | 4 | 4 | 8 | 8 | 8 |
| INPUT/OUTPUT CONTROL | | | | | | |
| Number of Channels | — | — | — | 1-5 | 1-8 | — |
| High-Speed Busses | None | None | None | MASSBUS (3 optional) | MASSBUS (4 optional) | MASSBUS (4 optional) |
| Low-Speed Busses | Q-Bus (1 standard) | UNIBUS (1 standard) | UNIBUS (1 standard) | UNIBUS (1 std., 1 opt.) | UNIBUS (1 std., 3 opt.) | UNIBUS (1 std., 3 opt.) |
| Minimum Disk Storage | 1.8MB | 52MB | 20MB | 121MB | 121MB | 121MB |
| Maximum Disk Storage | 28.8MB | 52MB | 2.0GB | 19GB | 30GB | 30GB |
| Number of Workstations | 8 | 8 | 24 | 128 | 384 | 384 |
| Communications Protocols | See Communications Control | See Communications Control | See Communications Control | See Communications Control | See Communications Control | See Communications Control |

The MicroVAX I central processor resides on two quad-height modules that occupy adjacent slots in the Q22 backplane. One module contains the 32-bit data path, microsequencer, and control store. The second is a memory management and cache module, which provides the logic for interfacing the Q-Bus to the internal 32-bit VAX architecture. The new system uses standard Q-Bus memory modules and performs all memory data transfers in block mode for optimal performance. The initial set of storage options are the 5¼-inch, 10-megabyte RD51 Winchester disk subsystem and the RX50 dual floppy diskette drive with total storage of 800K bytes. A 28-megabyte Winchester disk is also available. The system uses the same enclosure as the Micro/PDP-11 computer.

As DEC's smallest Unibus-based VAX system, the new general-purpose, multiuser VAX-11/725 contains a VAX-11/730 central processing unit with the new 52-megabyte RC25 Winchester disk subsystem in a small cabinet designed specifically for open-office locations. The VAX-11/725 system can serve as a single-user graphics workstation, or can support up to eight terminals in a multiuser environment. Two major implementations are envisioned for the VAX-11/725 systems in industry, commerce, government, and education: as support for technical workstations, and as a multiuser system for general-purpose computing applications. Configured with a VAXstation 100 graphic display

**DEC is a worldwide corporation and the world's largest manufacturer of minicomputer systems. The company employs about 67,000 persons and maintains sales and service offices in all major U.S. cities and in major cities throughout Canada and the Western world.**

## 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, 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,**

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subsystem or other monochrome or color display, the VAX-11/725 computer will support medium to high-speed graphics for integrated circuit design and logic simulation, geophysical mapping, genetic engineering, finite element pre- and post-processing, architectural design, and molecular modeling for chemical engineering.

As a multiuser system, the VAX-11/725 will support up to eight users for software development, order entry, material requirements planning and inventory control, scientific word processing, drafting, and general accounting applications. The console terminal can alternate as a user device, and Ethernet local area network links permit addition of more terminals.

The VAX-11/730 incorporates bit-slice and Programmed Array Logic (PAL) technology. The VAX-11/730 can be used as a standalone processor or 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, is implemented primarily in custom bipolar LSI Schottky logic. One Unibus adapter (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 users with 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 improve performance up to 100 percent over a single VAX-11/780 system. 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 are connected to the primary processor. Both processors must be at the same revision level and the same version of microcode.

**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.**

**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

**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 is 810 nanoseconds for the 11/730 and 11/725, and 250 nanoseconds for the MicroVAX I.**

**CAPACITY: Main memory capacities range from 256K bytes on the MicroVAX I to 12 megabytes on the VAX-11/**

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| CHART B. MASS STORAGE DEVICES | | | | | |
|---|---|---|---|---|---|
| **MODEL** | **RP07** | **RM05** | **RA81** | **RA60** | **RA80** |
| Type (Winchester, fixed, cartridge) | Fixed | Removable | Winchester | Removable | Fixed |
| Controller Model | Massbus | Massbus | Unibus | Unibus | Unibus |
| Drives Per Subsystem/ Controller | 8 | 8 | 4 | 4 | 4 |
| Formatted Capacity Per Drive, Megabytes | 516 | 256 | 456 | 205 | 121 |
| Number of Usable Surfaces | 16 data, 1 servo | 19 data, 1 servo | 7 data, 1 servo | 6 data | 7 data, 1 servo |
| Number of Sectors/Tracks Per Surface | 1260 data, 4 diagnostic | 823 tracks | 1248 tracks | 1600 tracks | 546 tracks |
| Bytes Per Sector or Track | 512/sector | 512/sector | 512/sector | 512/sector | 512/sector |
| Average Seek Time | 23 ms. | 30 ms. | 28 ms. | 41.7 ms. | 25 ms. |
| Average Rotational/Relay Time | 8.3 ms. | 8.3 ms. | 8.3 ms. | 8.3 ms. | 8.3 ms. |
| Average Access Time | 31.3 ms. | 38.3 ms. | 36.3 ms. | 50 ms. | 33.3 ms. |
| Data Transfer Rate | 1.3MB/sec. | 1200KB/sec. | 2.2MB/sec. | 1.98MB/sec. | 1.2MB/sec. |
| Supported by System Models | VAX-11/750, /780, /782 | VAX-11/750, /780, /782 | VAX-11/782, /780, /750, /730, /725 | VAX-11/782, /780, /750, /730, /725 | VAX-11/782, /780, /750, /730, /725 |
| Comments | | | | | |

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. Virtual memory management, 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, virtual memory management, 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, virtual memory management, integral floating-point, packed decimal and character-string instructions, interval timer, and a time-of-year clock. DEC's entry-level VAX-11/725 is a packaged product that contains a VAX-11/730 processor. The MicroVAX I implements a subset of the VAX architecture that retains all key elements of the family. These include: full virtual memory management with address capability of more than four billion bytes; sixteen 32-bit general registers; 32 hardware and software interrupt priority levels; and all native-mode instructions for byte, word, longword, quadword, and single- and double-precision floating point data types.

**780. For the main memory capacities on specific VAX systems, please refer to Chart A, the System Comparison Chart.**

**CHECKING: The system's ECC MOS memory incorporates Schottky TTL logic technology, with automatic error checking including parity checking on Massbus data, cache, translation buffer, and CPU microcode.**

**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.**

**RESERVED STORAGE: Minimum reserved storage for the VAX/VMS operating system is 1MB on the 11/725 and 11/730, 512KB on the 11/750, 11/780, and 11/782, and 2MB on the 11/780 VAXcluster with CI780.**

**CACHE MEMORY: An 8KB bipolar cache memory is available on the VAX-11/780 and 11/782 systems; 4KB of bipolar cache on the VAX-11/750; and no cache available on the VAX-11/725 and 11/730. The MicroVAX I has an 8KB direct-mapped cache 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,**

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| CHART B. MASS STORAGE DEVICES (Continued) | | | | |
|---|---|---|---|---|
| **MODEL** | **RL02** | **RD51** | **RX50** | **RC25** |
| Type (Winchester, fixed, cartridge) | Cartridge | Winchester | Dual Diskette | Fixed/Removable |
| Controller Model | Unibus | RQDX1 | RQDX1 | Unibus |
| Drives Per Subsystem/Controller | 4 | — | — | — |
| Formatted Capacity Per Drive, Megabytes | 10.4 | 10 | 800KB | 52 |
| Number of Usable Surfaces | 2 data | 4 | 2 | — |
| Number of Sectors/Tracks Per Surface | 512 tracks | 1200 tracks | 80 tracks per diskette | — |
| Bytes Per Sector or Track | 256/sector | 512/sector | 512/sector | — |
| Average Seek Time | 55 ms. | 76.7 ms. | 164 ms. | 35 ms. |
| Average Rotational/Relay Time | 12.5 ms. | 8.3 ms. | 100 ms. | 10.5 ms. |
| Average Access Time | 67.5 ms. | 85 ms. | 264 ms. | 45.5 |
| Data Transfer Rate | 512KB/sec. | 5MB/sec. | 250KB/sec. | 1.25MB/sec. |
| Supported by System Models | VAX-11/782, /780, /750, /730, /725 | MicroVAX | MicroVAX | VAX-11/725 |
| Comments | | | | |

- Operating System—includes a virtual memory manager, swapper, system services, device drivers, file system, record management services, command language, and operator's and systems manager's tools. MicroVMS is a general-purpose compatible subset of the VMS operating system specifically for MicroVAX computers.

- Languages—include 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, VAX-11 DIBOL and VAX-11 APL. 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—include 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—comprise 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; ACMS, a transaction processing software product set for developing and controlling complex, interactive commercial and industrial applications; DSM, a data management system and high-level interpretive language directed primarily toward the processing of variable-length string data; DBMS, a general purpose full-scale database management system suitable for both small and large database applications; CDD, a common data dictionary; and FMS, a forms management system.

**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 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, sixteen 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 sixteen 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.**

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## CHART C. TERMINALS

| DEVICE | DESCRIPTION |
|---|---|
| VT100-AA (AB) | High performance, tabletop, 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 |
| VT100-WA (WB) | Video Display terminal for DECmail applications; includes word processing features, 80 columns × 24 lines or 132 × 14; operates on full-duplex asynchronous communications lines with standard interface |
| VT102-AA (AB) | Video Display terminal for data processing or word processing with DECWORD |
| VT102-WA (WB) | Video Terminal with advaced video features and word processing keyboard |
| VT125-AA (AB) | Enhanced VT100 alphanumeric video display terminal with data plotting extensions, automatic vector and curve generation |
| VT125-WA (WB) | Video terminal with graphics, advanced video features, word processing keyboard and printer port |
| VS100-AA | VAX station 100 primary (VR100-AA) monochrome 19-inch (48 cm) monitor; includes UNIBUS interface, multibox with Graphics Processor, power supply and DS11-FA VAX UNIBUS-window/ fiber-optic transceiver card |
| VS11-AA (AB) | High performance, 16-color and monochrome raster graphics system; features graphics instruction set, bit-slice architecture, switch-selectable resolution for interlaced (512 × 512 × 2 bits) or non interlaced (512 × 256 × 4 bits) image memory operation. Requires VAX/VMS system configuration and driver |

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

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 diagnos-

**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 Unibus controller for peripheral devices. Two additional Unibus controllers may be configured with the 11/730. Massbus adapters are not available for the 11/730.**

