

Digital Equipment DECsystem-10

MANAGEMENT SUMMARY

In its tenth year of production, the DECsystem-10 today consists of three models: the 1091-S, 1090, and the dual-processor 1090 SMP (symmetric multiprocessor). The systems offer large-scale performance for interactive time-sharing, batch, and realtime remote, sensor-based applications, and are priced competitively with their IBM counterparts. Performance in the DECsystem-10 family compares to the IBM 4341-2 at the low end up to the 3033S at the upper end.

With a heritage dating to the mid-60's with the PDP-6 and PDP-10 systems, the DECsystem-10 has increased time-sharing and batch capabilities, and greatly improved user accessibility. Technological advances such as cache memory in the DECsystem-10 series improved performance dramatically, and paved the way for the DECSYS-TEM-20 (Report 70C-384-03).

PROCESSORS AND PERIPHERALS

The DECsystem-10 was originally introduced in September 1971. The present systems are based on the KL10 Model B processor. The KL10 can directly replace the older KA10 and K110 processors and achieves superior performance over the earlier models through the use of cache memory, a four-word-wide data path between main memory and the cache memory, and the use of emitter-coupled logic (ECL) circuitry. The KL10 also includes a set of business-oriented instructions that provide double-precision addition, subtraction, division, and multiplication of fixed-point operands and a string manipulation instruction that performs decimal/binary conversions and editing functions. The cache has a 160-nanosecond access time, which, according to DEC, allows an effective memory cycle time of 334 nanoseconds. ➤

The DECsystem-10 family includes the single-processor 1090 and 1091-S, and the dual-processor 1090 SMP. The systems are designed for interactive time-sharing, batch, and realtime, remote, sensor-based operations, and can have as many as 175 jobs operating concurrently.

The DECsystem-10 family of large-scale computers, the 1091-S, 1090, and 1090 SMP, offers interactive time-sharing, batch, realtime, and distributed processing capabilities with performance, according to DEC, ranging from the IBM 4341-2 to the 3033S. The DECsystem-10 has over 600 installations worldwide, and can handle large interactive and batch workloads concurrently, particularly in service bureaus and in other large commercial and scientific time-sharing organizations.

CHARACTERISTICS

MANUFACTURER: Digital Equipment Corporation, Large Systems Group, 200 Forest Street, Marlboro, Massachusetts 01752. Telephone (617) 467-5111.

CURRENT MODELS: DECsystem-10 Models 1090, 1091, dual-processor 1090 SMP, and DECSYSTEM-2020 running under TOPS-10.

PRIOR MODELS: DECsystem-10 Models 1040, 1050, 1055, 1060, 1066, 1070, 1077, 1080, 1088, and 1099.

NUMBER OF INSTALLATIONS: Over 350 in the U.S.

DATA FORMAT

BASIC UNIT: 36-bit word. In core memory, each word location includes one additional parity bit. MOS memory has multiple bits per word for single-bit error correction and double-bit error detection. The processor handles halfwords, but parity bits are not associated with halfword data representation. A full 36-bit word, however, is parity checked for halfword instructions. Variable-length bytes from 1 to 36 bits in length are also handled.

FIXED-POINT OPERANDS: Either 36-bit words or 18-bit halfwords for add and subtract instructions. The multiply ➤



Digital Equipment DECsystem-10

▷ The KL10 also incorporates a PDP-11 minicomputer to function both as a console processor and as a diagnostic processor. Included in the KL10 processor is a separate diagnostic bus that permits the PDP-11 to perform diagnostics on the central processor control logic and data paths. A separate asynchronous line interface is provided to permit remote diagnostics.

One of the processors employed in the DECsystem-10 series is the KL10-D, which is used in the Models 1090 and 1090 SMP. The KL10-D has the same memory bus interface used in earlier DECsystem-10 models. The latest versions of the KL10-D also have the integrated channel controls that mark the most significant difference between the original KL10 and its later versions.

The KL10-E processor, the latest version of the KL10, is used in the 1091 system. The 1091 is an upward growth path for DECsystem 1040 and 1060 users. The KL10-D and -E differ in cabinetry, memory interface, and in bootstrap device.

The DECsystem models 1090 and 1091-S can support up to 120 time-sharing users, and the 1090 SMP can handle up to 175 users. Up to 30 batch jobs can be run concurrently with interactive and real-time jobs on each system. The model 1090 can be field upgraded to the dual-processor 1090 SMP, but the 1091-S cannot be upgraded to the 1090.

The current KL10-based CPUs are about 5 percent faster than the older versions. Additional performance gains of 20 to 30 percent can be achieved by using internal MOS memory, according to DEC. The DECsystem models 1090 and 1090 SMP use the MH10 core memory modules, and the 1091-S uses the MF20 MOS memory. A previous model of the 1091, the 1091-P, used core memory. The 1090 and 1090 SMP can have from 256K words (1 megabyte) of memory up to 4,096K words (16 megabytes), in 64K-, 128K-, and 256K-word increments. The 1091-S can have from 256K words up to 3,072K words (12 megabytes) in 256K-word increments.

Input/output devices are controlled via a number of specific systems in the DECsystem-10 family. In all systems disk and tape subsystems are connected to the KL10 via the RH20 Massbus. The RH20 is the integrated controller and the Massbus is the channel. Up to eight RH20s can be configured in single-processor systems and up to 16 RH20s can be attached to a 1090 SMP. Each RH20 can accommodate up to eight disk drives, depending on the unit selected, or up to eight tape drives (TU45, TU72, and TU77 systems) per RH20. One RH20 must be reserved for disk, and the remaining seven RH20s can be designated for either tape or disk storage. DEC ▷

▷ instruction produces a double-word product, and the divide instruction uses a double-word dividend. There are also integer multiply and divide instructions which involve only single words. All arithmetic operations are performed in binary mode.

FLOATING POINT OPERANDS: The DECsystem-10 is currently based on the KL10 processor, which includes single- and double-precision floating point hardware. Single-precision floating point uses one word, consisting of a 27-bit-plus-sign fraction and 8-bit exponent.

The KL10 processors perform double-precision operations with additional hardware instructions. Double-precision fractions with 62 bits are handled in two words, with the high-order word containing one bit for the sign, 8 bits for the exponent, and 27 bits for the most significant portion of the fraction. An extension to this gives 9 bits for the exponent, 26 bits for the fraction, and provides an extended range. The low-order word contains a sign bit and 35 bits for the least significant portion of the fraction.

INTERNAL CODE: Seven-bit ASCII. Each 36-bit word is used to represent five 7-bit bytes, with one unused bit per word. Bytes from one to 36 bits in length can also be recognized and manipulated.

MAIN STORAGE

STORAGE TYPE: Magnetic core (used in the Model 1090), and Metal Oxide Semiconductor (MOS, used in the Model 1091 and the DECSYSTEM-2020).

CAPACITY: See table.

CYCLE TIME: See table.

CHECKING: Core: Parity bit with each 36-bit word is generated with writing and checked with reading. MOS: Single-bit error correction and double-bit error detection is provided.

STORAGE PROTECTION: A paging system maps up to 256K 36-bit words of memory, organized in 512-word pages. The individual pages need not be located in contiguous memory locations, thus eliminating the need to shuffle program segments in memory. Memory protection among user programs is implemented in both hardware and microcode. The paging hardware effectively permits addressing of 4 million words of memory based on 22-bit addresses. Three bits are used to denote the type of access possible for each page, such as read/write, read-only, proprietary, or denial of access.

CENTRAL PROCESSORS

Two basic central processor units are used on TOPS-10-based systems: the KL10 (KL10-D in the 1090 and KL10-E in the 1091) and the KS10 (used in the DECSYSTEM-2020 which can operate under TOPS-10).

REGISTERS: Both the KL10 and KS10 processors have eight sets of 16 fast general-purpose registers which can be used as accumulators, index registers, or as the first 16 locations in main memory. Register addressing is included in the basic instruction set, and no special access instructions are required. The register blocks can be assigned to the operating system and to individual user programs to provide for rapid context switching. Program switching between register blocks is estimated to require 500 nanoseconds for the KL10. For example, one or more register blocks also could be assigned for the exclusive use of a time-critical realtime program. ▷

Digital Equipment DECSYSTEM-10

CHARACTERISTICS OF THE DECSYSTEM-10 COMPUTERS

	1091S	1090P	1090 SMP
SYSTEM CHARACTERISTICS			
Date of introduction	June 1979	November 1976	July 1979
Date of first delivery	July 1979	March 1977	December 1979
CPU type	KL10-E	KL10-D	KL10-D
No of CPU's	1	1	2
Basic system purchase price	\$440,700	\$581,600	\$981,600
Basic system monthly maintenance	\$2,128	\$2,368	\$3,300
Relative performance level, approximate	1.0	1.2	1.7
Average no. of users per system	30-120	30-120	50-175
MAIN STORAGE			
Type	MOS	Core	Core
Read cycle time, nanoseconds	735	735	735
Effective cycle time, nanoseconds	334	334	334
Minimum capacity, words	256K	256K	256K
Maximum capacity, words	3,072K	4,096K	4,096K
Increment size, words	256K	64K, 128K, 256K	64K, 128K, 256K
No. of memory ports/module	8	8	8
Interleaving	2-way or 4-way	2-way or 4-way	2-way or 4-way
Error correction	Yes	Yes	Yes
CACHE MEMORY			
Type	Bipolar	Bipolar	Bipolar
Cycle time, nanoseconds	160	160	160
Capacity, words	2K	2K	2 x 2K
PROCESSOR			
Cycle time, nanoseconds	360	360	360
Dynamic address translation method	Page table	Page table	Page table
No. of page entries	512	512	512
Accumulators	8 sets of 16	8 sets of 16	8 sets of 16
No. of instructions	398	398	398
I/O CONTROL			
No. of hard-copy controls, max.	3	3	6
No. of Massbus controllers, max.	8	8	16
I/O bus data rate, words per second	370K	370K	370K
Memory bus data rate, words per second	4,000K	4,000K	4,000K
COMMUNICATIONS CONTROL			
No. of comm. processors, max.	3	3	4
No. of asynchronous lines, max.*	512	384	512
No. of synchronous lines, max.*	36	36	36

*Maximums are not possible if there is a mix of synchronous/asynchronous lines.

