Rev. 9/78

Digital Equipment DECsystem-10

MANAGEMENT SUMMARY

The DECsystem-10 represents the consolidation of Digital Equipment Corporation's large-scale computer systems efforts into a full-scale product line that features three high-performance processors, a number of high-speed peripherals, extensive data communications capabilities, and a mature and dependable operating system. The DECsystem-10 family was introduced by DEC at the Maynard, Massachusetts "minicomputer capital of the world" in September 1971. The family initially consisted of five models: the 1040, 1050, 1055, 1060, and 1070. A sixth member—the 1077—was announced in September 1972. Two newer models—the 1080 and 1090, with internal speeds estimated at twice those of the earlier processors—were announced on October 8, 1974.

On March 23, 1976, DEC topped off the product line with the dual-processor Model 1088, with estimated system performance ranging from 1.4 to 1.7 times that of the DECsystem-1080. The first 1088 system was delivered in May 1976.

DEC's PDP-10 central processor (called the KA10) is the heart of the smaller 1040, 1050, and dual-processor 1055 systems, which were actually introduced in 1967. An improved version of that processor (the KI10), which provides for faster execution speeds, better memory utilization, and a higher degree of overlap between processing functions, is used in the 1060, 1070, and dual-processor 1077 systems. Specific processor improvements added to the KI10 include instruction look-ahead, expanded register stack, improved adder, double-precision floating-point hardware, and paging registers.

The newer KL10 processor, used in the 1080 and 1088 systems, is an enhancement of the KI10 and achieves its ➢

The DECsystem-10 family of medium to large-scale computers has achieved significant penetration in the educational, laboratory, industrial, and time-sharing markets. The currently marketed models are the 1060 and dual-processor 1066, which incorporate refurbished KI10 processors, and the newer 1080 and dual-processor 1088, which are based on the KL10 processor. The systems include business data processing facilities and software that should make them attractive to the selective commercial market segment that DEC is now addressing.

CHARACTERISTICS

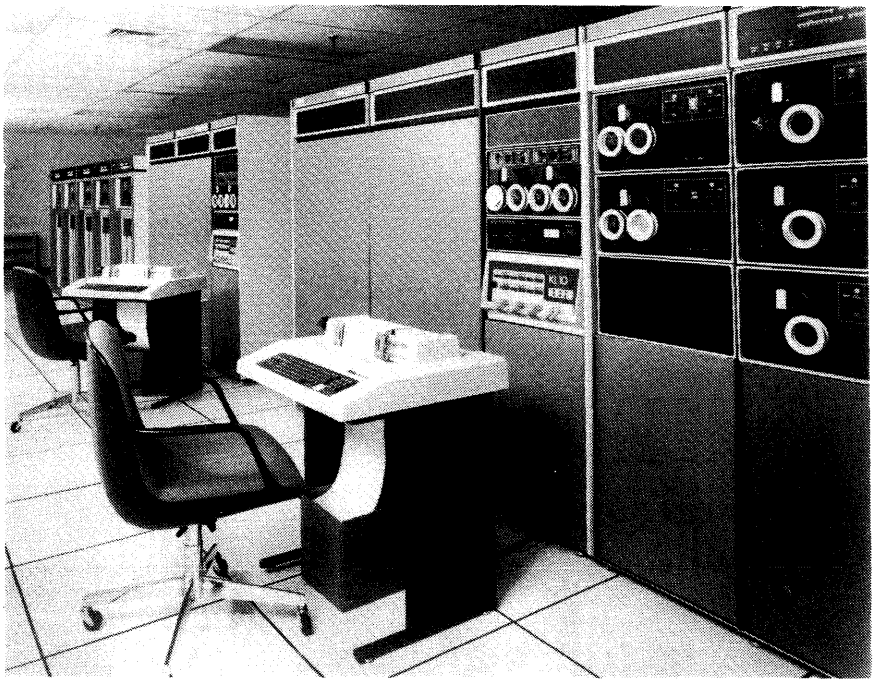
MANUFACTURER: Digital Equipment Corporation, 146 Main Street, Maynard, Massachusetts 01754. Telephone (617) 897-5111.

MODELS: DECsystem-10 Models 1040, 1050, 1055, 1060, 1066, 1070, 1077, 1080, 1088, and 1090. Only the Models 1060, 1066, 1080, and 1088 are currently marketed.

DATA FORMAT

BASIC UNIT: 36-bit word. In core storage, each word location includes one additional parity bit. The processor handles halfwords, but parity bits are not associated with halfword data representation. 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 instruction produces a double-word product, and the divide instruction uses a double-word dividend. There are also ➢



The Model 1088, newest and largest member of the DECsystem-10 family, includes two KL10 processors and can have up to 4 million 36-bit words of main memory. Announced in March 1976, the Model 1088 is completely software-compatible with the other DECsystem-10 models.