**DEC's entry-level VAX-11/725 is a packaged product that contains a VAX-11/730 processor.**

**The MicroVAX I implements a subset of the VAX architecture that retains all key elements of the family. These include: full virtual memory management with address capability of more than four billion bytes; sixteen 32-bit general registers; 32 hardware and software interrupt priority levels; and all native-mode instructions for byte, word, longword, quadword, and single- and double-precision floating point data types. The MicroVAX I central processor resides on two quad-height modules that occupy adjacent slots in the Q22 backplane. One module contains the 32-bit data path, microsequencer, and control store. The second is a memory management and cache module, which provides the logic for interfacing the Q-Bus to the internal 32-bit VAX architecture. The new system uses standard Q-Bus memory modules and performs all memory data transfers in block mode for optimal performance.**

**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**

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| CHART D. PRINTERS | | | | | |
|---|---|---|---|---|---|
| **MODEL** | **LA12** | **LA100** | **LA120** | **LQP02** | **LA50** |
| Type | Portable | Letter-quality | Printing terminal | Letter-quality | Dot-matrix |
| Speed | 150 cps | 30/80/24 cps | 180 cps | 32 cps | 50/100 cps |
| Bi-directional Printing | No | No | Yes | Yes | No |
| Paper Size | 8½ x 11 | Up to 15 inches | — | Up to 13.5 inches | Up to 10 inches |
| Character Formation | 9 x 9 dot matrix | — | 7 x 7 dot matrix | Daisywheel | 7 x 9 dot matrix |
| Horizontal Character Spacing (char. per inch) | Variable | Variable | Variable | 10 or 12 | .5-16.5 |
| Vertical Line Spacing (lines per inch) | Up to 12 | Up to 12 | Up to 12 | 6 or 8 | Up to 12 |
| Character Set | 94 | Varies | ASCII | Over 100 different sets | 94 |
| Buffer | — | — | 1K | — | — |
| Controller/Interface | EIA | EIA | EIA/CCITT | EIA | Attaches to VT100 terminal or PC |
| No. of Printers per Controller/ Interface | — | — | — | — | — |
| Printer Dimensions (h x w x d) inches | 5.7 x 18.3 x 15.5 | 7 x 22 x 15.5 | 33.5 x 27.5 x 24 | 7 x 25 x 16 | — |
| Graphics Capacity | Yes | Yes | No | No | Yes |

tics, 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.

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 sixteen 32-bit general registers, 32 priority interrupt levels (16-hardware,

**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, and the user-oriented console command language, with one TU58 tape cartridge drive for the VAX-11/750 and two TU58s for the 11/730. A remote diagnosis interface is optionally available for the console.**

**The MicroVAX I CPU supports Q-Bus options and interfaces including: a 256K byte dual-size board and a 512K byte quad-size board main memory module; 800K byte RX50 5.25 inch dual diskette drive, 10M byte RD51 5.25 inch Winchester drive, and 28M byte 5.25 inch Winchester drive mass storage devices; hardcopy, alphanumeric, and graphic video terminal peripheral interfaces; analog/digital converter, analog multiplexer, and digital input real-time laboratory interfaces; and the Ethernet local area network interface. Maximum Q-Bus I/O throughput is 2.5M bytes per second.**

**Medium-capacity disks, unit record devices, terminals, interprocessor communications links, and user-specified devices are Unibus peripherals supported on the VAX-11/725, 11/730, 11/750, 11/780, and 11/782. 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, 11/725, and MicroVAX I do 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.**

**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.**

# DEC VAX-11 Systems

| CHART D. PRINTERS (Continued) | | | | | |
|---|---|---|---|---|---|
| **MODEL** | **LXY** | **LP25** | **LP26** | **LP27** | **LN01** |
| Type | Dot matrix | Band | Band | Impact | Laser |
| Speed | 170 lpm-600 lpm | 300/215 lpm | 600/445 lpm | 1250/910 lpm | 12 pages/minute |
| Bi-directional Printing | No | No | No | No | No |
| Paper Size | — | Up to 15 inches | Up to 15 inches | Up to 18.5 inches | 8½ x 11 or 8½ x 14 inches |
| Character Formation | Variable | Variable | — | — | 300 x 300 dots per inch |
| Horizontal Character Spacing (char. per inch) | Variable | Variable | — | 10 | — |
| Vertical Line Spacing (lines per inch) | — | 6 or 8 | 6 or 8 | 6 or 8 | 8.57 |
| Character Set | 96 or 160 | 64/96 | 64/96 | 64/96 | 188 |
| Buffer | 132 characters | 132 characters | 132 characters | Single-line | — |
| Controller/Interface | LP11/RS232 | LP11 | LP11 | — | Parallel |
| No. of Printers per Controller/ Interface | — | — | — | — | — |
| Printer Dimensions (h x w x d) inches | 46.5 x 30 x 24.3 | 43.3 x 31.1 x 29.5 | 43.7 x 31.1 x 29.5 | 49 x 35 x 38 | 36 x 25.8 x 26 |
| Graphics Capacity | Yes | No | No | No | No |

16-software), nine addressing modes, and four hierarchical protection modes, each with read/write access control. The VAX-11/750, 11/730, and 11/725 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 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 dual cartridge tape drives 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 also available. Circuit technology is programmed array logic using large-scale 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.

Features of the VAX-11/725 include a VAX-11/730 CPU, up to 3M bytes of advanced 64K-chip main memory, a built-in VAX Unibus adapter, two TU58 tape cartridge drives, and the RC25 52M byte fixed and removable 8-inch Winchester drive. The 11/725 is available with the FP730 floating point accelerator, DMF32 controller, DMR11 high-speed DECnet card, DEUNA Ethernet communications interface, VAXstation 100 hardware and software, and choice of hard (LA100) or soft (VT100) copy console.

**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 and 11/725 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.**

**REGISTERS: The VAX systems provide sixteen 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.**

# DEC VAX-11 Systems

| CHART E. MAGNETIC TAPE EQUIPMENT | | | | |
|---|---|---|---|---|
| **MODEL** | **TU78** | **TU77** | **TE16** | **TU80** |
| Type | Reel to reel | Reel to reel | Reel to reel | Streaming |
| FORMAT | | | | |
| Number of Tracks | 9 | 9 | 9 | 9 |
| Recording Density, bpi | 1600/6250 | 1600/800 | 1600/800 | 1600 |
| Recording Mode | PE/GCR | PE/NRZI | PE/NRZI | PE |
| CHARACTERISTICS | | | | |
| Controller Model | Massbus adapter | Massbus adapter | Massbus adapter | Unibus |
| Drives per Controller | 4 | 4 | 8 | 1 |
| Maximum Storage Capacity, bytes | 145M | 40M (1600 bpi)<br>20M (800 bpi) | 40M (1600)<br>20M (800) | 40M |
| Tape Speed, ips | 125 | 125 | 45 | 100 |
| Data Transfer Rate, bps | 781K | 200K | 72K (1600 bps)<br>56K (800 bps) | 160K |
| Streaming Technology | No | No | — | Yes |
| Start/Stop Mode; Speed Switch Selectable | — Yes | — Yes | — Yes | 25 ips No |

The MicroVAX I features a 256KB dual-size board or a 512KB quad-size board main memory, both based on 64KB RAM chips. The MicroVAX I CPU supports Q-Bus options and interfaces including: 800K byte RX50 5¼-inch dual diskette drive, 10M byte RD51 5¼-inch Winchester drive, and 28M byte 5¼-inch Winchester drive mass storage devices; hardcopy, alphanumeric, and graphic video terminal peripheral interfaces; analog/digital converter, analog multiplexer, and digital input real-time laboratory interfaces; and the Ethernet local area network interface. Maximum Q-Bus I/O throughput is 2.5M bytes per second. The initial set of storage options are the 5¼-inch, 10-megabyte RD51 Winchester disk subsystem and the RX50 dual floppy diskette drive with total storage of 800K bytes. A 28-megabyte Winchester disk is also available. The system uses the same enclosure as the Micro/PDP-11 computer.

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 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

**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.**
- **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.**

# DEC VAX-11 Systems

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.

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.

**• 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.**

**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.**

**OPERATING ENVIRONMENT: 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 1100 pounds (498 kg). Power requirements are 120/280 volts. Maximum AC power consumption is 6225 watts, and maximum heat dissipation is 21,230 BTU/hour.**

**The VAX-11/750 is 42 × 29 × 30 inches (106 × 74 × 76 cm) in size, 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 1700 watts, and maximum heat dissipation is 5800 BTU/hour.**

**The VAX-11/730 Dual RL02 System is 41.8 × 21.3 × 31.5 inches (106.2 × 54.1 × 80 cm) in size, and weighs 500 pounds (227.0 kg). Power requirements are 120 volts at 20 amps, single phase. Maximum AC power consumption is 790 watts, and maximum heat dissipation is 2694 BTU/hour.**

**The VAX-11/725 is 24.5 × 17.5 × 28.5 inches (62.2 × 44.5 × 72.4 cm) in size, and weighs 205 pounds (93.0 kg). Power requirements are 120 volts at 7.1 amps, single phase. Maximum AC power consumption is 575 watts, and maximum heat dissipation is 1955 BTU/hour.**

# DEC VAX-11 Systems

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, 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.

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.

**The MicroVAX I is 24.5 × 10 × 27 inches (62.3 × 25.4 × 68.5 cm) in size in a floor-standing position, and its chassis weighs under 50 pounds (22.68 kg). Power requirements are 120 volts at 4.4 amps, single phase. Maximum AC power consumption is 320 watts.**

## INPUT/OUTPUT CONTROL

**Q-BUS: A four-row, eight-slot backplane incorporates the 22-bit Q-Bus for I/O with a variety of options on the MicroVAX I. Block mode data transfers allow data rates up to 2.5M bytes per second. The backplane can accept either quad- or double-height modules. There is a choice of two quad-height families of Digital memory modules, 256K bytes or 512K bytes of RAM storage.**

**The MicroVAX I CPU communicates with peripheral devices on the Q-Bus through standard Q-Bus pinning. Four patch panels allow device connection and data transmission rate selection from 50 to 19.2K baud without opening the system unit. One panel connects the console terminal, two panels are available to support four EIA communication lines each, and another panel is available for attaching communication gear such as Ethernet.**

**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 one Unibus on the 11/730 and 11/725.**

**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, 11/730, and 11/725.**

**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, 11/730, and 11/725 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, 11/730, and 11/725. 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 or the 11/725.**

# DEC VAX-11 Systems

VAX systems attach to Ethernet local area networks (LANs) through the Ethernet-to-Unibus communications controller (DEUNA) which links VAX and PDP-11 computers to Ethernet networks. With this controller, systems designers can implement full VAX- and PDP-11-based Ethernet local area networks, using Digital hardware. Both DECnet and device driver level software support are available. The DEUNA complies with the Ethernet Specifications, transmits and receives 10M bit/second, and provides full-address filtrating to off-load the host computer.