➤ recommends that minimum systems be configured with at least one RH20 each for disk and tape systems. A maximum of 24 billion bytes of on-line disk storage can be configured on the models 1090 and 1091, while the 1090 SMP can handle up to 49 billion bytes of storage.

Unit record devices can be connected via an I/O Multiplexer Bus or the PDP-11 Unibus depending on the processor and the system configuration. Each DECSYSTEM-10 can support up to three line printers (six in the 1090 SMP) and two card readers.

DECSYSTEM-10 users can select from several high-speed drum or charaband printers, with speeds up to 1200 lines per minute possible. Card readers are available in 300- or 1200-cpm models. Tape drives are available in 75- or 125-ips systems, with recording densities of 800, 1600, and 6250 ➤

JUNE 1981

➤ **INDIRECT ADDRESSING:** Possible on all processors. Indirect addressing may occur at multiple levels, with indexing at each level.

INSTRUCTION REPERTOIRE: The KL10 processor used in the 1090 and 1091 systems has a Business Instruction Set that includes four arithmetic instructions to add, subtract, multiply, and divide double-precision fixed-point operands. A STRING instruction also performs a variety of functions including editing, decimal/binary translations, and moving and comparing strings composed of ASCII or EBCDIC characters. The 398-instruction repertoire of the KL10 processor is microprogrammed and includes 64 data transfer instructions which operate on half-words; 20 instructions to shift the location of one or more full words; 5 byte manipulation instructions; 26 fixed-point arithmetic instructions, 35 floating-point instructions, 8 for double-precision floating-point arithmetic, and 3 for conversion between fixed-point and floating-point formats. In addition, the processor provides 64 "programmable operators" that are used as monitor or user calls. ➤

Digital Equipment DECsystem-10

▷ bpi possible. There are two basic disk drives available, and recommended, by DEC. Users have a choice of the 220-megabyte (unformatted) RP06 or the newer RTP20, with 1,200 megabytes (unformatted) per unit. A large variety of DEC terminals is available to support a user's needs.

The DECsystem-10 family supports a wide variety of synchronous and asynchronous communications devices. The 1091 can accommodate up to 128 asynchronous lines via the DC20 Communications Multiplexer, which is connected to the system's PDP-11 front end. Both the 1090 systems and the 1091 can use the 128K-word (MOS) DN20 Communications Front End processor. The DN20 handles various asynchronous/synchronous configurations. Up to 128 asynchronous and 12 synchronous lines are possible, although not at the same time. As many as three DN20s can be connected to single-processor systems, and up to four can be attached to the 1090 SMP. Remote job entry (RJE) devices can be connected to the DN20 via the DN200 Remote Station. Communications with the 1090 and 1090 SMP can also be supported by the older DN87 front-end processor. The DN87 is no longer sold, however, DEC continues to support the existing units.

SOFTWARE AND SUPPORT

All members of the DECsystem-10 family operate under control of the TOPS-10 operating system, of which the latest release is Version 7.01. A multi-purpose operating system, TOPS-10 permits concurrent execution of interactive time-sharing, local and remote batch, realtime, remote, sensor-based, and transaction-oriented processing. Time-sharing on the DECsystem-10 is classified as "general-purpose," that is, time-sharing users have access to all system facilities, such as the command language, I/O facilities, and data files, under operating system control. Any input character or character string can be either data or commands to the TOPS-10 operating system. TOPS-10 is designed to service up to 512 time-sharing terminals, and time-sharing users have access to the COBOL, FORTRAN, BASIC, APL, ALGOL, CPL (an interactive PL/1 subset), BLISS-36, and AID (a version of JOSS) languages plus a wide variety of interactive debugging and program preparation aids.

A separate module of TOPS-10 version 7.01 is provided (unbundled) in dual-processor 1090 SMP systems. The SMP (symmetric multiprocessing) option permits sharing of memory and I/O devices between the two CPUs and offers greater system availability and performance.

Virtual memory capabilities are provided with the VMSE feature. Jobs are divided into 512-word pages, which are moved in or out of memory/secondary storage as needed. The virtual memory technique permits programs to execute in a greater address space than actually permitted in real memory.

DEC's GALAXY-10 Batch System is designed to greatly enhance DECsystem-10 production throughput, and can be used in interactive as well as production batch ▷

▶ **INSTRUCTION TIMES:** See table below. All times are in microseconds and are for the basic mode using direct addressing without indexing, and assuming no effects from multiprogramming, such as paging. The dual-processor systems permit execution of two instructions simultaneously.

	1090/1091-S 1090 SMP
Fixed-point add/subtract	0.52
Fixed-point multiply	2.4
Floating-point add/subtract (single-precision)	1.8
Floating-point add/subtract (double-precision)	2.2
Floating-point multiply (double-precision)	4.8
Floating-point divide (double-precision)	10.2
Increment and move byte	1.4
Move from memory	0.48
Unconditional jump	0.36

CACHE: The KL10 processor includes a fast-access MOS cache memory with a 160-nanosecond access time. The cache, which is 2,048 words in size, actually consists of four caches, each with a capacity of 512 words (or one page) that operate in parallel. Each cache is a two-dimensional array consisting of 128 horizontal lines and 4 vertical columns containing one word of data each. Data is loaded into the cache from main memory four words at a time, thereby providing an instruction look-ahead feature. The effective memory access time is 334 nanoseconds.

Physical memory addresses, in contrast to logical user addresses, are maintained by the cache to facilitate context switching and the use of re-entrant code. A "written" bit is activated each time a user program has written a location in the cache, but the entry is not "written through" to main memory until it becomes necessary to provide cache space for newly-accessed data. When an entire user program is swapped out by the Monitor, a "cache sweep" feature writes all altered pages in the cache associated with that program back to main memory before the program is swapped out of main memory.

PAGING: The KL10 processors provide a mapping capability from physical memory addresses of up to 4 million words (which require 22 bits for representation) to shorter effective address contained in 18 bits. The most significant half of the 18-bit effective address is used as an index to a page table which contains up to 8,192 physical page numbers. The referenced physical page number is linked with the low-order 9 bits of the effective address (which indicates one of the 512 words on a page) to produce a 22-bit main memory address that can reference any of the 4 million words (maximum memory size of the 1090 and 1090 SMP). The KL10 processor maintains a 512-word hardware version of the entire page table to perform address translation. In the KL10, the high-order bits of the virtual address are used to perform a table look-up to locate the 13-bit most significant portion of the resulting 22-bit physical address.

PROCESSOR MODES: The KL10 processor has two modes: User Mode and Executive Mode.

The Executive Mode is divided into the Supervisor Submode and the Kernel Submode. Kernel Submode is used for the most frequently performed segments of the DECsystem-10 Monitor, which handle system I/O and any functions which affect all users of the system. The rest of the DECsystem-10 Monitor executes in the Supervisor Submode and performs general management of the system and functions which affect only one user at a time. All instructions are permitted for use in the Executive Mode.

User Mode on the KL10 permits the execution of all instructions except those which would cause interference with other users or the integrity of the DECsystem-10 Monitor. ▶

Digital Equipment DECsystem-10

- processing environments. At least 30 batch jobs can be run concurrently with timesharing and realtime activities.

DBMS-10 is the DEC data base management system that contains all the features of DEC's earlier CODASYL-compatible DBMS packages plus enhanced capabilities. The new features include a simultaneous-update facility, which permits multiple jobs to update one file simultaneously, and a new data base format designed to improve system performance.

As a complement to the DBMS package, the Interactive Query Language (IQL-10) processes DBMS files through user-initiated queries. IQL is a retrieval and report-writing system that includes condition processing, computational expressions, built-in summary statements, and formatting capabilities for the generation of multiple reports.

Communications can be handled by either the DECNET or ANF-10 (Advanced Network Features) program products. DECNET supports communications with other DECNET operating systems which use the DECNET Architecture (DNA). ANF-10 has features that afford greater network availability and flexibility, such as multipathing (more than one link between two points), dynamic reconfiguration (automatic redefinition of network topology and operation if a node fails), and route through (sending messages via alternate nodes).

DECsystem-10 computers are marketed in "system packages," which include a basic complement of main memory, peripheral controllers, and a System Software Package that consists of the TOPS-10 Operating System, the GALAXY batch system, loader, assembler, editor, and utilities. Compilers such as FORTRAN-10, COBOL-74, BASIC-10, and ALGOL-10 are separately priced. The system package also includes system installation, software documentation, software support, and customer training.

Many potential customers in DEC's targeted market segments are conditioned to acquiring their computers through rental agreements. Although most DECsystem-10 computer systems are acquired by outright purchase, DEC does arrange both full-payout lease and monthly rental agreements with customers who elect to acquire their equipment through these arrangements.