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greater speeds through the use of a cache memory, an expanded four-word-wide data path between core memory and the cache memory, and the use of emitter-coupled-logic (ECL) circuitry. A significant addition to the KL10 architecture is a set of business-oriented instructions that perform double-precision addition, subtraction, division, and multiplication on fixed-point operands, and a string manipulation instruction that performs decimal/binary conversions and editing functions.

Distinctions between models in the DECsystem-10 family are based largely on configuration rules and marketing strategy. The 1040 may have from 64K to 256K 36-bit words of core storage and uses an I/O Bus and a Memory Bus for attachment of up to 128 peripheral devices. The 1050 differs from the 1040 only in the addition of a swapping subsystem. The 1055, in turn, is a dual-processor version of the 1050. The 1060 replaces the KA10 processor used in the 1050 with the improved KI10 processor, while the 1070 includes the KI10 processor plus a swapping subsystem. The 1077 is a dual-processor version of the 1070.

The more recently announced 1080 system incorporates the faster KL10 processor, and, like the KI10 processor, can have from 128K to 4,096K 36-bit words of main memory. All of the DECsystem-10 models still utilize core memory (after all, DEC manufactures core memories), but the KL10 processor includes a cache memory that provides a buffer between the faster CPU and the 1-microsecond main memory. DEC claims that the expanded Memory Bus architecture and the cache provide an effective memory access time of 174 nanoseconds for the KL10 processor. The 1088, a dual-processor configuration using KL10 processors, is the most recent and most powerful addition to the DECsystem-10 product line.

To enhance its reliability and maintainability, the KL10 processor includes a PDP-11 minicomputer that serves both as a console and diagnostic computer. A separate diagnostic bus permits the PDP-11 to perform diagnostics on the central processor control logic and data paths either in local or remote mode.

All members of the DECsystem-10 family operate under control of the TOPS-10 operating system, which is the evolutionary result of DEC's large-scale operating system experience since it introduced the DECsystem-10's PDP Series forerunners in 1964. A multi-purpose operating system, the TOPS-10 permits concurrent execution of interactive time-sharing, local and remote batch, real-time, 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), and AID (a version of JOSS) languages plus a wide variety of interactive debugging and program preparation aids.

integer multiply and divide instructions which involve only single words. All arithmetic operations are performed in binary mode.

FLOATING-POINT OPERANDS: Standard floating-point hardware is included on the KA10, KI10, and KL10 processors. The KI10 and KL10 have both single- and double-precision floating-point, while the KA10 has only single-precision and a "long mode," which approximates double-precision through the use of software subroutines. Single-precision floating-point on either processor uses one word, consisting of a 27-bit-plus-sign fraction and 8-bit exponent. The KA10 "long mode" consists of two words with a 54-bit fraction, half of which is in bits 9-35 of each word, with the sign and 8-bit exponent in the high-order portion of the word containing the most significant portion of the fraction. Bit positions 0-7 in the other word are not used for floating-point number representation. KA10 floating-point operations are performed in a double-word register, only the most significant word of which is recognized for single-precision.

The KI10 and 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. The low-order word contains a sign bit and 35 bits for the least significant portion of the fraction.

INSTRUCTIONS: For all but I/O, each instruction consists of one word with a 9-bit operation code, a 4-bit accumulator or flag address, and 23 bits for development of the effective address. The effective address field uses one bit to specify the type of addressing, 4 bits as an index register designator, and 18 bits to reference a memory location. In I/O instructions, the first 3 bits identify the instruction as I/O, and the next 7 bits address an I/O device, with 2 more bits as an operation code. The next 23 bits are used to develop an effective address just as in the non-I/O instructions described above.

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 1 to 36 bits in length can also be recognized and manipulated.

MAIN STORAGE

STORAGE TYPE: Magnetic core.

CAPACITY: See table.

CYCLE TIME: See table.

CHECKING: Parity bit with each 36-bit word is generated with writing and checked with reading.

STORAGE PROTECTION: The KT10A Dual Memory Protection and Relocation Registers, required on the KA10 processor, allow 1040, 1050, and 1055 users to define up to two memory areas for each program. Typically, each program is divided into a re-entrant (sharable) portion and a non-re-entrant, user-specified portion. The extents and physical locations of the two program segments are specified, and protection is provided from other users. Memory may be allocated to user programs in multiples of 1024 words. As core memory becomes fragmented during multiprogramming operations, or as swapping occurs in time-sharing, memory segments consisting of less than 1024 words become unusable, requiring realignment of user programs to more appropriate memory boundaries to eliminate the effects of checkerboarding.