## COMPETITIVE POSITION

With the October 1983 announcements of the first of its desk level hardware products, the MicroVAX I and the VAX-11/725, and the VAX-11 ACMS (Application Control and Management System), DEC has taken further major steps in the realization of a six-year-long strategic engineering and user-interface-level development effort.

DEC's aggressive two-fold interlinked strategy—first, to provide a single powerful 32-bit architecture made available (through VAX System Building Blocks and VAXcluster multiprocessor systems) in a wide range of configuration and application possibilities, and second, to provide the ability to implement an organization-wide set of computing solutions customized to the specific needs of the central, departmental, and individual user within the framework of a uniform and compatible operating/communications/user-level environment (through, e.g., VAX/VMS, MicroVMS, DECnet networking, VAX-to-Ethernet local area network communications, VAX-11 ACMS, and the VAX-11 ALL-IN-1 menu-driven office automation software package)—has come together into an overall market concept embracing financial, data processing, production, and office functions in a closely integrated, single-system, single-vendor solution.

DEC's future success in marketing this integrated, single-system, single-vendor solution will depend in large measure upon its ability to both provide and support appropriate systems solutions packages to organizations with very complex production/data processing/communications/MIS environments. Because DEC has chosen such a wide market scope for its VAX-11 systems strategy, it will face head-to-head market-specific competition from such data/transaction/office information processing vendors as IBM, Tandem, and Wang, as well as from an ever-expanding arena of 32-bit systems including Perkin-Elmer's 3200 Series systems, Gould CONCEPT/32 Series, Data General's MV/Family, the Prime 50 Series, Harris's 600, 700, 800, and 1000 family, Wang's VS systems, IBM's 4300, Tandem's TXP system, Apollo's Domain Series, and the high-end of the Honeywell DPS 6, NCR I-9000, and Hewlett-Packard HP 3000 lines.

## ADVANTAGES AND RESTRICTIONS

VAX-11 Systems are manufactured, sold, and supported by DEC. Throughout its years in the industry, DEC has managed to capture a major portion of the minicomputer market, and maintain a strong user base. DEC states that

**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.**

**INTELLIGENT CONTROLLER: The HSC50 (Hierarchical Storage Controller) is a Computer-Interconnect-based intelligent disk/tape server that offers full architectural support for and optimizes data integrity, throughput, and subsystem availability of high-density disks such as the removable RA60 disk drive, and the RA80 and RA81 fixed (Winchester) disk drives, which reguire the UDA50 (Unibus Disk Adapter) intelligent controller to function in a multiprocessing environment. The HSC50 supports high-speed disks and tapes as well as the computer interconnect (CI), and can contain up to six data channel interfaces, each channel interfacing up to four disk drives, enabling concurrent serving of multiple CI-Bus interconnected processors. The HSC50 has a CI port bandwidth of 4.25M byte/second; a disk data-channel bandwidth of 3.125M byte/second, each; a tape data-channel bandwidth of 1.25M byte/second, each; a data buffering bandwidth of 13.3M byte/second, total; and a request processing overhead of 1.6 millisecond per request.**

## CONFIGURATION RULES

**VAX SYSTEM BUILDING BLOCKS (SBBs): begin with a core of components: CPU, two or four megabytes of 64K or 16K ECC MOS memory, cabinetry, and the VAX/VMS operating system license. To this core the user must add selections from the system device, load device, communications interface, console terminal, and software menus (*see* Equipment Prices and Software Prices, below). SBBs are available for the VAX-11/730, 11/750, 11/780, and 11/782. After ordering one of these CPU models, the user must then order one from each of the mass storage, communications, and console terminal menus. Selection from the software menu is optional.**

**VAXclusters: A VAXcluster is composed of one or more VAX-11/750, 11/780 or 11/782 processors running on VAX/VMS connected by a high-speed bus, one or more mass storage servers, and communication links to the user community. VAXcluster systems are configured by starting with a standard Building Block system and adding a CI750 or CI780 Computer Interconnect. There are two types of System Building Blocks. The first type is a basic system element, which, for the 11/78X CPUs, consists of a VAX-11/780 CPU with 2MB of memory, or a VAX-11/782 CPU with 4MB of memory, CI780 computer interconnect, HSC50 intelligent controller, and one each disk and tape interface (each with four ports), plus a VAX/VMS operating system license. The second type of Cluster System Building Block is an upgrade to an existing VAXcluster. The 11/78X series CPU upgrade consists of a VAX-11/780 CPU with 2MB of memory or a VAX-11/782 with 4MB of memory, and the CI780 computer interconnect and VAX/VMS operating**

# DEC VAX-11 Systems

the VAX-11/780 has set the standard for the 32-bit marketplace, and it is significant that companies such as Data General and Perkin-Elmer conduct major advertising campaigns comparing their systems to the VAX.

The VAX-11 Systems offer hardware and software compatibility which extends from the MicroVAX through the high-end 11/780. Printers and terminals would move easily to an upgraded system, as would the larger Unibus disk drives (from a VAX-11/730 or 11/750), and Massbus disk drives (from an 11/750).

All VAXs run only one operating system, VAX/VMS. Under VAX/VMS, users of a low-end VAX-11/725 have easy software migration to a larger VAX system. However, moving up from DEC's PDP Family would be trickier. PDP systems using the RXS-11M operating system would find support under VAX/VMS compatibility mode, but only migration tools are offered to move from other PDP operating systems into the VAX arena.

Hardware support is enhanced for the VAXs through the use of remote diagnosis.

Possible restrictions in the use of VAX-11 systems as recorded in Datapro's 1983 Computer User Survey and confirmed by a checkback with respondents, include: system recommended and installed by vendor too small to meet processing needs; excessively noisy equipment; too many vendor changes to hardware/software; late delivery of required software; system costs (for hardware, vendor-supplied software, and support) exceeding the expected total; and late installation of equipment.

## USER REACTION

Ninety-nine people reported on their VAX-11 systems in Datapro's 1983 Computer Users' Survey. Their responses described a total of 143 systems that had been installed for an average of 28 months. The major industries represented were engineering/scientific (20 users), manufacturing (13 users), government (9 users), and retail/wholesale (9 users). Principal applications included accounting/billing (44 users), engineering/scientific (43 users), mathematics/statistics (31 users), order processing/inventory control (31 users), and payroll/personnel (30 users).

Average configurations included from 1024KB to less than 8192KB of memory, from 6 to 60 local workstations, from 1 to 15 remote workstations, and from 80MB to about 1200MB disk storage.

Seventy-four users purchased their systems, five rented or leased from the manufacturer, and 19 leased from a third party. Database management systems were used by 39 respondents, while word processing was implemented by 36. Ninety-one responses indicated that the VAX-11s were located in a central processing installation, with the other eight mentioning a distributed processing site.

Only 6 of the 99 users plan to replace their hardware during 1983, and 4 of these are staying with DEC. However, many

**system license. To this must be added an LA120 console terminal, and an optional system disk such as the RA60, RA80 or RA81 disk drives.**

**GENERAL: 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.**

**Both systems also include in the standard System Building Block configuration 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 CPU and Unibus expansion cabinets. The following options are available for the 11/782 CPU: shared memory option, H7112 Memory Battery Backup, FP782-AA(AB) high performance Floating-Point Accelerator with power supply, DW780 Unibus adapter, KE780 G & H floating point microcode, CI780 interface, and a serial line unit for remote diagnosis.**

**VAX-11/782 System Building Block communications options include the DZ11, DZ32 and/or DMF32 Asynchronous Interfaces, and the DMP11, DMR11 and DUP11 Communications Interfaces.**

**The following options are available for the 11/780 CPU: additional 64K chip MS780 memory modules up to a total of 32MB, DR780 General Purpose Interface, MA780 Multipoint Memory Controller, H7112 Memory Battery Backup, FP780 Floating Point Accelerator, DW780 Unibus Adapter, KE780 G & H floating point microcode, KU780 User Writable Control Store, CI780 interface, and a serial line unit for remote diagnosis.**

**VAX-11/780 System Building Block communications options include the DZ11, DZ32 and/or DMF32 Asynchronous Interfaces, and the DMP11, DMR11 and DUP11 Communications Interfaces.**

**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 in the standard System Building Block configuration is the console subsystem made up of an integral TU58 tape cartridge unit and an LA100 or LA12 terminal.**

**Expansion space for 11/750 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 basic system. The following options are available for the 11/750 CPU: additional 64K chip MS750 memory modules up to a total of 8 modules (8MB), DR750 General Purpose Interface, DW750 Second Unibus Adapter, FP750 Floating Point Accelerator, KU750 User Writable Control Store, H7112 Memory Battery Backup, CI750 computer interconnect, and a serial line unit for remote diagnosis.**

**VAX-11/750 System Building Block communications options include the DZ11, DZ32 and/or DMF32 Asynchronous Interfaces, and the DMP11, DMR11 and DUP11 Communications Interfaces.**

**The basic equipment for the VAX-11/730 system includes the CPU, virtual memory management, bootstrap loader, integral floating point, packed decimal, and character string**

# DEC VAX-11 Systems

users have plans for enhancing their VAXs during 1983: 61 will expand present hardware; 58 will add software from other suppliers; 41 will expand their data communication facilities, and 40 will order additional software from DEC.

The following table shows the users' ratings of the VAX-11 systems.

| | Excellent | Good | Fair | Poor | WA* |
|---|---|---|---|---|---|
| Ease of operation | 56 | 40 | 1 | 1 | 3.5 |
| Reliability of mainframe | 65 | 29 | 1 | 1 | 3.7 |
| Reliability of peripherals | 36 | 50 | 8 | 2 | 3.3 |
| Maintenance service: | | | | | |
| Responsiveness | 40 | 48 | 7 | 3 | 3.3 |
| Effectiveness | 34 | 52 | 8 | 3 | 3.2 |
| Technical support: | | | | | |
| Trouble-shooting | 16 | 59 | 19 | 2 | 3.0 |
| Education | 17 | 57 | 22 | 0 | 3.0 |
| Documentation | 29 | 49 | 18 | 1 | 3.1 |
| Manufacturer's software: | | | | | |
| Operating system | 53 | 36 | 3 | 0 | 3.5 |
| Compilers & assemblers | 42 | 46 | 2 | 0 | 3.4 |
| Applications programs | 16 | 40 | 14 | 2 | 3.0 |
| Ease of programming | 46 | 46 | 3 | 0 | 3.5 |
| Ease of conversion | 18 | 52 | 10 | 1 | 3.1 |
| Overall satisfaction | 46 | 48 | 3 | 0 | 3.4 |

*Weighted Average based on a scale of 4.0 for Excellent.