One key reason why the DECsystem-10 models are less expensive than functionally comparable IBM systems is that DEC competes only in system environments which favor the DECsystem-10's particular strengths. Those strengths are largely derived from the excellent applicability of the DECsystem-10 operating system to a "multi-mode" environment, including on-line processing plus local batch plus remote batch plus computer network requirements. Interactive time-sharing has been the area in which the DECsystem-10 has clearly been most successful, and DEC has a significant share of the market for computers in independent time-sharing utilities.

- User Mode is subdivided into the Public Submode and the Concealed Submode. Concealed Submode protects any program in that category from being copied or modified, even by the program itself, and is normally used for proprietary software. Concealed Submode programs can read, write, execute, and transfer to any Public location, while Public programs can access addresses in Concealed programs only by transferring to locations which have ENTRY instructions. In User Mode, a program can access up to 256K words.

INTERRUPT STRUCTURE: The KL10 has seven standard prioritized channels associated with the I/O bus that transfers interrupt signals between system devices and the CPU. Assignment of the channels to specific devices is under user program control, and can be altered during processing. The processor itself is treated as a device and internal overflow or priority checks can cause signals to be sent to the user program. In addition to the initial seven-level interrupts available, the KL10 uses up to 135 Programmed Trap Instructions. The trap instructions can be executed in the same address space as the instructions which caused the trap. This allows user programs to handle their own interrupts by directing the monitor to place a jump to a user routine in the trap location. Up to 40 programmed traps may be specified which execute in the executive area. These trap routines are loaded into the system at monitor generation time. Interrupts on the KL10 are decoded with one instruction.

MAIN MEMORY: DECsystem-10 external memory is multiported; the MH10 subsystem has eight ports. DECsystem-10 internal memory, as used on the Model 1091, is single-ported. Each port provides direct access to any combination of four processors and/or high-speed data channels. Each memory module supports either two-way or four-way interleaving. The memory bus for the KL10 processors permits full 36-bit word parallel transfers at a rate of 1 million words (5 million 7-bit characters) per second. Thus, a memory module can transfer up to 3 million words (15 million 7-bit characters) per second on high-speed I/O channels concurrently with computation, for a total memory bandwidth of 4 million words (20 million 7-bit characters) per second. The MH10 subsystem has a 735-nanosecond read access time.

SIMULTANEOUS OPERATIONS: Each controller is capable of transferring data to or from only one of the devices attached to it at a time. Disk or tape drives have several paths to memory, such as the RH20 Massbus and the UNIBUS, allowing direct transfer of data to memory while control information is passed through the bus. The I/O bus, memory bus, and processor can each operate concurrently with asynchronous computing. Up to four-way memory interleaving is possible, which causes consecutive addresses to be stored in alternate physical memory banks. Aggregate maximum data transfer rates for the I/O bus and memory bus are 1.2 million and 20 million 7-bit characters per second, respectively. Instruction look-ahead is provided on KL10 processors, where the next sequential instruction is decoded during execution of any given instruction.

INPUT/OUTPUT CONTROL

All DECsystem-10 systems incorporate up to eight integral RH20 Massbus controllers for managing the data flow from disk and tape devices to memory. One RH20 is standard in the 1090 and two are standard in the 1091 systems. The RH20 operates synchronously or asynchronously and transfers data between devices and their respective controllers. Massbus controllers can each control up to eight devices and can buffer up to 16 data words.

Controllers for slow-speed devices in the Models 1090 and 1090 SMP can be attached via the BA10 interface to the Multiplexed I/O Bus, which provides a full 36-bit-word

Digital Equipment DECsystem-10

➤ DEC's fundamental approach to the marketplace for the DECsystem-10 is to avoid head-on encounters with IBM except upon DEC's terms. These terms specify a sophisticated user (generally in the top 20 to 30 percent of the current computer installations) and one who generally meets the criteria outlined earlier. (For example, general-purpose commercial batch-oriented installations are definitely not sought after, if not actually discouraged.) Furthermore, DEC has historically been conservative in accepting business that is predicated upon heavy systems responsibility. This approach has resulted in a very high level of customer loyalty and has contributed to continued growth for DEC's large-scale systems business.

USER REACTION

This year, DEC ranked second in overall satisfaction in Datapro's 1981 Survey of Computer Users, and the DECsystem-10 continues to be well received in the user community. We received 15 responses representing a total of 19 systems. Only one organization, a service bureau, reported more than one system installed. This particular firm had four DEC-10s in use. Purchased systems outnumbered leased ones by four to one.

Among the 15 respondents were ten universities, three service bureaus, and two government users. This distribution is typical of DEC's marketing philosophy for its large systems.

The following table contains the ratings supplied by DECsystem-10 users.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	11	4	0	0	3.73
Reliability of mainframe	7	8	0	0	3.47
Reliability of peripherals	3	8	3	1	2.87
Responsiveness of maintenance service	6	6	2	0	3.29
Effectiveness of maintenance service	2	10	1	1	2.93
Technical support:					
Trouble-shooting	1	8	3	1	2.69
Education	1	8	1	1	2.82
Documentation	1	8	4	2	2.53
Operating systems	7	7	0	0	3.50
Compilers and assemblers	5	7	3	0	3.13
Applications programs	1	4	3	2	2.40
Ease of programming	12	2	1	0	3.73
Ease of conversion	8	4	1	0	3.54
Overall satisfaction	8	6	1	0	3.47

*Weighted average based on 4.0 for Excellent.

Of the users responding, the most recently installed system was in April, 1980 and the oldest was installed in February, 1972. The average installed life was just under 60 months. Memory sizes ranged from 64K to 2,048K words and averaged 512K words. Disk storage sizes ranged from about 200 to well over 1,200 megabytes. Each user had local terminals at their site, and only two did not have any remote workstations in their operation. All users except one said their DEC-10s were the central processing

➤ parallel path between the processor and the devices. Data can be transferred in words or blocks of up to 256K words by a single instruction at a maximum rate of 370,000 words per second. Slow-speed devices can be connected to the PDP-11 front end in the 1091, as well as the BA10. DEC indicates the PDP-11 method provides better performance with slow-speed devices, particularly printers.

CONFIGURATION RULES

Memory for the 1090 systems is incremented in 64K-, 128K-, or 256K-word increments up to 4,096K words (16 megabytes). In the 1091 memory is incremented in 256K-word modules, up to 3,072K words (12 megabytes).

An RP06 disk drive is bundled in the basic system package for all models. It is connected to the RH20 included on the 1090, and on one of the two RH20s standard on the 1091.

Up to eight Massbus controllers can be connected to 1090 and 1091 systems. The first Massbus is designated for disk units only, the second is recommended for tapes, and the last six can be designated for either. Up to eight RP06 disk drives can be connected to a Massbus. A tape transport and a line printer must be included within a basic system configuration.

When using the new high-capacity RP20 disk drives: 1) one RTP20 controller with up to four RP20 disk units per RH20 channel can be connected via a DX20 Massbus Adapter, 2) the RTP20 controller cannot share the RH20 channel with any other device, 3) as many as six RTP20 controllers can be connected to a KL10 CPU, 4) the remaining two RH20 channels on a KL10 must be used for an RP06 disk drive and any tape drive, and 5) the RP20 drive cannot be used as a front-end device, hence the need for at least one RP06 drive.

The TU72 and TU77 tape systems can be connected to the Massbus. Each TU77 tape controller can have a maximum of four TU77-AF/AJ tape drives. These systems may be varied in configuration but must not exceed eight tape drives per RH20 channel. On a second channel up to eight TU72 tape drives can be connected to a TX02 tape controller.

Up to three line printers and two card readers can be connected in single-processor systems. Up to six printers can be connected to the 1090 SMP.

The I/O console and up to 128 asynchronous communications lines (via the DC20 subsystem) can be connected to the PDP-11 front end processor in the 1091. The console only is connected to the PDP-11 in the 1090 systems.

Up to 512 asynchronous lines can be connected to a 1091 system via the PDP-11 (DC20 subsystem; 128 lines maximum) and up to three DN20 Communications Front Ends (128 lines on each DN20). Up to 384 lines can be connected to a single-processor 1090 via either the DN87 or DN20 Front Ends. Each controller can handle up to 128 asynchronous lines. An additional DN87 or DN20 can be configured in the 1090 SMP for a maximum of 512 lines.

Up to 12 synchronous communications lines (2.4K to 56.0K bits per second) can be configured, in various combinations, within a DN20 or DN87 Front End. Both synchronous and asynchronous lines can be mixed within either a DN20 or DN87.

DEC recommends installation of the newer, high-performance DN20 Front Ends for use with the DECsystem-10s, and continues to support the older DN87 on a replacement basis.

On all DECsystem-10 processors, hardware internally is EIA with support for EIA lines and terminals only. All 20mA

Digital Equipment DECsystem-10

▷ systems. The TOPS-10 operating system was reported in use by all respondents, and the COBOL and FORTRAN languages were fairly evenly divided among users, some of which were using both. Development of applications in-house was reported by each user, and half of them reported purchasing their applications from a software house. Nine users were operating with some type of data base management system, and only six reported using any communications package.

Datapro telephoned several DECsystem-10 users around the country for their comments. We first contacted a northeastern university with a large DECsystem-10 installation. They have found the DEC equipment quite flexible and easy to use. The DP director told Datapro that although his system is very hungry for power and air-conditioning, it is "very reliable," and has "lots of redundancy built in." He is quite "at ease" with TOPS-10, and his only complaint was that DEC sometimes "gets out of sync" with the school's processing requirements, and has been slow to respond to their needs on occasion. Their applications were mostly developed in-house, and they even did their own maintenance for a while, eventually returning to DEC.