The KI10 and KL10 processors provide 1060, 1070, 1077, 1080, and 1088 system users with a more efficient and flexible storage protection scheme than is available for the smaller DECsystem-10 models. A paging system reserves up to 256K 36-bit words of memory in as many as 512 pages of 512 words each. The individual pages need not be

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CHARACTERISTICS OF THE CURRENTLY MARKETED DECSYSTEM-10 MODELS

	1060	1066	1080	1088
SYSTEM CONFIGURATION				
Type of CPU	KI10	KI10	KL10	KL10
Number of CPU's supported by standard software	1	2	1	2
Paging	Yes	Yes	Yes	Yes
Typical system purchase price	$826,000	$970,000	$969,500	$1,760,700
Date of announcement	Sept. 1972	3rd qtr. 1975	Sept. 1974	March 1976
Date of first delivery	Dec. 1972	3rd qtr. 1975	July 1975	May 1976
MAIN STORAGE				
Minimum capacity, 36-bit words	128K	128K	128K	256K
Maximum capacity, 36-bit words	4,096K	4,096K	4,096K	4,096K
Increment size, 36-bit words	32K/64K/128K/256K	32K	64K/128K/256K	64K/128K/256K
Memory cycle time, microseconds (new/old)	0.95/1.0	1.0	0.95/1.0	0.95/1.0
Words accessed per cycle	1	1	4	4
Storage interleaving	2 or 4-way	2 or 4-way	2 or 4-way	2 or 4-way
CENTRAL PROCESSOR				
Number of hardware instructions	378	378	386	386
Instruction look-ahead	Yes	Yes	Yes	Yes
Index registers	4 x 15	4 x 15	8 x 15	8 x 15
Register stack switching time, microseconds	2.5	2.5	0.5	0.5
Interrupt service time, microseconds	3	3	3	3
Maximum interrupt delay, microseconds	10	10	10	10
Double-precision floating-point hardware	Yes	Yes	Yes	Yes
I/O CONTROL				
High speed data channel cycle time, microseconds	0.25	0.25	0.25	0.25
I/O Bus cycle time, microseconds	2.70	2.70	2.70	2.70
Interrupts	7 levels plus up to 135 trap instructions	7 levels plus up to 135 trap instructions	7 levels plus up to 135 trap instructions	7 levels plus up to 135 trap instructions

Interactive time-sharing has been the area in which the DECsystem-10 has clearly been most successful; and DEC, with approximately 20 percent of the market for computers in independent time-sharing utilities already under its belt, says that it intends to become "Number One" in marketing to interactive-oriented users. With ambitious plans to produce one KL10 central processing unit (used in the DECsystem-1080 and 1088 and in the DECsystem-20) per day in its new Marlboro facility by the middle of 1977, DEC is looking to expand its marketing efforts into commercial general-purpose processing environments, as well as to enlarge its share of the scientific time-sharing and education markets. Hence the addition of business-oriented instructions to the Model 1080 and 1088 microprogrammed instruction sets, as well as the announcement of enhancements to the DECsystem-10's Data Base Management System (providing access to the data base from both COBOL and FORTRAN programs) and the release of the MCS-10 Message Control System, a general-purpose communications monitor designed to ease the development of communications software for on-line applications.

The DECsystem-10 family offers a range of computational capability that stretches across the current IBM product line from the 370/125 through the 370/158—at equipment prices estimated to be about one-half those of their IBM counterparts. The KL10 central processor utilized in the 1080 and 1088 systems is estimated to surpass the internal performance of an IBM System/370 Model 158 in scientific processing environments and to approximately equal the performance of a 370/158 in business-oriented processing.

CENTRAL PROCESSORS

REGISTERS: Each 1040, 1050, and 1055 processor has sixteen 36-bit general-purpose KM10 registers which can be used as multiple accumulators, index registers, or memory locations. Each of these integrated-circuit registers has a cycle time of 200 nanoseconds, and 15 of them can be used as fast-access memory to increase the execution speed of instructions or program loops (not to exceed 15 instructions) stored in them. The KM10 registers occupy the first 16 locations of main memory.

The KI10 processor used in the 1060, 1070, and 1077 systems has 64 general-purpose registers contained in 4 blocks of 16 registers each. Fifteen registers in each block can be used as high-speed memory. Because of the greater degree of overlap between the operation of the KI10 registers and main memory, the effective execution time for the high-speed registers ranges between 70 and 200 nanoseconds.