As the table indicates, users were well satisfied with their VAX-11s. Specifically, these advantages were described: 78 said that the system was easy to expand/reconfigure; 62 stated that they were happy with the response time; 47 felt that productivity aids helped to keep programming costs down; and 33 thought that the terminals/peripherals carried over from other systems were compatible, as the vendor had promised.

On the negative side, 20 users cited that the installation of equipment was late; 14 added that system costs (for hardware, vendor-supplied software, and support) exceeded the expected total; 13 mentioned that both the delivery of the required software was late, and that there were too many vendor changes to hardware/software.

Finally, when users were asked if they would recommend their systems to others, 88 said yes, 10 were undecided, and one said no. □

**instructions, high-precision programmable real-time clock, and time-of-year clock with battery backup. Also included in the standard System Building Block configuration is the console subsystem made up of two integral TU58 tape cartridge units and an LA100 or LA12 terminal.**

**Expansion space for 11/730 is available in both the CPU backplane and the Unibus expansion backplane within the CPU cabinet. The optional VAX-11/730 general purpose expansion cabinet is used for expansion beyond the basic system. The following options are available for the 11/730 CPU: additional 64K chip MS730 memory modules up to a total of 3MB, FP730 Floating Point Accelerator, H7750 Memory Battery Backup, TU80 Magnetic Tape Controller, LP11 Printer Controller, and LP32 Printer via the DMF32 port.**

**VAX-11/730 System Building Block communications options include the DZ11, DZ32 and/or DMF32 Asynchronous Interfaces, the DR11-W general purpose interface, the DEUNA Ethernet communications controller, and the DMP11, DMR11 and DUP11 Communications Interfaces.**

**DEC's entry-level VAX-11/725 is a packaged product that contains a VAX-11/730 CPU, up to 3M bytes of advanced 64K-chip main memory, a built-in VAX Unibus adapter, two TU58 tape cartridge drives, and the RC25 52M byte fixed and removable 8-inch Winchester drive. The 11/725 is available with the FP730 floating point accelerator, DMF32 controller, DMR11 high-speed DECnet card, DEUNA Ethernet communications interface, VAXstation 100 hardware and software, and choice of hard (LA100) or soft (VT100) copy console.**

**The MicroVAX I CPU supports Q-Bus options and interfaces including: a 256K byte dual-size board and a 512K byte quad-size board main memory module; 800K byte RX50 5.25 inch dual diskette drive, 10M byte RD51 5.25 inch Winchester drive, and 28M byte 5.25 inch Winchester drive mass storage devices; hardcopy, alphanumeric, and graphic video terminal peripheral interfaces; analog/digital converter, analog multiplexer, and digital input real-time laboratory interfaces; and the Ethernet local area network interface. Maximum Q-Bus I/O throughput is 2.5M bytes per second.**

**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 multipoint memory (MA780) and a high-speed channel interface (DR780). The DR11-W is a general-purpose interface that performs high-speed block data transfers between the VAX memory and user peripheral devices.**

**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 DMF32 controller). With the 11/730 expander cabinet, the recommended maximum number of terminals is 24. The 11/725 may be configured with up to eight terminals.**

**DISK STORAGE: Each Massbus adapter can support up to eight disk drives. Up to eight disk drives may be configured per Unibus. 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 one Unibus. 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 or the 11/725.**

**MAGNETIC TAPE: Maximum of two TS11 subsystems on the 11/750 and one TS11 subsystem on the 11/730. Each Massbus adapter can support up to eight tape formatters.**

**PRINTERS: One LP11 lineprinter is required on the 11/730 (a maximum of 1 per system). Up to 4 lineprinters can be configured on the 11/750, and up to 16 can be configured on the 11/780 and 11/782.**

## MASS STORAGE

**For information on available mass storage devices for VAX systems, please refer to Chart B, Mass Storage Devices.**

## INPUT/OUTPUT UNITS

**For information on available terminals please refer to Chart C, Terminals. For information on available printers please**

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refer to Chart D, Printers. For information on available magnetic tape equipment please refer to Chart E, Magnetic Tape Equipment.

## 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 maufacturers' 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.

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 *DZ Statistical Multiplexer* consists of one DZS11-EA (asynchronous multiplexer emulator and statistical multiplexer) and a combination of one or two VT1XX-EB remote statistical multiplexers. A maximum of eight remotely located asynchronous terminals may share a common composite communications link, when using the statistical multiplexer.

The *DMF32 Multipurpose Communications Controller* is an intelligent, high-performance communications controller which enables a combination of modems and terminals to communicate with the VAX system. This upgrade option contains three basic elements: 1) an eight-line asynchronous interface for operation with modems and terminals, 2) a single-line synchronous interface for connection to a network communication facility, and 3) a parallel interface for either a lineprinter (in DMA mode) or a user-developed device. The DMF32 uses the Direct Memory Access (DMA) mode and SILO (first-in/first-out) buffers in the controller to permit fast data transfers and reduce CPU interrupt overhead. It is supported by VAX/VMS, DECnet/VAX, VAX-11 PSI, VAX-11 2780/3780, and 3271 Protocol Emulators.

The *DMP11 Multipoint Synchronous Interfaces* permit 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 Auxiliary Communications Microprocessor* 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 *PCL11 Parallel Communications Link* is a multidrop computer link used to connect up to 16 processors to form a local distributed network. Full duplex interfaces, residing in each CPU, are interconnected by a single high-speed bus which can operate at speeds up to 1M bit/second depending on the bus length. The maximum bus length is 300 ft (91 m). CRC and word parity error detection are supported by the hardware.

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

# DEC VAX-11 Systems

communications, resource sharing, and distributed computation. DECnet is highly modular and flexible, and enables the user to select the appropriate hardware and software to build a network that satisfies a particular application's requirements.

*Ethernet Communications Servers* are small, dedicated computer systems which enable cost-effective resource sharing in a network. They provide specific communications functions for all hosts attached to the Ethernet, freeing individual hosts from performing those functions themselves.

Digital's Ethernet Communications Servers include: the DECnet Router Server (connects DECnet nodes in one Ethernet LAN to those in another or to remote DECnet nodes), the DECnet Router/X.25 Gateway (connects an Ethernet LAN to X.25 Packet-Switched Data Networks), and the DECnet/SNA Gateway (connects an Ethernet LAN to an IBM SNA network). All Ethernet Communications Servers require a host CPU with Phase IV DECnet software running under the VAX/VMS, RSX-11M, or RSX-11M-Plus operating systems. Both server hardware and software are customer installed.

A Communications Server requires an Ethernet LAN including all the physical channel hardware, Phase IV DECnet host installed on the Ethernet, an H4000 transceiver or DELNI (Local Network Interconnect), and a transceiver drop cable to connect the server to the H4000 or DELNI.

The *H4000 Digital Ethernet Transceiver* is a device that provides the functional interface between the Ethernet coaxial cable and an Ethernet station. The H4000 station transmits signals onto and receives signals from the cable, and detects any message collisions that may occur.

The *DEUNA Ethernet Communications Controller* connects a Unibus system to an Ethernet local area network (LAN). Both DECnet and device driver level software support are available. The DEUNA complies with the Ethernet Specifications, transmits and receives 10M bit/second, and provides full-address filtrating to off-load the host computer.

The *DELNI Local Network Interconnect (LNI)* allows Ethernet-compatible devices to be grouped up to 50 meters away from the LNI. The LNI can be configured three ways: stand-alone, hierarchical stand-alone, and connected. The stand-alone LAN configuration supports up to eight systems or system-based devices (not terminals) using standard Ethernet transceiver cables up to 50 meters away. The hierarchical stand-alone LNI LAN configuration supports a combination of LNIs and devices using standard Ethernet transceiver cables up to 50 meters away. Hierarchical LNI LANs are not connected to the Ethernet coaxial cable. The connected LNI LAN configuration supports up to eight devices using the standard Ethernet transceiver cable up to 50 meters away. The LNI LANs are connected to the Ethernet coaxial cable via H4000 Ethernet transceivers.

The *DEREP Ethernet Repeater* is a tabletop, stand-alone device with its own power supply, and allows for connection of multiple segments of Ethernet coaxial cable for expansion of the network. The local DEREP extends the Ethernet for 500 meters per repeater while the remote repeater extends the Ethernet for an additional 1000 meters per repeater. The repeater times, amplifies, and repeats all signals it receives from one segment to the other segment. Both local and remote repeater are connected to the Ethernet via the H4000 transceivers and two transceiver cables. The remote repeater consists of two local repeaters each with a fiber-optic interface board.

*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.

# DEC VAX-11 Systems

- 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, up-line 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.

## SOFTWARE

OPERATING SYSTEMS: Operating systems for the VAX systems include the general-purpose VAX/VMS; MicroVMS, a specially packaged version of the VMS system that supports the less-expensive, Q-Bus-based MicroVAX I configurations; and ULTRIX, Digital's version of Berkeley UNIX.

*VAX/VMS* is a general purpose operating system that provides the environment for the concurrent execution of 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

# DEC VAX-11 Systems

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.

*MicroVMS* is a specially packaged version of the VMS system that supports the less-expensive, Q-bus-based MicroVAX I configurations, yet provides the same runtime environment as that on larger VAX computers. Featuring full compatibility with the latest version of the VMS operating system, it offers users the widest access to the large, existing base of 32-bit VAX software, including applications, languages, and development tools. To be available in modular form, MicroVMS begins with a base system for application execution, to which one or more system options can be added to tailor operation to particular environments. Options will handle specific requirements for networking, program development, and multiuser authorization and accounting.

*ULTRIX* is a Digital-developed and supported software product based on the University of California at Berkeley VM UNIX system, which takes advantage of the VAX virtual memory architecture. Applications are in high-technology, nonrealtime design and analysis, and in added-value systems requiring a generic software base.

DATABASE MANAGEMENT SYSTEM: 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 three on-line multiuser data management facilities: VAX-11 RMS (Record Management Services), VAX-11 DBMS (Database Management System), and VAX-11 ACMS (Application Control and 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 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.