Moving to the west coast, we interviewed a service bureau that replaced an RCA SPECTRA system with their present DECsystem-10, and can now run up to 80 jobs concurrently. The DP manager praised the system's versatility, flexibility, and price, but panned the DEC applications software. He was also generally pleased with DEC's maintenance efforts.

Our last call was a university on the west coast that had not only a DECsystem-1090 but also a DECSYSTEM Model 2020 used in a hospital associated with the school. The 1090 is new—there were no previous systems. It is primarily an interactive system with only an occasional batch job. The DP manager was happy with the system's reliability, TOPS-10 operating system ("very good"), time-sharing facilities ("very good"), and peripherals. He was dissatisfied with DEC's service, saying that DEC is not strong on preventive maintenance. According to him, "DEC's position is 'Let's wait until we have a solid failure.'" He also believed that "DEC should pay more attention to TOPS-10," even though he was pleased with it. Overall, he was quite pleased with his DECsystem-1090, saying it typically operated at 99 to 99.5 percent uptime. □

▶ current loop terminals must be converted to EIA for use with the DECsystem-10. For asynchronous speeds up to 2400 bps, cabling must not exceed 1000 feet; for asynchronous speeds up to 9600 bps, cabling must not exceed 250 feet.

MASS STORAGE

RP06 DISK PACK DRIVE: Provides large-capacity random access storage. The RP06 disk drive has a storage capacity of 39.6 million 36-bit words (or 176 million 8-bit characters). A maximum of seven channel subsystems, each with up to eight disk drives, can be connected to a

DECsystem-10 for a total of 56 disk drives and 2,250 million words. The RP06 drive uses an industry-standard IBM 3336-11-type disk pack that contains 12 disks and uses 19 recording surfaces. Data is organized into 128 words per sector, 20 sectors per track, 19 tracks per cylinder, and 815 cylinders per pack.

RP20 DISK DRIVE: Announced in August, 1980, this drive is similar to the IBM 3370 direct access storage system and has a capacity of 1,270 megabytes of unformatted storage. Each RP20 unit contains two data modules with 469 megabytes of formatted storage each. A module has 15 recording surfaces with two read/write heads per surface and 1,119 cylinders. Data is organized into 25 128-word blocks per track, with a track density of 957 tracks per inch. Access time ranges from 8 to 45 milliseconds, and averages 25 milliseconds. The transfer rate is 1.2 megabytes per second. The systems have dual-port and dual-channel features. The RP20 is part of the RTP20 disk subsystem. The RTP20 subsystem includes one RP20 drive and a controller which connects to an RH20 Massbus via a DX20 Massbus Adapter. Up to three additional RP20 disk drives can be added to an RTP20. Over 30 billion bytes of online storage (unformatted) can be provided on a KL-10 CPU with a maximum configuration of 24 RP20 drives.

INPUT/OUTPUT UNITS

TU72 MAGNETIC TAPE DRIVE: The TU72-E drives are 9-track, 125 ips units with program-selectable recording densities of 6250 bpi group encoded or 1600 bpi in PE mode. Up to eight drives per TX02-E controller are possible. The TX02-E/TU7X can be configured on all DECsystem-10 models via the DX20 Data Channel.

TU77 MAGNETIC TAPE SUBSYSTEMS: The TU77 tape drive is a 9-track, 125-ips unit with program-selectable recording densities of 800 bpi NRZI or 1600 bpi PE. The TU77 controller can have up to four tape drives. The TU77-CB/CD controller is used in all DECsystem-10 models.

LP20A AND LP20B LINE PRINTERS: These are drum-type printers that feature a choice of either 64- or 96-character drums. Using the 64-character drum, the printer operates at 300 lpm, but when the 96-character drum is specified, the printing speed becomes 240 lpm. Both models are 132-position printers (10 characters per inch) that feature programmable vertical format units. Switches on the units permit line spacing of either six or eight lines per inch. Users have a choice of either EDP or scientific character fonts for both the 64- or 96-character models. Available for the 1091 only.

LP20C and LP20D LINE PRINTERS: Similar to the LP20A and LP20B printers above, these units feature a choice of either 64- or 96-character drums. Using the 64-character drum, the printer operates at 890 lpm, and with the 96-character drum, at 650 lpm. Both models are 132-position printers (10 characters per inch) with a 12-channel direct access vertical format unit containing its own memory loaded from the main memory via normal data lines. Available for the 1091 only.

LP20B LINE PRINTER: This unit is a "chain-type" printer, and provides the flexibility and interchangeability of the train printer. It is a 900/1200-lpm unit with either 64- or 96-character fonts. It has 132 print positions at 10 characters per inch. Users have a choice of four Charabands, and both the 64-character and the 96-character set can be included on the same Charaband. Other features of the LP20B include a 12-channel paper tape-controlled vertical format unit and operator-selectable line spacing (6 or 8 lines per inch.) Users may optionally specify special character fonts. Available for the 1091 only.

LP100B LINE PRINTER: The LP100B printer is a 1200-lpm unit that includes a controller and either a 64- or 96-character font. Users have a choice of four Charabands, and both the ▶

Digital Equipment DECsystem-10

► 64-character and the 96-character set can be included on the same Charaband. Available with the 1090 models only.

LP100D and LP100E LINE PRINTERS: These are both drum-type printers that feature a choice of either a 64- or 96-character drum. Each printer includes a controller. Using the 64-character drum, the printer operates at 300 lpm, but when the 96-character drum is specified, the printing speed becomes 240 lpm. Both models are 132-position printers and are available with the 1090 models only.

LP100F and LP100H LINE PRINTERS: These are drum-type units that feature a choice of 64- or 96-character drums. The models print at 890 lpm and 650 lpm using the 64- and 9-character drums, respectively. Both EDP and scientific fonts are available. Both models are available for the 1090 only.

CD20A CARD READER: A tabletop-mounted card reader which reads 80-column cards at 300 cards per minute. The CD20A is recommended for use in remote batch entry applications. The controller for the CD20A is built into the unit and interfaces the Unibus of the PDP-11 front-end processor in the 1091.

CD20C CARD READER: A free-standing unit, similar to the CD20, that reads 80-column cards at 1200 cpm.

CR10F CARD READER: A tabletop-mounted card reader that reads 80-column cards at 300 cards per minute. It uses a built-in controller and connects to the BA10 interface on 1090 systems.

CR10H CARD READER: A free-standing version of the CR10F that includes a controller and reads 80-column cards at 1200 cpm.

PC10/PC20 PAPER TAPE READER/PUNCH: Reads 8-channel paper tape at 300 cps, using a photo-electric reader, and punches tape at 50 cps by electromechanical means. The PC10 can be attached to 1090 systems and the PC20 can be attached to the 1091 via their external I/O bus interfaces.

TERMINALS

LA38 DECWRITER IV HARD-COPY TABLE-TOP TERMINAL: The LA38 is designed for entry-level applications with a maximum print speed of 30 characters per second. This model is an addition to the DECwriter IV series and features serial printing by 9-by-7 dot matrix, a 128-character buffer, and communication speeds of 110 or 300 bps. In the LA38, paper movement is by use of tractor feed. The unit prints 128 ASCII upper- and lower-case characters. The LA38 also has a 19-key pad for rapid entry of numerical data. Like other new terminals from DEC, the LA38 is microprocessor-based and incorporates a self-check feature as standard.

LA120 DECWRITER III: This terminal has a maximum print speed of 180 characters per second using a bidirectional print mechanism. It is designed for highly interactive time-sharing applications. The standard character set features 128 ASCII symbols, uses a 7-by-7 dot matrix bidirectional printing mechanism, and a tractor paperfeed. The LA120 uses 132 print positions, and will accept data at 15 standard rates between 50 and 9600 bps; a 1000-character buffer is standard, with 4000 characters optional. The LA120 is microprocessor-based and incorporates a self-check feature as standard. The LA120 uses a typewriter-style keyboard with optional 14-key numeric pad. The keyboard generates all 128 ASCII character codes. Control functions include Line Feed, Return, Break, Escape, Repeat, Caps Lock, Tab, Delete, Bell, Space, Backspace, Shift, and Control Shift. The keyboard also contains a cluster of 8 function keys and 5 status indicators.

LA180 DECPRINTER RECEIVE-ONLY TERMINAL: The LA180 is a serial impact printer that prints at the rate of

180 characters per second. It is a matrix unit that prints the full 128-character ASCII set using a 7 x 7 dot matrix. It also prints rows of 132 characters. Horizontal spacing is 10 characters per inch, and vertical spacing is 6 lines per inch. The LA180 will accept data at standard rates between 110 and 9600 bps. Operation can be full duplex, half duplex, or echoplex. The LA180 is manufactured by DEC.

VT100 VIDEO DISPLAY TERMINAL: This performance-oriented terminal contains a 12-inch screen with either an 80-characters by 24-lines or 132-characters by 14-lines display and a detachable keyboard with an 18-key numeric/function keypad. The VT100 features a 7 x 9 dot matrix character font displayed on a 10 x 10 space. Standard features include 44, 66, 80, or 132 characters per line, line-selectable, double-width and double-height characters, line drawing graphic characters, bidirectional scrolling, split screen, tabulation, and highlighting attributes including dual intensity, normal or reverse video on a character-by-character basis, blinking, and underline. The advanced video option adds selectable blinking, underline, and dual-intensity characters (in any combination) to the existing reverse video attribute. Data rates range from 50 to 19,200 bps. The asynchronous terminal is equipped with an EIA RS-232C (VT52 compatibility mode only) or 20mA current loop interface. All operating parameters are established via the keyboard in the Set-Up mode. The VT100 is manufactured by DEC.