*VAX-11 ACMS* is a transaction processing software product set for developing and controlling complex, interactive commercial and industrial applications. The VAX-11 ACMS product set comprises two components: VAX-11 ACMS/AD, for developing and maintaining applications; and VAX-11 ACMS, for monitoring and controlling execution of applications developed with VAX-11 ACMS/AD as well as those developed with existing VMS tools. VAX-11 ACMS also provides facilities for creation of operator control menus and for authorization of terminals and users.

VAX-11 ACMS and DEC's ALL-IN-1 menu-driven office automation software package can be combined on one VAX system to provide users with both high-level office functionality and transaction processing capabilities. For users who require an integrated office automation/data processing solution accessible to all end-users, ALL-IN-1 software can be modified to run ACMS under the ALL-IN-1 menu. This avoids the need for an ACMS menu and presents a consistent user interface for both office and data processing tasks. ALL-IN-1 and VAX-11 ACMS software can also be installed without modification and run separately where common access to office and data processing functions is not required.

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 multiuser, general purpose, 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. VAX-11 DBMS is used to administer databases ranging from simple hierarchies to complex, multisystem networks with multilevel relationships. It supports full concurrent access and update activities for large numbers of users while maintaining the integrity and consistency of the database. The VAX information architecture allows DBMS data to be accessed directly from programming languages, through VAX-11 Datatrieve, or through special DBMS utilities. Version 2 of VAX-11 DBMS provides: a new security schema; improved system performance through a page feature for managing free space in storage locations, a Boolean record selection expression on FIND and FETCH data manipulation language statements, and batch retrieval; and improved control utilities.

# DEC VAX-11 Systems

*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. It also includes several extensions to this specification. The sharable, reentrant interpreter takes advantage of the VAX/VMS packed decimal and character string instruction set, virtual memory, and I/O capabilities of the operating system. VAX-11 DSM provides a language precompiler to optimize routine execution in an application environment. The DSM language is directed primarily toward the processing of variable-length string data, making interactive database systems easier to implement and maintain.

*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.

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

*VAX-11 Pascal* is a reentrant, 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

# DEC VAX-11 Systems

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-11 C* is a general-purpose programming language featuring control and data structures with concise operations. Based on "The C Programming Language," VAX-11 C 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-11 C 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.

COMMUNICATIONS: 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 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 nontransparent 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.

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 its converse, up-line system dumping, are 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

# DEC VAX-11 Systems

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-11 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.)

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, a code management system, an application development environment (ADE) package, a DECalc spreadsheet package, and a ReGIS graphics library (RGL) package. 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.

*VAXElan* software acts as a compatible subsystem to the VMS operating system for development of applications in real-time control and distributed computing environments. It consists of development utilities for creating target applications and a run-time kernel of device drivers and service code that becomes a part of each application. Finished programs are entirely memory-resident, although optional disk support is available for data files.

VAXElan applications are written in an optimizing, native-mode version of Pascal. Completed applications can be downline-loaded across network (local or wide area) links or transferred to target systems by disk or tape. While the MicroVAX system is the principal target system for VAXElan applications, VAX-11/750 and 11/730 systems are also supported as target systems.

*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

# DEC VAX-11 Systems

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 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 ongoing 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.

The *Application Development Environment (ADE)* software package is designed for the nonprogrammer who develops small, simple applications such as personnel records, order processing, department budgets, financial/forecasting models, and mail/telephone lists. ADE provides easy-to-use facilities and functions for users to create their own databases, add, change or delete data, produce simple bar graphs and write reports—without waiting for formal programming and report generation. In addition, ADE uses full-screen handling, prompts the user after each input, offers extensive "HELP" messages, provides user protection of data, and automatic sorting alphabetically, numerically, or in date order.

*VAX-11 DECalc* is an interactive applications package for creating, editing, and manipulating the electronic equivalent of an accountant's spreadsheet. VAX-11 DECalc executes in native mode under VAX/VMS and drives a VT100-series terminal. Since DECalc is self-teaching, users require little previous computer experience. This package was designed for the following applications categories: loans and investments, advertising and sales, general business, and engineering.

The *VAX-11 ReGIS Graphics Library (RGL)* is a collection of subroutines conforming to the standard VAX/VMS calling interface and designed to support the graphics capabilities of the VT125. RGL is written in Fortran and executes under the VAX/VMS operating system.

*DECdx/VMS* is an exchange facility that allows two-way transfer of documents between Digital word processing systems and VAX systems while fully preserving document content and format.

*VAX Bisync Terminal Support (BTS)* is a VAX-based software package that enables VAX/VMS systems to support blockmode synchronous terminals using the Binary Synchronous Communications (BSC) protocol. Bisynch terminal users can then either run applications on the VAX system, or use the VAX as a pass-through device to access applications on an IBM mainframe.

*External Document Exchange* is a VAX-based software package that permits full, two-way document transfer and conversion between a Digital VAX system and a Wang OIS.

OFFICE AUTOMATION: *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, WPS8/78, 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.

*VAX-11 ALL-IN-1 Office Menu* provides office applications such as electronic mail, document processing, desk management, and forms development on VAX/VMS-based systems. A flow-control facility allows a user at a VT100 family terminal to select from an option menu, moving from one application to another. The VAX-11 ALL-IN-1 software requires a VAX/VMS system with at least 2M bytes of dedicated main memory.

*DECpage* is an ALL-IN-1 application that unites the ease-of-use features of Digital word processing with the capabilities of the DEC LN01 laser printer to produce stylized documents using a variety of print styles and fonts.

# DEC VAX-11 Systems

APPLICATIONS: ***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.**

**TYPICAL CONFIGURATIONS: Typical small, medium, and large VAX-11 System Building Block components can be configured as follows:**

**VAX-11/370 System Building Block Configuration**

| | | |
|---|---|---|
| 730XA-AE(AJ) | VAX-11/730 CPU, 2MB ECC MOS memory, VAX/VMS license only | $21,500 |
| RUA80-AA(AD) | RA80 121MB fixed disk | $19,000 |
| TU80-AA(AB) | TU80 magnetic tape | $ 9,900 |
| DMF32-LP | Multipurpose communications interface | $ 3,995 |
| LA100-BA | 1 Hardcopy Terminal | $ 2,195 |
| VT102-AA | 10 Video Terminals | $17,100 |
| LP11-AA | Two 300 lpm printers | $16,700 |
| TOTAL | | $90,390 |

**VAX-11/750 System Building Block Configuration**

| | | |
|---|---|---|
| 750XA-AE(AJ) | VAX-11/750 CPU, 2MB ECC MOS memory, VAX/VMS license only | $ 47,000 |
| MS750-CA | 1MB ECC MOS expansion memory | $ 4,900 |
| RUA80-AA(AD) | RA80 121MB fixed disk | $ 19,000 |
| RGM05-FA(FB) | RM05 256MB removable disk | $ 46,000 |
| TU80-AA(AB) | Two TU80 magnetic tapes | $ 19,800 |
| DZ11-HP | 8-line 20mA asynch serial communications interface | $ 2,500 |
| LA100-BA | 1 Hardcopy Terminal | $ 2,195 |
| VT102-WA | 20 Video Terminals | $ 34,200 |
| LP11-EA | Two 600 lpm printers | $ 27,200 |
| TOTAL | | $202,795 |

**VAX-11/780 System Building Block Configuration**

| | | |
|---|---|---|
| 780XA-AE(AJ) | VAX-11/780 CPU, 2MB ECC MOS memory, VAX/VMS license only | $145,000 |
| MS780-DD | 2MB ECC MOS expansion memory | $ 13,000 |
| REP07-FA(FB) | RP07 516MB fixed disk | $ 50,000 |
| REM05-FA(FB) | Two RM05 256MB removable disks | $ 92,000 |
| TU80-AA(AB) | Four TU80 magnetic tapes | $ 39,600 |
| DZ11-HP | 8-line 20mA asynch serial communications interface | $ 2,500 |
| LA120-DA | 1 Hardcopy Terminal | $ 2,800 |
| VT102-WA | 40 Video Terminals | $ 68,400 |
| LP27-UA(UB) | 1250/910 lpm printer | $ 28,990 |
| LN01-CA(CB) | 12 pg/min laser printer | $ 19,995 |
| TOTAL | | $462,285 |