VT105 GRAPHING TERMINAL: A waveform graphing terminal, the VT105 is based on the VT100 and includes all its capabilities. Additional features such as direct cursor addressing, two independent graph fields (512 points each), vertical and horizontal lines at any point, a graphic character set, shade to line or axis, and 240-point vertical resolution, permit simultaneous display of one or two graphs, histograms, or any other combination of text and graphics. The advanced video option is standard with the VT105. The terminal operates on full-duplex asynchronous lines and includes an output port for a video monitor or hard-copy device.

COMMUNICATIONS EQUIPMENT

Terminals can be connected to the DECsystem-1090 via either the DN20 or the older DN87 Communications Front-End systems. In the 1091 the user has a choice of either the DC20 Communications Subsystem, connected to the PDP-11 front end, or the DN20 front end. Synchronous lines, for connecting high-speed communications systems, can be accommodated by the DN20 or DN87 front end processors.

DC20 DATA COMMUNICATIONS SUBSYSTEM: The interfaces in this system support up to 128 asynchronous lines on the DECsystem-1091. The DC20-AA multiplexer is standard with both systems and terminates 8 lines. It can be expanded to 16 lines using a DC20-DA 8-line expansion unit. Through additional DC20-AA and DC20-DA units, plus up to three DC20-EC expansion cabinets, the maximum of 128 lines can be obtained.

DN20 DATA COMMUNICATIONS FRONT END: One basic processor, the DN-20CA, is available, with 32K words of core memory. Up to three DN20-CA units can be connected to the 1090 and 1091 systems, and up to four units can be attached in a 1090 SMP. The DN20-CA can support up to one DECnet line. A separate DN20-CA must be established when operating in a bisync (2780/3780) mode, and up to six bisync lines can be connected to this unit. ANF-10 software is the primary communications product used in the DN20. DECnet-10 software can also be used when communicating with RSX-11M-based systems. The DN20 can support up to 128 asynchronous lines and up to 12 synchronous lines, in various configurations.

DN87 DATA COMMUNICATIONS FRONT END: Based on the PDP-11 processor, this subsystem supports various

Digital Equipment DECsystem-10

► configurations of synchronous and asynchronous lines. The DN87 has been eclipsed by the DN20 but is still supported in the field by DEC. The two models available, the DN87 and DN87S, have 16K and 32K bytes of memory, respectively. Each can support up to 112 asynchronous and 12 synchronous lines in various configurations, and can support DECnet-10 and ANF-10 software. Up to three DN87 front ends can be connected to a DECsystem-1090, and a maximum of four in the 1090 SMP.

DN200 REMOTE STATION: Used for remote job entry (RJE) operations, this terminal is connected to either DN20 or DN87 front ends and is supported by the TOPS-10 software. The DN200 can connect up to 2 synchronous and 32 asynchronous lines, in various combination, and can support a card reader and line printer as well. Up to 12 DN200s can be configured per DN20 or DN87.

SOFTWARE

OPERATING SYSTEM: A single operating system and Command Control Language is provided for all DECsystem-10 models. TOPS-10 consists of a resident portion and a nonresident portion. The resident operating system, in turn, consists of the following components:

- **Service Request Handler:** Accepts requests for allocation of system resources such as main memory, processor time, and I/O device availability. Includes the cyclic Command Decoder, which is responsible for validity checking and interpreting user requests and passing them to the appropriate system program.
- **Shareable Resource Allocator:** Distributes system resources to individual users in accordance with messages from the service request handler. Includes two cyclic programs: the Scheduler and the Swapper. The Scheduler determines which user program is to be run during a given time-slice, using a round-robin queued monitor. The Scheduler is activated by the system clock 60 times per second, and user jobs are given time-slices of 1/2 second for execution. Jobs which do not issue I/O requests during their 1/2-second time-slice are considered to be compute-bound, and are placed in a different queue where they get 2-second time-slices at less frequent intervals. The Swapper transfers jobs between disk and main memory after determining which user programs must be present in core for a job to run and which programs must be removed from core in order to make room for the run.
- **I/O Service Routines:** These routines process user program requests for I/O devices, and consist of three non-cyclic routines. The Programmed Operator Handler traps user service requests to the operating system and is the only means by which the user can switch to Exec Mode for operating system service. Input/Output routines are initiated by the Programmed Operator Handler to manage data transfers between peripheral devices and user programs in core memory. The I/O System permits the use of symbolic device names and allows the user to have device independence. The File Handler permits users to define protected output files for permanent storage.

TOPS-10 allows five basic concurrent modes of operation: interactive time-sharing, realtime processing, batch, multiprogramming and remote communications. Up to 512 interactive terminals associated with 175 active jobs can be handled by the Monitor, with multiple remote batch stations multiplexed through the DN20 and DN87 Communications Systems.

The most recent release of TOPS-10, Version 7.01, has been enhanced to include improvements in reliability and availability. These improvements include an enhanced monitor dump process, improved error logging, diagnostics, memory configuration and improved network management

routines. TOPS-10 Version 7.01 supports the dual-processor 1090 SMP, and I/O requests are handled by a queued I/O protocol which assures prompt CPU attention. TOPS-10 Version 7.01 has a Dual Processor Extension (DPE) option for multiprocessor support on older KI10- and KL10-based systems.

The TOPS-10 monitor, as well as the command language for the monitor, is common to all modes of operation on all single- and dual-processor DECsystem-10 models. This hierarchy of capabilities within one operating system, as well as the flexible hardware boundaries between the models, permits relatively simple upward growth for DECsystem-10 users, without extensive retraining or reprogramming.

The non-resident portion of TOPS-10 is stored on disk and includes the language processors, debugging programs, and operating system support programs. Standard languages available for the DECsystem-10 include COBOL, FORTRAN IV, ALGOL-60, BASIC, APL, and the Macro Assembler. Each language processor consists of a "pure" or re-entrant portion and a user portion which contains parameters defining a specific user job. The language processors produce sharable, re-entrant user programs.

Time-sharing users have the same command languages available to them as do multiprogramming batch users, allowing time-sharing terminals to initiate batch jobs. Commands are available to let terminal users manipulate files and control their own programs from creation through execution. Individual peripherals can be dedicated to a user for exclusive use on a given job, or the user can create and access files on peripheral devices shared with others. File protection schemes allow sharing of files among multiple designated users, with differing degrees of access authorized to each. Mass storage devices such as the drum cannot be exclusively dedicated to an individual user.

In multiprogramming mode, users are scheduled on a modified round-robin basis by the queue manager program, using disk or drum to hold swapped-out segments. The swapping device is usually connected directly to main memory via a high-speed data channel. The re-entrant or shareable nature of many monitor segments, as well as the shareable code segments produced by the shareable DECsystem-10 compilers, results in additional core utilization by minimizing swapping.

► Multiprogramming batch mode allows operation of up to 30 jobs concurrently with time-sharing. The batch user places his program in an input stream which is loaded into the system through an input device: cards, tape, or disk.

The batch controller system accepts parameters specified by the user, such as start and deadline times, which then are used by the queue manager (QUASAR) to modify the basic round-robin scheduling algorithm inherent in the system. During concurrent operation with time-sharing, batch jobs may occupy any available area in main memory. No partitions are set up to separate main memory into areas exclusively reserved for time-sharing or batch processing.

Realtime applications are handled by the TOPS-10 monitor using the system facilities available for time-sharing and multiprogramming, as well as the additional feature of guaranteed residence, where user programs are locked into core, and are available when needed. The DECsystem-10 provides seven standard priority levels.

Realtime devices may be serviced in single mode or block mode. Single mode service runs the user's interrupt program each time the device interrupts. Block mode allows an entire block of data to be read from the realtime device before the interrupt program is executed.

Remote communications hardware and software capability on the DECsystem-10 permits simultaneous use of multiple ►

Digital Equipment DECsystem-10

► remote stations with other DECsystem-10 modes of operation. Synchronous full-duplex communication between small remote computer stations allows remote users to send or receive data typically at speeds up to 9600 bits/second. The remote batch terminals (such as the DN200) may have printers, card readers, etc., locally attached, and may also support additional remote terminals. Operating system commands allow the user to drive peripherals at the central station as well as at other remote locations. Remote stations may change their logical addresses to back up or copy file functions of a different remote station.

VIRTUAL MEMORY: The Virtual Memory Feature (VMSER) provides an optional virtual-memory mode of operation for DECsystem-10 installations with a KL10 processor and at least Release 7.01 of TOPS-10. The VMSER option supplies a system Page Fault Handler that works in conjunction with the central processor hardware and Swapper to effect a demand paging mode of operation for designated user programs. When a page fault is detected by the Swapper, control is transferred to the Page Fault Handler, which specifies the pages to be swapped out to make room for currently referenced data.

Any user program can be made to run in the virtual-memory mode without modification by specifying "virtual core" in the SET job control command that allocates memory to the program. The REACT administrative control program permits each installation to restrict the use of the virtual memory option to specified users, to set limits on the amount of physical and virtual storage allocated to user programs, and to establish installation standard paging rates for all virtual-memory programs. The VMSER option provides a limited fail-soft facility in the event of a partial memory failure by permitting jobs to be reloaded to execute in the virtual memory mode of operation.

The VMSER Virtual Memory Feature requires a minimum configuration consisting of a KL10 processor with 256K words of main memory, two disk drives, one swapping disk system, and a communications system.

GALAXY-10 BATCH PROCESSING: The GALAXY-10 Multistream Batch and Spooling System permits concurrent execution of multiple batch jobs with time-sharing jobs. It uses the same command language as that used in time-sharing, contains a centralized queue manager and job scheduler, and simplifies the execution of a batch job via a time-sharing terminal. GALAXY-10 requires a KL10 processor with a minimum 256K words of memory, TOPS-10 Version 7.01 or later, VMSER Version 7.01, one disk unit, and one tape unit.

ADVANCED NETWORK FEATURES (ANF-10): This facility provides an efficient method of queuing, routing, and journaling messages processed within a network of terminals and interactive programs. The network typically can include the DN87 and DN20 Communications Front Ends. Messages into the system are queued, routed to the desired location, and then processed by the appropriate program module. Dynamic reconfiguration of nodes within the network is provided, and the entire network is designed to be transparent to the user, whether local or remote.

DECnet-10 COMMUNICATIONS SOFTWARE: Known as the DECnet-10 Compatible Port (DCP), this program product permits the DECsystem-10, suitably configured, to communicate with PDP-11 systems running similar software. DEC advises that DECnet-10 Version 2.0, does not support communications among DECsystem-10s and other DEC computers employing the Phase II DECnet protocols (known as Digital Network Architecture, or DNA). DECnet-10 supports task-to-task communications with the RSX operating system and the DEC Data Communications Message Protocol (DDCMP). DCP is supported by the DN87 and DN20 front-ends, and the DN200 RJE station.

DATA BASE MANAGEMENT SYSTEM: DBMS-10 is a full-scale data base organization and management system that uses both COBOL and FORTRAN as host languages and provide a data management language (DML) based largely on the April 1971 CODASYL Data Base Task Group (DBTG) specifications. DBMS-10 supports hierarchical data structures in simple tree format or in more complex network structures and provides a high degree of data independence from physical devices as well as user applications programs. Owner and member relationships are defined by chained pointers. DBMS-10 permits access to data through the DIRECT, CALCULATION, or VIA set location modes, permitting clustering of records normally accessed in groups. In addition to the Schema, multiple subschemas can be associated with the Schema to minimize the program modifications required due to the addition of data and new relationships to the files. A temporary subschema area is used to permit program testing on data without jeopardizing the integrity of the data base.

The Data Base Control System module is composed of re-entrant routines that permit concurrent retrievals to the same data areas. Data areas can be subjected to an exclusive update provision that grants exclusive update rights of a data area to a given processing program. The protected update option permits concurrent retrievals from a data area but proscribes concurrent updating activities. Concurrent updates to the same data area can be performed by a multiple-update queuing mechanism. Privacy of data within the data base is provided by privacy locks of up to 30 characters in length which are associated with the schema, subschemas, and data areas. Data base support utilities include initialization, print schema update, and statistics logging routines. Recovery files are maintained for each file each time it is opened for protected update. The COBOL extension module, LIBOL, provides an interface to an on-line communications network. DBMS-10 and DBMS-20 are separately priced program products. DEC claims that current users of TOTAL, from Cincom Systems, or IDMS, from Cullinane Corp., can migrate to DBMS-10 with only minor changes.

A detailed analysis of DBMS-10 can be found in Report 70E-384-01.

IQL-10: The DEC Interactive Query Language is an information retrieval and report writing system that uses English-like requests to read a file or group of files and process data contained in those files. IQL-10 extracts, summarizes, reorganizes, and copies file information, and produces reports in specified formats. The language interfaces both the file management system of the operating system and DBMS-10. Data files can be sequential DBMS data bases, or index-sequential with fixed and/or variable record length. IQL-10 can perform sorting, conditional processing, computation, including multiply and divide; perform built-in functions, such as tallies, totals, and averages; generate multiple reports in nine or more formats; perform matrix reporting through manipulation of summaries or individual items; define, modify, and examine dictionaries for the pre-sorting of files, records, or items; and operate in either interactive or batch mode.

IQL-10 contains a DBMS interface. In interactive mode, IQL operating under control of a terminal front-end module can define dictionaries reflecting schema files for DBMS data bases.

COBOL-74: A complete implementation of the ANSI standard COBOL X3.23 (Level 4B) is available for TOPS-10. An ISAM package is also included in the compiler to allow access to data files which may employ a variety of file organizations. The COBOL Compiler may be used for line-by-line compilation or for batch compilation. A separately-priced SORT/MERGE package is available. ►

Digital Equipment DECSYSTEM-10

► **FORTRAN-10:** FORTRAN-10 contains both extensions to the ANS FORTRAN-IV standard and global and local optimization capabilities for improving execution times. It requires a minimum memory area of 35K words, Version 7.01 of TOPS-10, and executes in either batch or time-sharing mode. An interactive debugger, FORDDT, is provided.

ALGOL-10: An implementation of the ALGOL-60 language that consists of a one-pass, single-phase compiler with a full range of diagnostics, extended-precision floating-point representation, byte-string manipulation capability, "while" and "for" statements for iterative procedures, and independent program and procedure compilation. DECSYSTEM-10 ALGOL is limited by the following restrictions: labels are not allowed, all formal parameters must be specified, and ALGOL-60 identifiers are restricted to 63 symbols. Use of the compiler requires 14K-word re-entrant segment in memory and a non-sharable user segment consisting of 2K words plus an amount of core dependent upon the size of the user's ALGOL program. The ALGOL-60 object-time system provides a basic I/O system including teletype I/O default with 16 logical channels, storage management, on-line debug tools, and a library of attachable routines including FORTRAN interface, byte-string manipulation, bit-field manipulation, single- and double-precision mathematical functions, etc.

APL: A conversational programming language that is particularly well suited for operating on numeric and character array-structured data, the DEC APL system runs under the DECSYSTEM-10 time-sharing Monitor. Two versions are available: APL-BASIC version 2.0 and APL-SF Version 2.0. APL-BASIC is an entry-level implementation and APL-SF is an extended version. Both have double-precision arithmetic facilities plus a dynamically-variable user workspace. APL-SF includes the Divide-Quad, Execute, Quote, and Dyadic formats for performing matrix inversions, solving linear equations, and evaluating character strings. Also included are user-level file access to standard ASCII sequential files, internal format random access and sequential files, and immediate I/O to any peripheral through an OUTPUT command.

APL-BASIC requires a minimum of 30K words of storage space, and APL-SF requires a minimum of 50K words of storage and at least 45K words of user space.

BASIC-10: A fully re-entrant implementation of extended BASIC that can handle both sequential- and random-access files, and can have up to nine files open simultaneously.

RPG-II: DEC's implementation of the Report Program Generator is called Instructional RPG-II, and is designed for teaching students the RPG-II language. A one-pass multiphase compiler and run-time system is used. File structures supported include sequential, random, and indexed.

CPL-10: The Conversational Programming Language (CPL) is an interpreter that supports a subset of the PL/1 language. CPL-10 is designed for use by beginning programmers or the non-programmer, and provides the user with the ability to track his program as it is developed.

BLISS-36: A high-level language developed by DEC for building compilers, realtime processors, utilities, and operating systems. BLISS is intended to complement DEC's other languages, such as COBOL, FORTRAN, or BASIC. Programs written in BLISS can be compiled and executed either in batch or interactive mode under TOPS-10.

MACRO ASSEMBLER: This two-pass symbolic assembler is device-independent, allowing the user to select I/O devices for source program entry, program listing output, and object code storage. Powerful macro capabilities permit creation of user-defined language extensions for frequently used coding sequences. The pure, re-entrant code for the macro assembler

occupies 7K words of main storage, and each user's portion of the assembler requires a minimum of 1K words.

TOPS-10 SORT/MERGE: A disk sort utility which operates stand-alone or in configuration with COBOL-68/74 and FORTRAN IV. Sort/Merge reorders the records of ASCII files, sixbit files, EBCDIC files, and binary files produced by COBOL and FORTRAN in a sequence determined by the sorting parameters prepared by the user. Sort/Merge automatically controls the use and allocation of disk work space with user specified memory limits. The merging of files into a single sorted file can be invoked either stand alone or via the COBOL MERGE verb. Optional support of magnetic tape for input or output is provided by Sort/Merge.

LINED (LINE EDITor) is used to create files of numbered command statements at a terminal. LINED can then be used for editing the files prior to their submission for compilation to a DECSYSTEM-10 language processor. Lines may be inserted, replaced, or deleted.

TECO (Text Editor and CORrector) is used to edit individual ASCII characters in an input file. The file is read into a memory buffer from any device except a user terminal, where 30 TECO editing commands of two types may be applied to the data. The first type consists of elementary commands usually found in text editing systems. The second type consists of more sophisticated commands including those which perform character string searching, text block movement, testing and conditional branching, command sequence iterations, and programmed editing where text in the buffer is modified with data received from a user terminal or a command file.

PIP (Peripheral Interchange Program) transfers data files from one I/O device to another. Files from more than one source device may be stored on a single destination device, either as one combined file or as a series of individual files.