# DEC VAX-11 Systems

## EQUIPMENT PRICES

| | | Purchase Price | Monthly Maint. |
|---|---|---|---|
| **VAX PACKAGED SYSTEMS** | | | |
| SVCXNZA-EK(EN) | VAX-11/725 System Package; includes 1MB of memory, two TU58 tape cartridge drives (for system startup, diagnostics, and as alternate load devices), RC25 disk subsystem and VMS software (license only) | $24,950 | — |
| SVCXNZB-EK(EN) | VAX-11/725 System Package; includes 2MB of memory, DMF32 communications interface, two TU58 tape cartridge drives, RC25 disk subsystem and VMS software (license only) | 29,950 | — |
| SVCXNZC-EK(EN) | VAX-11/725 System Package; includes 2MB of memory, DMF32 communications interface, floating point accelerator, DEUNA Ethernet adapter, two TU58 tape cartridge drives, RC25 disk subsystem, DECnet software, and VMS software (license only) | 36,800 | — |
| 610QA-XZ | MicroVAX I; rack-mounted, diskless unit with 512KB of memory | 9,995 | — |
| 610QH-XZ | MicroVAX I; floor-standing unit with 512KB of memory, RX50 diskette, and RD51 Winchester disk drive | 13,880 | — |
| **VAX SYSTEM BUILDING BLOCKS** | | | |
| | Vax System Building Blocks (SBBs) begin with a core of components: CPU, two or four megabytes of 64K or 16K ECC MOS memory, cabinetry, and the VAX/VMS operating system license. To this core the user must add selections from the system device, load device, communications interface, console terminal, and software menus. SBBs are available for the VAX-11/730, 11/750, 11/780, and 11/782. After ordering one of the models below, the customer must then order one from each of the mass storage, communications, and console terminal menus. Selection from the software menu is optional | | |
| 782XA-AE(AJ) | VAX-11/782 dual CPU, 4MB ECC MOS shared memory, H9652 Unibus expansion cabinet with BA11-K and DD11-K, and VAX/VMS license only | 320,000 | $1,816 |
| 780XA-AE(AJ) | VAX-11/780 CPU, 2MB ECC MOS memory, H9652 Unibus expansion cabinet, and VAX/VMS license only | 145,000 | 407 |
| 750XA-AE(AJ) | VAX-11/750 CPU, 2MB ECC MOS memory, and VAX/VMS license only | 47,000 | 226 |
| 730XA-AE(AJ) | VAX-11/730 System Building Block; includes VAX-11/730 CPU, 2MB ECC MOS memory, and VAX/VMS license only | $21,500 | 124 |
| **VAXCLUSTER BUILDING BLOCKS** | | | |
| | A VAXcluster is composed of one or more VAX-11/750, 11/780 or 11/782 processors running on VAX/VMS connected by a high-speed bus, one or more mass storage servers, and communication links to the user community. VAXcluster systems are configured by starting with a standard Building Block system and adding a CI750 or CI780 Computer Interconnect. There are two types of System Building Blocks. The first type is a basic system element, which, for the 11/78X, consists of a VAX-11/780 CPU with 2MB of memory, or a VAX-11/782 with 4MB of memory, CI780 computer interconnect, HSC50 intelligent controller, and one each disk and tape interface (each with four ports), plus a VAX/VMS operating system license. The second type of Cluster System Building Block is an upgrade to an existing VAXcluster. The 11/78X upgrade consists of a VAX-11/780 CPU with 2MB of memory or a VAX-11/782 with 4MB of memory, and CI780 computer interconnect and VAX/VMS operating system license. To this must be added an LA120 console terminal, and an optional system disk such as the RA60, RA80 or RA81 disk drives | | |
| 782CA-AE(AJ) | VAX-11/782 VAXcluster Building Block; includes VAX-11/782 dual CPU, 4MB shared ECC MOS memory, C1780 Computer Interconnect, SC008-AC Star Coupler, intelligent disk/tape server, interface for four SDI disks, interface for four STI tapes, VAX/VMS license, and Unibus expansion cabinet with BA11-K expander box and DD11-DK backplane | 370,000 | 2,133 |
| 782CA-AP(AT) | VAX-11/782 VAXcluster Upgrade; includes VAX-11/782 dual CPU, 4MB shared ECC MOS memory, H9652-MA(MB) cabinet, computer interconnect, and VAX/VMS license | 320,000 | 1,966 |
| 780CA-AE(AJ) | VAX-11/780 VAXcluster Building Block; includes VAX-11/780-EA(ED), 2MB ECC MOS memory, computer interconnect, star coupler, intelligent disk/tape controller, interface to four SDI disks, interface to four STI tapes, VAX/ VMS license, and Unibus expansion cabinet with BA11-K expander box and DD11-DK backplane | 217,000 | 744 |
| 780CA-AP(AT) | VAX-11/780 VAXcluster Upgrade; includes VAX-11/780-EA(ED), 2MB ECC MOS memory, Unibus expansion cabinet, computer interconnect, and VAX/VMS license | 173,000 | 577 |
| **PROCESSOR AND MEMORY 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; for VAX-11/782 | 22,400 | 96 |
| FP780-AA (AB) | High performance floating-point accelerator for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL; power supply included; for VAX-11/780 | 11,200 | 50 |
| FP750 | High performance floating-point accelerator for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL; for VAX-11/750 | 8,500 | 45 |

# DEC VAX-11 Systems

## EQUIPMENT PRICES

| | | Purchase Price | Monthly Maint. |
|---|---|---|---|
| FP730 | High performance floating-point accelerator for single- and double-precision floating-point instructions plus POLY, EMOD, and MULL; for VAX-11/730 | 3,995 | 25 |
| E75VC-AG | One FP750 high performance floating-point accelerator, 1M-byte of ECC MOS memory, and VAX-11 Fortran with support; for VAX-11/750 | 15,000 | 74 |
| E75VC-DZ | Same as E75VC-AG except VAX-11 Fortran license only | 12,000 | 74 |
| E75VD-AG | One FP750 high performance floating-point accelerator, 2M-bytes of ECC MOS memory, and VAX-11 Fortran with support; for VAX-11/750 | 18,500 | 103 |
| E75VD-DZ | Same as E75VD-AG except VAX-11 Fortran license only | 15,500 | 103 |
| E782A-AY | Two FP780 high performance floating-point accelerators, 1M-byte of ECC MOS memory, and VAX-11 Fortran with support; for VAX-11/782 | 36,700 | 266 |
| E782A-DZ | Same as E782A-AY except VAX-11 Fortran license only | 32,700 | 266 |
| E782B-AY | Same as E782A-AY, except uses FP782-AB and requires 240 V/50 Hz power | 36,700 | 266 |
| E782B-DZ | Same as E782B-AY, except VAX-11 Fortran is license only | 32,700 | 266 |
| E782C-AY | Two FP780 high performance floating-point accelerators, 2M-bytes of ECC MOS memory, and VAX-11 Fortran with support; for VAX-11/782 | 41,700 | 376 |
| E782C-DZ | Same as E782C-AY except VAX-11 Fortran license only | 37,700 | 376 |
| E782D-AY | Same as E782C-AY, except uses FP782-AB and requires 240 V/50 Hz power | 41,700 | 376 |
| E782D-DZ | Same as E782D-AY, except VAX-11 Fortran is license only | 37,700 | 376 |
| C1780-AA (AB) | Optional microcoded intelligent adapter to the dual path computer interconnect; supported by DECnet-VAX and VAX/VMS; for VAX-11/780 | 19,500 | 150 |
| C1780-SA (SB) | C1780 Starter Kit; includes two C1780-ABs, cables, and one star coupler | 40,000 | 322 |
| C1750-AA(AD) | An expansion C1750 adapter for mounting into the cabinet supplied with the C1750-AA(AB); for VAX-11/750 | 17,500 | 150 |
| C1750-BA(BB) | Microprocessor-controlled, fully buffered high speed interface between the memory interconnect (MI) of the CPU and the dual path CI bus; the C1750 is mounted in a 101.6 cm (40.6 inch) high, freestanding cabinet; the unit consists of three extended-length, Hex-height modules, an associated backplane, and a power supply contained within a 26.6 cm (10.5 inch) high mounting enclosure; the C1750 adapter operates together with the SC008 Star Coupler option to form the CI bus; a VAX-11/750 processor option | 18,500 | 150 |
| C1750-SA(SD) | Two node starter kit containing two C1750-BA(BB), SC008 Star Coupler, and cables; for VAX-11/750 | 39,000 | 322 |
| SC008-AC | Star coupler; 8-mode with cabinet | 7,500 | 22 |
| SC008-AD | Upgrade to Star Coupler; for 9 to 16 nodes | 5,500 | 22 |
| DR750-F | An intelligent, high-performance, general purpose interface which can be used to connect customer-designed devices to a VAX-11/750, to connect two VAX-11/750 systems together, or to connect a VAX-11/750 to a VAX-11/780 using a DR780; includes a 3.2MB/sec transfer rate, command and data chaining, dynamic memory mapping, separate data and control paths; for VAX-11/750 | 7,000 | 55 |
| DW750 | VAX-11/750 second Unibus adapter | 7,000 | 20 |
| DW780-AA (AB) | UNIBUS adapter; for the VAX-11/780 | 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); for VAX-11/780 | 1,500 | N/C |
| KU780-A | 2K words (99-bit words) User Control Store; for VAX-11/780 | 11,000 | 53 |
| KU750-YG | 1K words (88-bit words) User Writable Control Store plus Extended G and H Floating Point type supported in KU750-loadable microcode; for the VAX-11/ 750 | 6,000 | 47 |
| MA780-BA(BB) | Additional 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 | 10,600 | 26 |
| MA780-JA(JB) | 256KB ECC MOS Multiport Memory subsystem, which can be shared by up to four VAX-11/780 systems; for VAX-11/780 systems | 39,500 | 188 |
| MS730-CA | 1MB ECC MOS expansion memory (one 64K chip array); for VAX-11/730 | 4,900 | 29 |
| MS730-CB | 2MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/730 | 9,000 | 58 |
| MS730-CC | 3MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/730 | 13,000 | 87 |
| MS730-CD | 4MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/730 | 17,000 | 116 |
| MS730-CF | 10MB ECC MOS Multiple System Memory Expansion Package (in 64K chip arrays); for VAX-11/730 | 34,000 | NA |
| MS730-CH | 25MB ECC MOS Multiple System Memory Expansion Package (in 64K chip arrays); for VAX-11/730 | 75,000 | 725 |