PRICING

CONTRACT TERMS: DEC offers a purchase agreement for immediate ownership of the DECSYSTEM-10, conditional sales agreement, and full-payout accrued-equity lease contracts. The conditional sales agreement is used primarily by non-profit institutions and state and local governments. This agreement carries a three- to seven-year term and is noncancelable with the title passing to the user, DEC retaining a security interest. The most common is a five-year accrued-equity contract that yields DEC a full payout in four years. An end-of-contract option permits the direct purchase of the system for the then-fair market value, which DEC estimates will be 10 percent of the original purchase price. The monthly charges for accrued-equity contracts for new DECSYSTEM-10 systems are negotiated on an individual basis in order to reflect prevailing interest rates. These full payout leases may extend from three to seven years and are noncancelable. Five years is typical. There are no extra-use charges for the equipment, although maintenance contracts may be negotiated for any amount of daily maintenance from 8 to 24 hours (see below). Liberal educational discounts are given to qualified institutions.

SOFTWARE: A system software package is included with each system. This package includes the TOPS-10 operating system with the GALAXY batch processor, the linking loader, editor, and other utilities; and the macro assembler. All other language processors and the SORT utility are licensed separately. License fees are listed in the Software Prices section of this report.

USER GROUP: The worldwide DEC Users' Society (DECUS) was founded in 1961 and currently has about 30,000 members in over 40 countries. This group is directly supported by DEC and schedules two international meetings annually in addition to publishing a bi-monthly newsletter. DECU-SCOPE. DECUS is composed of four chapters (listed ►

Digital Equipment DECsystem-10

below), special interest groups (such as the DECsystem 10/20 Group), local users groups, and national users groups. Symposia are held throughout the year in each of the DECUS chapters. The DECUS Program Library Catalog lists more than 2,600 programs written by DEC users, most of which are available at no charge, or in some cases for a nominal handling fee. DECUS Membership is limited to DEC users, although some meetings are open to general attendance. Inquiries should be directed to:

DECUS Australia
P.O. Box 384
Crows Nest
New South Wales 2067 Australia
61-2-439-2566

DECUS Canada
P.O. Box 11500
Ottawa, Ontario
K2H 8K8 Canada
613-592-5111 Ext. 2115

DECUS Europe
12 Avenue des Morgines
C.P. 510
1213 Petit-Lancy 1
Geneva, Switzerland
022-93-33-11

DECUS U.S.
One Iron Way
Marlboro, Massachusetts 01752
617-481-9511 Ext. 4100

SUPPORT: System software is installed by DEC, followed by 90 days of software warranty support. The warranty support includes telephone and on-site assistance, and software product updates that are released during the software warranty period.

Included with each system is a consulting services package that provides up to 50 days of applications consulting support to aid users in development of their application software. These 50 days must be used within one year of operating system installation.

Self-Maintenance Service for Software (post-warranty) is available on a yearly contractual basis. This program includes software Product and Documentation updates, which are sent automatically during the contract period. They include Software Dispatch, a monthly newsletter with information about new software developments and programming enhancements, and Software Performance Reports (SPRs), a more detailed publication on software problem diagnosis. The annual price for Self-Maintenance Service when using TOPS-10 is \$2,462.

In addition to the Software Notebook Set provided with the system, an additional set may be purchased, including a one-year update capability, for \$1,100. A one-year update service on the original Notebook can be purchased for \$559. An additional Software Dispatch subscription of \$440 annually. Additional consulting services are available on a per-call basis.

Ninety days of installation support (warranty) are provided at no charge following delivery of a system on an 8 hours per day, 5 days per week basis. More intensified coverage over a shorter period of time is also available (for example 24 hours per day, 7 days per week for 50 days). Thereafter, systems integration assistance and field support by DEC's Systems Engineering Group are available at several prices, depending upon the level of support provided.

The DECservice agreement for hardware provides on-call remedial maintenance between 8 a.m. and 5 p.m. and preventative maintenance between 8 a.m. and 8 p.m., both Monday through Friday. There is no additional charge for

remedial service begun during the contracted hours of coverage but which must extend beyond these coverage hours. There is a guaranteed four-hour response for service calls placed during the contract period and on-call maintenance on a best-effort basis at per call rates with no charge for materials outside the contract period. The following table gives premiums to be added to regular rates (Monday-Friday, 8 a.m.-8 p.m.) for service outside the standard contract period.

	<u>16 hours</u>	<u>24 hours</u>
Daily Mon. through Fri.	8%	16%
Saturday or Sunday	11.2%	13.6%

The Basic service agreement for hardware provides maintenance between 8 a.m. and 5 p.m. Monday through Friday and priority response (typically next day) during hours of coverage. Extended coverage rates for basic service agreements can be obtained by adding the premiums in the following table to standard Basic service rates.

	<u>12 hours</u>	<u>16 hours</u>	<u>24 hours</u>
Daily/no weekends	13%	26%	43%
Sat. & Sun.	10%	13%	17%

EDUCATION: Each DECsystem-10 user is entitled to 10 man-weeks of training. On-site training, including course materials, is provided for specialized customer requirements at individually arranged rates.

Currently available courses include DECsystem-10 User Course, Administration Course, Assembly Language Programming, Programming, Operating System, COBOL, and Operator Course.

UPGRADE POLICY: DEC offers a trade-in policy giving credits toward the purchase of more advanced DECsystem devices. Older PDP-10 equipment or slower DECsystem equipment may be upgraded to higher-performance devices. Traded-in equipment must be in generally good condition (i.e., DEC-maintained by Field Service) or is subject to a refurbishing charge. Allowances depend upon device type and vary widely from about 20 to 50 percent of the original purchase prices.

EQUIPMENT: The following systems are representative of basic DECsystem-10 configurations that are used and supported by the TOPS-10 operating system. All necessary controllers, processor features, and interfaces are included in the indicated prices.

DECsystem-1091: Includes a KL10-E CPU with 512K words (2 megabytes) of MOS memory, a cache memory, one LA120 DECwriter III console, two RH20 Massbus interfaces for disk or tape drives, 16 asynchronous communications lines, six RP06 disk units with 240 million words (960 megabytes) of storage, four TU45A tape drives with controller, one LP200 Charaband printer (1200 lpm), one CD20 card reader (300 cpm), TOPS-10 operating system, GALAXY batch system, installation with 90-day warranty, and 50 days of applications software consulting. The purchase price is \$819,000 and monthly maintenance is \$5,475.

DECsystem-1090: Includes a KL10-D CPU with 768K words (3 megabytes) of core memory, a cache memory, one LA120 DECwriter III console, two RH20 Massbus interfaces for disk or tape drives, 16 asynchronous communications lines connected via a DN20 Communications Front End, eight RP06 disk drives with 320 million words (1.3 billion bytes) of storage, four TU45A tape drives with controller, one LP100 Charaband printer (1200 lpm), one CR10 card reader (300 cpm), TOPS-10 operating system, GALAXY batch system, installation with 90 day warranty, and 50 days of applications software consulting. The purchase price is \$1,233,880 and monthly maintenance is \$7,766.■

Digital Equipment DECsystem-10

EQUIPMENT PRICES

		<u>Purchase Price</u>	<u>12-hr./5-day Maint. Service</u>
SYSTEM PACKAGES			
1090	1090 System Package; includes KL10-D CPU with cache memory, 256K-words of core memory, RP06 disk system, communications subsystem, LA36-C maintenance terminal and console terminal, and system software package including TOPS-10 operating system; requires one 800/1600- or 1600/6250-bpi magnetic tape subsystem and one line printer	\$639,800	\$2,540
1091	1091 System Package; includes KL10-E CPU with cache memory, 256K-words of MOS memory, RP06 disk system, communications subsystem with 16 asynchronous lines, I/O bus, LA36-C console, and system software package including TOPS-10 operating system; requires one 800/1600- or 1600/6250-bpi magnetic tape subsystem and one line printer	476,000	2,157
PROCESSOR OPTIONS			
1090-V	1090 Upgrade Package, upgrades KA10 or KI10 systems to KL10-based processor	502,095	1,304
1090-S	1090 SMP Upgrade Package, includes second KL10-D processor	440,000	1,056
DIB-20	Internal I/O bus interface for 1091 system	6,490	52
MAIN MEMORY			
MH10-H	Core Memory; 128K words, 1.2-microsecond, includes 8 memory ports	70,620	605
MH10-L	Core Memory; 256K words, 1.2-microsecond, includes 8 memory ports (includes MH10-HA and two MH10-Es)	117,700	878
MH10-E	Expansion Module for MH10-HA, 64K words; two required to upgrade MH10-HA memory unit to MH10-L memory unit	37,070	137
MF20-LA/LB	MOS Expansion controller (first backplane) with 256K-word memory module	50,400	588
MF20-LC/LD	MOS Expansion unit (second backplane) with 256K-word memory module	50,400	382
MF20-LH/LJ	MOS External expansion controller (first backplane) with 256K-word external memory module	50,400	588
MF20-LK/LL	MOS External expansion unit (second backplane) with 256K-word external memory module	50,400	382
MF20-E	MOS memory modules (two max. per backplane)	42,000	233
MASS STORAGE			
RH20	Massbus Controller for disk or tape	15,000	35
RP06-AA/AB	39.6-megaword Add-On Single-Access Disk Drive	34,000	260
RP06-BA/BB	39.6-megaword Add-On Disk Drive, dual-access version of RP06-A above; max. 7 per subsystem	39,140	287
RP06-C	Dual-access kit; converts one RP06-A single-access drive to RP06-B dual-access drive	5,150	27
RTP20-EA/EE	Disk Drive Subsystem includes controller and one RP20 1.2 gigabyte disk drive	140,000	649
RP20-AC/AD	1.2 gigabyte Add-on Single Access Disk Drive; max. 3 per RTP 20 subsystem	49,000	308
RTP20-EC/EN	Dual-channel option	60,000	151
MAGNETIC TAPE EQUIPMENT			
TU77-CB/CD	Magnetic Tape Subsystem with tape controller and TU77 Tape Drive	34,800	321
TU77-AF/AJ	Add-On Tape Drive for TAU77-EC/ED and TU77-CB/CD; 125 ips, 800/1600 bpi, NRZ1/PE; maximum of three	23,100	239
TX02-EC/ED	Magnetic Tape Controller and DX20 Channel for TU72 Series Tape Drives; requires RH20	96,800	619
TU72-EC/ED	Add-On Tape Drive for TX02-E; 125 ips, 1600/6250 bpi, PE/GCR	35,300	205
TX03-A	Two Channel Switch for TX-2-EE/EF	7,040	14
TX03-EE/FF	Two channel switch option and DX20 channel for TX02-E	54,600	257
TX03-FB	Two channel switch option for two TX02-E	12,800	27
TX05-EC/ED	Two control unit tape switch option and one TX02-E; requires one TX02-E	74,400	390
TX05-FB	Two control unit tape switch option; requires two TX02-E	25,700	27
PRINTERS			
LP20-AA/AB	Line Printer and Controller; 132 positions; 64-character, 300 lpm; 1091 only	17,700	333
LP20-BA/BB	Line Printer and Controller; 132 positions; 96-character, 230 lpm; 1091 only	18,700	333
LP20-CA/CB	Line Printer and Controller; 132 positions; 64-character; 900 lpm; 1091 only	36,500	338
LP20-DA/DB	Line Printer and Controller; 132 positions; 96-character; 650 lpm; 1091 only	37,900	338
LP100-BA/BB	Line Printer, 1200 lpm; includes controller, requires Charaband; 1090 only	63,100	525
LP07-Y	Charaband for LP100-B line printer	4,300	—
LP100-DA/DB	Line Printer, drum-type, 64-character, 300 lpm; 1090 only	25,800	449
LP100-EA/EB	Line Printer, drum-type, 96-character, 240 lpm; 1090 only	28,100	449
LP100-FA/FB	Line Printer, drum-type, 64-character, 890 lpm; 1090 only	44,300	360
LP100-HA/HB	Line Printer, drum-type, 96-character, 650 lpm; 1090 only	45,400	360
LP200-BA/BB	Line Printer and Controller; 132 positions; Charaband-type mechanism; includes software, long line interface, and diagnostics, does not include Charaband; 900/1200 lpm; 1091 only	54,600	525
LP07-Y	Charaband for LP200-B line printer; dual-sided; choice of 64- and 96-character EDP fonts, two 64-character EDP fonts, two 96-character EDP fonts, 64- and 96-character OCR-A fonts, two 96-character scientific fonts, 96-character EDP and scientific fonts, two 96-character Swedish/Finnish fonts, 64- and 96-character British fonts, two 64-character open Gothic fonts, or customer specified character fonts	4,300	—

Digital Equipment DECsystem-10

EQUIPMENT PRICES

		<u>Purchase Price</u>	<u>12-hr./5-day Maint. Service</u>
PUNCHED CARD EQUIPMENT			
CD20-AA/AB	Card Reader and Controller; tabletop mounting, 300 cpm; 1091 only	7,920	122
CD20-CA/CB	Card Reader and Controller; free-standing, 1200 cpm; 1091 only	27,960	209
CR10-HA/HB	Card Reader, console Model, 1200 cpm; 1090 only	31,440	225
CR10-FA/FB	Card Reader, table model, 300 cpm; 1090 only	12,480	147
PUNCHED TAPE EQUIPMENT			
PC20-BL/BM	Paper Tape Reader/Punch; includes cabinet and power supplies; requires external I/O bus interface DIB-20; 300 cpm Reader; 50 cps Punch; 1091 only	17,050	160
DIB-20	External I/O Bus Interface	6,490	52
PC10-CL/CM	Paper Tape Reader/Punch; includes cabinet and power supplies; 300 cpm Reader, 50 cps Punch; 1090 only	18,260	148
COMMUNICATIONS EQUIPMENT			
DC20-AA	Basic Asynchronous Multiplexer; 8 lines, can be expanded to 16 lines with one DC20-DA expander, max. 7 per system; for 1091 only	6,160	104
DC20-DA	Expansion group for use with DC20-AA above; 8 lines, max. 1 per DC20-AA	1,870	91
DC20-EC/ED	Communications Expansion Cabinet; required for over 64 communications lines, includes one DC20-AA basic 8-line group, max. 1 per system; for 1091 only	12,980	222
DC20-CD	Cables and Distribution Cabinet; for configuration between 32 and 128 lines	2,585	—
DN20-CC/CD	Data Communications Front End; requires DN20-BX synchronous line units and software; for 1090 and 1091	33,220	200
DN20-BA	Synchronous Line Controller; one allowed per DN20-C; includes DN20-BB; for 1090 and 1091	4,235	39
DN20-BB	Synchronous Line Unit; for expansion of DN20-BA; max. of 3 DN20-BB per DN20-BA	1,650	17
DN21-BA	Synchronous Line Controller and Interface for speeds between 19.2K and 56K bps; for 1090 and 1091	3,200	38
DN25-AA	Asynchronous Line Controller and interface for speeds from 2.4K to 9.6K bps; includes eight lines; for 1090 and 1091	5,335	53
DN25-BA	Asynchronous Line Unit, eight lines; for 1090 and 1091	2,035	39
DN200-AA	Remote job entry terminal; connects up to 2 synchronous and/or 32 asynchronous lines	22,800	131
Facilities for the DN87 Communications Front End			
DN81-EE/EF	Synchronous Expansion Cabinet; includes DN81-H controller	13,320	43
DN81-H	Synchronous Line Controller Expansion Line for speeds up to 10K bps	4,560	38
DN81-J	Synchronous Line Controller Expansion Line for speeds up to 40.8K bps	6,960	39
DN83-A	Null Modem for DN81-H controller; 2.0, 2.4, 4.8, 9.6, and 19.2K bps	648	4
DN81-EA/EB	Asynchronous Expansion Cabinet; includes DN81-EC asynchronous, 16-line expansion group; maximum 64 asynchronous lines; required for addition of asynchronous lines; maximum two cabinets per DN87	13,320	86
DN81-EC/ED	Asynchronous 16-Line Expansion Group; requires two DN81-FX 8-line terminators and DN81-EA cabinet	8,760	78
DN81-FA	8-Line Terminators with 20-mA current-loop local interface	1,200	25
DN81-FB	8-Line Terminators with EIA local interfaces	2,880	25
DN81-FC	8-Line Terminators with EIA modem control interfaces	2,880	42
DN81-FD	8-Line Terminators with integral auto-answer modems	7,200	117
DN81-FF	Controller for two Bell 801-type Automatic Calling Units	1,800	27
DN81-FG	Expander for two additional Bell 801-type Automatic Calling Units	1,104	16
TERMINALS			
DF01-A	Acoustic Telephone Coupler	345	16
LAXX-LG	EIA Interface with modem control	130	—
LA38-GA	DECwriter IV Hard Copy Table-Top Terminal; 30 cps; KSR; 132 positions, EIA interface, 14 position keypad	1,750	23
LA38-HA	With Universal power supply	1,850	23
LAX34-CL	20mA Current Loop Interface for LA38	120	4
LA120-DA	DECwriter III; 180 cps, numeric pad, EIA interface	2,800	42
LA12X-AL	20mA Current Loop Interface for LA120	140	—
LA180-EA/ED	DECprinter; 180 cps, serial, EIA interface	4,455	75
LA180-PA/PD	DECprinter for hardcopy use with VT61; parallel interface	3,795	69
VT100-AA/AB	CRT Terminal with detached keyboard, EIA keyboard, EIA interface supported in the VT52 compatible mode only	2,150	23
VT1XX-AA	20mA Current Loop Interface for VT100	140	5
VT105-MA/MB	Graphics CRT Terminal with detached keyboard, similar to VT100 and includes advanced video option		

Digital Equipment DECsystem-10

SOFTWARE PRICES

		<u>One-Time License Fee</u>	<u>Monthly Self-Maint. Fee</u>
QH502-XM	ALGOL-10 binaries and source code supplied	\$11,500	\$66
QH072-AM	APL; same as APL-SF, but without file I/O; binaries only supplied	11,500	79
QH071-AM	APL-SF; binaries only supplied	23,000	132
QH503-XM	BASIC-10; binaries and source supplied	6,900	79
QH099-XM	COBOL-74 plus QT011-AM; binaries and source supplied	15,000	115
QH060-AM	CPL-10 (ANS-76 PL/1 subset interpreter; binaries only supplied)	6,900	58
QH500-XM	FORTTRAN-10; binaries and source supplied	11,500	84
QH300-XM	Sort/Merge; binaries and source supplied	3,450	31
QH101-AM	DBMS-10; binaries only supplied	34,500	242
QH045-AM	IQL-10; extended with DBMS interface, both ISAM and sequential; binaries only supplied	19,600	106
QH074-AM	APL to APL-SF upgrade	17,300	—
QH615-XM	GALAXY-10 Batch System; binaries and source supplied	4,600	—
QH601-XM	VMSE Virtual Memory System	8,900	—
QH302-XM	TOPS-10 Support for 1090 SMP	11,600	216
QH682-XM	DECnet-10, Version 2.0	17,300	220
QH603-XM	IBM 2780/3780 emulator/terminator	8,600	132
QT115-AM	BLISS-36	13,800	—