# DEC VAX-11 Systems

## EQUIPMENT PRICES

| | | Purchase Price | Monthly Maint. |
|---|---|---|---|
| MS730-CJ | 50MB ECC MOS Multiple System Memory Expansion Package (in 64K chip arrays); for VAX-11/730 | 137,500 | 1,450 |
| MS750-CA | 1MB ECC 64K MOS expansion memory; for VAX-11/750 | 4,900 | 29 |
| MS750-CB | 2MB ECC 64K MOS expansion memory; for VAX-11/750 | 9,000 | 58 |
| MS750-CC | 3MB ECC 64K MOS expansion memory; for VAX-11/750 | 13,000 | 87 |
| MS750-CD | 4MB ECC 64K MOS expansion memory; for VAX-11/750 | 17,000 | 116 |
| MS750-CF | 10MB ECC 64K MOS expansion memory (single system maximum is 8MB); for VAX- 11/750 | 34,000 | 290 |
| MS750-CH | 25MB ECC MOS Multiple System Memory Expansion Package (in 64K arrays); for VAX-11/750 | 75,000 | 725 |
| MS750-CJ | 50MB ECC MOS memory Multiple System Memory Expansion Package; for VAX-11/ 750 | 137,500 | 1,450 |
| MS750-DA | 11/750 64K upgrade, 1M-byte, no BP (battery pack); prerequisite; VAX-11/750-BA CPU-serial # less than BTO3096 | 10,000 | 29 |
| MS750-DC | 11/750 64K upgrade, 1M-byte, with BP (battery pack); prerequisite; VAX-11/750-BA CPU-serial # less than BTO3096 | 10,000 | 29 |
| MS780-CH(CJ) | 1MB ECC MOS, 16K chip memory with MS780-C controller; for VAX-11/780 | 23,400 | 242 |
| MS780-DA | 256KB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780 | 2,400 | 61 |
| MS780-DB | 512KB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780 | 4,000 | 103 |
| MS780-DC | 1MB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780 | 7,000 | 179 |
| MS780-DD | 2MB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780 | 13,000 | 294 |
| MS780-DE | 3MB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780 | 18,000 | 380 |
| MS780-DF | 4MB ECC MOS expansion memory (in 16K chip arrays); for VAX-11/780 | 22,000 | 460 |
| MS780-EA(EB) | 4MB ECC MOS, 64K chip memory with memory backplane, SBI interface, and one interleaved controller; for VAX-11/780 | 36,000 | 184 |
| MS780-EC(ED) | 2MB ECC MOS memory, 64K chip memory with memory backplane, SBI interface, and one interleaved controller; for VAX-11/780 | 28,900 | 126 |
| MS780-FA | 2MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/780 | 9,000 | 58 |
| MS780-FB | 4MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/780 | 17,000 | 116 |
| MS780-FC | 6MB ECC MOS expansion memory (in 64K chip arrays); for VAX-11/780 | 24,000 | 174 |
| MS780-FF | 10MB ECC MOS memory (in 64K arrays); for VAX-11/780 | 34,000 | 290 |
| MS780-FH | 25MB ECC MOS expansion memory (in 64K arrays); for VAX-11/780 | 75,000 | 725 |
| MS780-FJ | 50MB ECC MOS Multiple System Memory Expansion Package (in 64K arrays); for VAX-11/780 | 137,500 | 1,450 |
| H7112-A (B) | MOS memory battery backup; for VAX-11/780 | 1,800 | 12 |
| 782UP-FA(FD) | VAX-11/782 Upgrade Package; for upgrading a VAX-11/780 to a VAX-11/782; includes a processor unit, multiport memory subsystem, cache invalidate option, 1MB of memory, and an LA120 console terminal | 180,000 | 1,029 |
| 11780-VA(VB) | VAX-11/780 Upgrade Package; includes VAX-11/780 processor unit, 2MB memory, LA120 console terminal, two MBAs, one UBA, VAX-11/780 expansion cabinet, and VAX/VMS license with software support | 155,000 | 439 |
| 11780-VC(VD) | Same as 11780-VA(VB) except without software support | 145,600 | 439 |
| 11750-VH(VJ) | VAX-11/750 Upgrade Package; includes VAX-11/750-CA CPU with 1MB memory, LA120 console terminal, TU58 magnetic tape cartridge, and VAX/VMS license | 46,200 | 243 |
| **MASS STORAGE** | | | |
| RA60-AA | 205MB rack-mounted RA60 drive (no cabinet) | 15,000 | 80 |
| RA60-CA(CD) | 205MB cabinet-mounted RA60-AA add-on drive | 17,000 | 80 |
| RUA60-CA(CD) | 205MB RA60-AA cabinet mounted drive and UDA50 controller | 22,000 | 110 |
| RA80-AA(AD) | 121MB rack-mounted RA80 drive (no cabinet) | 14,000 | 81 |
| RA80-CA(CD) | 121MB cabinet-mounted RA80 add-on drive | 16,000 | 81 |
| RUA80-AA(AD) | 121MB RA80 rack-mounted drive (no cabinet) and UDA50 controller | 19,000 | 111 |
| RUA80-CA(CD) | 121MB RA80 cabinet-mounted drive and UDA50 controller | 21,000 | 111 |
| RA81-AA(AD) | 456MB RA81 drive (no cabinet) | 19,000 | 90 |
| RA81-CA(CD) | 456MB cabinet-mounted RA81 drive | 21,000 | 90 |
| RUA81-CA(CD) | 456MB RA81 cabinet-mounted drive and UDA50 controller | 26,000 | 120 |
| RL02-AK | 10.4MB RL02 add-on cartridge drive | 3,000 | 63 |
| RL02K-DC | 10.4MB cartridge for the RL02 | 210 | NA |
| RL211-AK | 10.4MB RL02 top-loading, rack-mounting, removable cartridge drive and controller with interconnect cabling | 6,900 | 71 |

# DEC VAX-11 Systems

## EQUIPMENT PRICES

| | | Purchase Price | Monthly Maint. |
|---|---|---|---|
| REM05-FA(FB) | Single-access, 256MB removable disk pack drive and VAX-11/780 MASSBUS adapter | 46,000 | 326 |
| REM05-FC(FD) | Dual-access, 256MB removable disk pack drive and two VAX-11/780 MASSBUS adapters | 60,600 | 415 |
| REM05-FE(FF) | Dual-port conversion kit with RM05 dual-port kit, power supply and VAX-11/780 MASSBUS adapter | 16,700 | 89 |
| REP07-FA(FB) | 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-FC(FD) | 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-FE(FF) | RP07 dual-port conversion kit with RP07-C dual-pot kit and VAX-11/780 MBA with power supply to convert REP07-FA to REP07-FC | 16,700 | 80 |
| RGP07-FA(FB) | Single-access, free-standing 516MB fixed Winchester disk drive and VAX-11/750 MASSBUS adapter, 1.3 megabytes per second peak transfer rate | 46,000 | 240 |
| 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 |
| RM05-C | RP07 dual-port kit with dirve logic and cables to convert RP07-A to RP07-B | 5,150 | 16 |
| RM05-P | 256KB removable disk pack for RM05 | 1,215 | N/A |
| RM05-PX | RM05 disk pack, hard error (flag) free | 1,435 | N/A |
| 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 |
| RPO7-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 |
| 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 |
| **MAGNETIC TAPE EQUIPMENT** | | | |
| TE16-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 | 15,900 | 97 |
| TEE16-FA(FE) | TE16 magnetic tape transport, formatter, and VAX-11/780 MBA | 27,000 | 163 |
| TEU77-FB(FD) | 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-FB(FD) | 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-FF(FJ) | Dual-ported TU78 magnetic tape transport, formatter, and two VAX-11/780 MBAs | 68,600 | 420 |
| TGE16-FA(FD) | TE16 magnetic tape transport, formatter, H9604-AC stand-alone option expansion kit, and VAX-11/750 MBA | 27,000 | 155 |
| TGU77-FB(FD) | TU77 magnetic tape transport and VAX-11/750 MBA | 36,800 | 259 |
| TGU78-FB(FD) | TU78 magnetic tape transport and VAX-11/750 MBA | 54,000 | 340 |
| TM78-C | TU78 dual-port kit containing drive logic and cables to provide dual-porting capability to TEU78-AB(AD) or TU78-AB(AD); prerequisite: TU78 Master | 5,150 | 20 |
| TU77-AF(AJ) | TU77 magnetic tape transport; prerequisite: TGU77 or TEU77 | 23,800 | 193 |
| TU78-AB(AD) | TU78 magnetic tape transport and formatter (master); requires a TM78-C for dual-porting capability | 48,000 | 280 |
| TU78-AF(AJ) | TU78 magnetic tape transport (without formatter); prerequisite: TU78 Master | 25,500 | 170 |
| TU80-AA (AB) | 1600 bpi; 9-track, 25 ips (100 ips streaming) magnetic tape subsystem, UNIBUS adapter and power controller in a dedicated 40-inch H9643 cabinet | 9,900 | 63 |
| **UNIBUS OPTIONS** | | | |
| DMF32-LP | Direct Memory Access UNIBUS controller; system option, supported by VAX/VMS, DECnet/VAX, VAX-11 PSI, VAX-11 2780/3780, and 3271 Protocol Emulators; external cables for terminals not included | 3,995 | 55 |

# DEC VAX-11 Systems

## EQUIPMENT PRICES

| | | Purchase Price | Monthly Maint. |
|---|---|---|---|
| H9642-FA(FB) | Front loading expander cabinet and power control, with space for one BA11-K expander box and one 10.5 inch (26.6 cm) disk; I/O connection panel space to mount three groups of four panels each and one group of one panel unit; for VAX-11/750 and VAX-11/730 | 2,200 | N/C |
| H9642-FC(FD) | Expander cabinet and power control, with space for one BA11-K expander box; I/O connector panel space to mount seven groups of four panel units each and one group of one panel unit; for VAX-11/750 and VAX-11/730 | 2,050 | N/C |
| H9652-MF (MH) | Single-width, high-boy general purpose UNIBUS expansion cabinet, with space for two additional BA11-K expander boxes; for VAX-11/780 | 3,700 | N/C |
| BA11-KU (KV) | Rack-mountable expansion box with bezel and slides for UNIBUS expansion cabinet; provides mounting space for five system units and is compatible with DD11-CK/DK expansion backplanes | 3,500 | 20 |
| HSC50-AA(AB) | HSC50 with space for six HSC5X-BA; cables not included | 32,500 | 95 |
| HSC5X-BA(BB) | Data channel interface for interfacing up to four disk drives | 7,100 | 25 |
| HSC5X-EA(EB) | Second power supply for over three HSC5X-BA on the HSC50 | 2,600 | 25 |
| DD11-CK | Expansion backplane mounting for BA11-K box; provides for two hex- and two quad-slot modules | 470 | N/C |
| DD11-DK | Same as DD11-CK except for providing seven hex- and two quad-slot modules | 940 | N/C |
| **ASYNCHRONOUS MULTIPLEXERS** | | | |
| DZ11-DP | System option; eight-line multiplexer with distribution panel for EIA/CCITT terminals; with modem control for use with DF01, DF02, DF03, and Bell 103, 113, or 212 modems or equivalent; external cables not included | 2,175 | 33 |
| DZ11-HP | System option; eight-line multiplexer for use with 20 mA current loop terminals; terminal cables not included | 2,500 | 33 |
| DZ11-M | Upgrade option; RS232 interface; includes base module only | 1,560 | 33 |
| DZ11-N | Upgrade option; 20 mA interface; base module only | 1,635 | 33 |
| DZ32-AP | System option; eight-line EIA/CCITT multiplexer comprised of a single UNIBUS Hex module and a panel insert; external cables not included | 2,988 | 36 |
| DZ32-M | Upgrade option; EIA/CCITT interface; includes base module only | 2,055 | 36 |
| **STATISTICAL MULTIPLEXERS** | | | |
| DZS11-EA | Single module containing a DZ11-A asynchronous multiplexer emulator and a VT1XX-EB statistical multiplexer | 4,050 | 38 |
| VT1XX-EB | Eight-channel statistical multiplexer | 3,250 | 28 |
| **SINGLE-LINE SYNCHRONOUS INTERFACES** | | | |
| DUP11-AP | System option; interfaces to Bell 200 series modems or equivalent at speeds up to 9600 bit/second; includes data set control and BC22f-25 cable | 1,575 | 12 |
| DUP11-M | Upgrade option; includes only the base module | 1,230 | 12 |
| DMR11-AP | System option; interfaces to EIA RS232/CCITT synchronous modems at speeds up to 19.2K bit/second | 4,400 | 39 |
| DMR11-FP | System option; interfaces to EIA RS423/RS429 V.24 synchronous modems at speeds up to 56K bit/second | 4,400 | 39 |
| DMR11-BP | System option; interfaces to CCITT V.35/DDS synchronous modems at speeds up to 1M bit/second | 4,400 | 39 |
| DMR11-CP | System option; includes integral modem for local interconnection | 4,400 | 39 |
| DMR11-EP | System option; interfaces to EIA RS422/RS429 V.24 synchronous modems, suppports speeds up to 1M bit/second (FDX) | 4,400 | 39 |
| DMR11-M | Upgrade option; inlcudes base module only | 4,110 | 39 |
| **MULTIPOINT SYNCHRONOUS INTERFACES** | | | |
| DMP11-AP | System option; interfaces to EIA RS232/CCITT synchronous modems at speeds up to 19.2K bit/second | 6,900 | 74 |
| DMP11-FP | System option; interfaces to EIA RS423/RS449 V.24 synchronous modems at speeds up to 56K bit/second | 6,900 | 74 |
| DMP11-BP | System option; interfaces to CCITT V.35/DDS synchronous modems at speeds up to 56K bit/second | 6,900 | 74 |
| DMP11-CP | System option; includes integral modem for local interconnection | 6,900 | 74 |
| DMP11-EP | System option; interfaces to EIA RS422/RS449 V.24 synchronous modems; supports speeds up to 1M bit/second (HDX) or 500K bit/second (FDX) | 6,900 | 74 |
| DMP11-M | Upgrade option; includes base module only | 6,450 | 74 |

# DEC VAX-11 Systems

## EQUIPMENT PRICES

| | | Purchase Price | Monthly Maint. |
|---|---|---|---|
| **MULTIPOINT PARALLEL INTERFACE** | | | |
| PCL11-B | Multidrop computer link used to connect up to 16 processors to form a local distributed network; full duplex interfaces, residing in each CPU, are interconnected by a single high speed bus which can operate at speeds up to 1M bit/second depending on bus length | 7,750 | 66 |
| **AUXILIARY COMMUNICATIONS MICROPROCESSORS** | | | |
| KMS11-BD/KMS11-BE | Intelligent, full-duplex, 8-line, synchronous, communications, front-end interface with concurrent data transfers over eight lines | 12,500/12,200 | 97 |
| KMS11-PX | High-performance network link for interconnection of VAX-11 and PDP-11 computers; includes EIA RS232-C interface operating at speeds up to 19.2K bit/second and EIA RS423-A/CCITT V.10 interface operating at speeds up to 56K bit/second | 6,000 | 76 |
| KMS11-PY | High-performance network link for interconnection of VAX-11 and PDP-11 computers; includes ISO 2593/CCITT V.35 interface operating at speeds up to 56K bit/second | 6,000 | 76 |
| KMS11-PZ | High-performance network link for interconnection of VAX-11 and PDP-11 computers; includes CCITT V.11 interface operating at speeds up to 56K bit/second | 6,000 | 76 |
| **GENERAL PURPOSE UNIBUS INTERFACES** | | | |
| DR11-W | General purpose DMA controller, interfaces to VAX UNIBUS | 1,650 | 11 |
| **DECnet COMMUNICATIONS** | | | |
| DECSA-AH | DECnet/SNA Gateway (RL02) including server unit, gateway software, and one synchronous RS-232-C/CCITT V.24 line card (DCSAX-LA) | 26,995 | 135 |
| DECSA-AM | DECnet/SNA Gateway (9-track 1600 bpi magtape) including server unit, gateway software, and one synchronous RS-232-C/CCITT V.24 line card (DCSAX-LA) | 26,995 | 135 |
| DECSA-DZ | DECnet/SNA Gateway including server unit, one synchronous RS-232-C/CCITT V.24 line card (DCSAX-LA), and a right-to-copy, no support license for software | 25,795 | 135 |
| DECSA-EA | DECnet Router Server and DECnet Router/X.25 Gateway unit, including server unit and one synchronous RS-232-C/CCITT V.24 line card (DCSAX-LA). Note: configuration to either Router Server or Router/X.25 Gateway unit requires purchase of Router Server or Router/X.25 Gateway software | 25,795 | 135 |
| **ETHERNET COMMUNICATIONS** | | | |
| H4000 | Digital Ethernet transceiver; provides functional interface between the Ethernet coaxial cable and an Ethernet station | 300 | N/A |
| DEUNA-AA | Ehternet communications controller; connects Unibus system to an Ethernet local area network | 3,500 | 44 |
| DELNI-AA | Local Network Interconnect; allows Ethernet-compatible devices to be grouped up to 50 meters away from the LNI; can be configured three ways; supports up to eight systems | 985 | N/A |
| DEREP-AA | Ethernet Repeater; tabletop device with its own power supply; allows for connection of multiple segments of Ethernet coaxial cable for expansion of the network | 1,500 | N/A |
| DEREP-RA | Same as DEREP-AA, but remote | 4,400 | N/A |
| **PACKAGED LABORATORY PERIPHERAL OPTIONS** | | | |
| The following options are supported only with the LPA11-K bus. | | | |
| 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 |
| 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 |
| 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-EA | Freestanding lineprinter operating at a speed of 600 lines/min for 64 character set | 13,600 | 143 |
| LP11-EB | Same as LP11-EA; also operates at 450 lines/min for 96-character set | 14,400 | 143 |
| LP27-UA(UB) | 132-column fully formed character impact lineprinter with 30 ft data cable and controller | 28,990 | 247 |
| LSP25-CA | 300 line/min, 64- and 96-character-long line band printer | 9,990 | 113 |

# DEC VAX-11 Systems

## EQUIPMENT PRICES

| | | Purchase Price | Monthly Maint. |
|---|---|---|---|
| LP32-AA | 132-column, 64-character printer and universal power supply, 300 lpm; prerequisite, DMF32 UNIBUS controller | 8,350 | 93 |
| LP32-EA | 132-column, 64-character printer and universal power supply, 600 lpm; prerequisite, DMF32 UNIBUS controller | 13,600 | 136 |
| LP32-EB | 132-column, 64-/96-character printer and universal power supply, 600/450 lpm; prerequisite, DMF32 UNIBUS controller | 14,400 | 136 |
| **LASER PRINTERS** | | | |
| LN01-CA (CB) | Nonimpact laser-quality page printer; prints 12 pages per minute, 13.6 cps, 188-character fixed-space font plus a variety of application-oriented font kits, up to 132 print columns, 300 x 300 dots per square inch, compatible with standard line printer interface (LP11) | 19,995 | 320 |
| LN01-DA (DB) | Same as LN01-CA (CB), but includes DMF32-compatible cable | 19,995 | 320 |
| **LETTER-QUALITY PRINTER** | | | |
| LQP02-AA (AD) | 132 columns at 10 cpi, 158 columns at 12 cpi, over 100 different character sets, 10/12 cpi variable, 6/8 lines per inch variable, 32 cps, 110 to 9600 bps | 2,800 | 29 |
| LQPXX-AC | Dual-tray cut sheet feeder for use with regular office stationery | 1,800 | 17 |
| **PRINTERS/PLOTTERS** | | | |
| LXY12-CA (CB) | Free-standing line printer/plotter; 96 characters, 170, 240, or 300 lpm print speed, 16.7 inches per minute plot speed; with Unibus interface | 11,250 | 99 |
| LXY12-DA (DB) | Same as LXY12-CA (CB); with RS232-C interface | 11,250 | 99 |
| LXY12-EA (EB) | Same as LXY12-CA (CB); with DMF32 interface | 11,250 | 99 |
| LXY22-CA (CB) | Free-standing line printer/plotter; 96 characters, 320, 465, or 600 lpm print speed, 33.3 inches per minute plot speed; with Unibus interface | 15,800 | 129 |
| LXY22-DA (DB) | Same as LXY22-CA (CB); with RS232-C interface | 15,800 | 129 |
| LXY22-EA (EB) | Same as LXY22-CA (CB); with DMF32 interface | 15,800 | 129 |
| **CARD READERS** | | | |
| CR11 (-A) | Tabletop 300 cpm reader and control unit; reads 80-column punched cards | 9,495 | 74 |
| CR11-BC (BD) | Tabletop 600 cpm reader and control unit; reads 80-column punched cards | 13,455 | 76 |
| CME11-K | Tabletop 250 cpm reader and control unit; reads 80-column punched cards; not for VAX-11/730 | 5,695 | 96 |
| **TERMINALS** | | | |
| LA12-D | Portable correspondent hardcopy terminal with EIA interface and accessories; 150 cps, 96 characters, 40 to 72 print columns 9 x 9 dot matrix, 50 to 9600 bps | 1,445 | 21 |
| LA12-C | Includes LA12-D plus 300 baud acoustic coupler, carry case, shoulder strap | 1,545 | 21 |
| LA12-B | Includes LA12-D plus 300/1200 baud modem, carry case, shoulder strap | 1,995 | 21 |
| LA12-A | Includes LA12-D plus 300/1200 baud modem, 300 baud acoustic coupler, carry case, shoulder strap | 2,095 | 21 |
| LA100-AA | Letterwriter 100 desktop KSR hardcopy terminal; English language with Orator and Courier fonts; 30, 80, or 240 cps; 217 print columns, 50 to 9600 bps | 2,860 | 27 |
| LA100-AB | Same as LA100-AA except with international, English, and foreign character sets | 2,860 | 27 |
| LA100-BA/-BB | Includes LA100-AA/-AB plus tractors, cable, ribbon cartridge, and one roll of paper | 2,195 | 27 |
| LA100-CA/-CB | Includes LA100-BA/-BB plus multiple font capability | 2,295 | 27 |
| LA100-RA | Letterwriter 100 desktop RO printing terminal with Courier-10 and Orator-10 fonts; 30, 80, or 240 cps; 217 print columns, 50 to 9600 bps | 2,215 | 25 |
| LA100-RB | Same as LA100-RA except with international, English, and foreign character sets | 2,215 | 25 |
| LA100-YA | Includes LA100-RA/-RB plus tractors, ribbon cartridge, and one roll of paper | 2,475 | 25 |
| LA100-ZA/-ZB | Includes LA100-YA/-YB plus multiple font option | 1,595 | 28 |
| LA120-DA | Free-standing DECwriter III high-speed interactive KSR hardcopy terminal; 180 cps bidirectional printing with baud rates up to 9600 bps | 2,800 | 32 |
| LA120-RA | DECprinter III RO hardcopy terminal | 2,420 | 37 |
| VT100-AA (AB) | High performance, tabletop, 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 | 1,945 | 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 | 2,140 | 22 |