The KL10 processor used in the 1080 and 1088 systems has 128 integrated-circuit general-purpose registers, contained in 8 blocks of 16 registers each, that can be used as accumulators, index registers, or for other high-speed memory functions. In both the KI10 and KL10 processors, 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 2.5 microseconds for the KI10 and located in contiguous memory locations, thus eliminating the need to shuffle program segments in memory to counteract checkerboarding. The paging registers effectively permit addressing of 4 million words of memory through use of special hardware on the KI10 and KL10. 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.

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One key reason why the DECsystem-10 models are so much 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 Monitor to a "multi-mode" environment, including on-line processing plus local batch plus remote batch plus computer network requirements. In order for IBM, as an example, to satisfy these requirements, a full-scale OS or OS/VS system with the Time-Sharing option (TSO) and a host of other ancillary software support products is needed. Even where part of the DEC software is now separately priced, the difference in the cost of the required hardware (main and auxiliary storage plus high-performance processor) usually leads to a sizeable overall cost advantage for DEC.

The new GALAXY-10 Batch System, introduced with the dual-processor Model 1088 in March 1976, is designed to greatly enhance DECsystem-10 production throughput, and can be used in interactive as well as production batch processing environments.

DEC's initial entry into the large-scale computer business was made in 1964 with the 36-bit PDP-6, which was succeeded in 1967 by the PDP-10. Some 25 PDP-6 systems were delivered, followed by about 175 PDP-10 installations. Since the announcement of the DECsystem-10 family in September 1971, DEC has doubled its annual volume of business in large-scale computer systems, and has installed almost 500 DECsystem-10's. Revenues from the DECsystem-10 now contribute approximately 15 percent of DEC's sales revenues.

Ranking second only to IBM in terms of the number of computers of all types installed, DEC has a broad minicomputer customer base, with an overall total of more than 50,000 installed systems worldwide. Many of these installations are in scientific laboratories and industrial control applications, and it is from these ranks that the bulk of new customers for Digital's large-scale DECsystem-10 will come. Many of the early DECsystem-10 installations have been upgrades for PDP-10 users. In order to facilitate the upward migration of its customer base, DEC provides a liberal upgrade policy that allows substantial trade-in allowances for older systems and slower peripherals.

To support the ambitious marketing plans that DEC announced for its DECsystem-10 family at the recent unveiling of its newest member, new business will have to come from sources other than the existing DEC customer base. DEC, of course, is counting on cashing in on the expanding market for time-sharing systems, an application where the DECsystem-10 has already proved its worth. In addition, DEC is looking for substantial growth in commercial environments, particularly in applications in which the strengths of the DECsystem-10 can be put to good use in interactive program development and in communications networks (DECNET). To provide momentum for its marketing thrust, DEC has assembled a field organization of nearly 200 sales and software engineers and close to 300 field engineers dedicated to selling and servicing DECsystem-10 installations.

500 nanoseconds for the KL10. One register block also can be assigned for the exclusive use of a time-critical real-time program.

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

INSTRUCTION REPERTOIRE: The DECsystem 1040, 1050, and 1055 processors have 366 standard instructions, all of which are one word in length. The processor has 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, and comprehensive logical testing, and branching facilities. The more powerful 1060, 1070, and 1077 processors have 11 additional standard instructions: 8 for double precision floating-point arithmetic and 3 for conversion between fixed-point and floating-point formats.

In addition, the KL10 processor used in 1080 and 1088 systems has a Business Instruction Set that includes four new arithmetic instructions to add, subtract, multiply, and divide double-precision fixed-point operands. A new 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 386-instruction repertoire of the KL10 processor is microprogrammed.

INSTRUCTION TIMES: See table below. All times are in microseconds and are for the basic mode using direct addressing without indexing (i.e., with no effective address calculation) and assuming no effects from multiprogramming, such as program segment relocation, etc. Note that the dual-processor 1066 and 1088 systems permit execution of two instructions simultaneously.

	1040, 1050, & 1055	1060 & 1066	1080 & 1088
Fixed-point add/subtract (36 bits)	2.6	1.5	0.7
Fixed-point multiply	9.8	4.1	2.4
Floating-point add/subtract (single precision)	5.6	3.2	1.9
Floating-point multiply (single precision)	10.5	4.2	*
Floating-point add/subtract (double precision)	59.4	7.6	5.0
Floating-point multiply (double precision)	59.4	7.6	*
Jump	1.5	1.1	0.5

*Timing not available.

CACHE: The KL10 processor used in 1080 and 1088 systems includes a fast-access MOS cache memory with a 125-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. In addition, the cache accesses a list of physical page addresses calculated by the memory-mapping hardware that correspond to the four columns of program data. For each processor fetch operation, a simultaneous search is performed of all four cache pages to determine if the data is present in the cache. If not, the referenced data must be retrieved from main memory. Data is loaded into the cache from main memory four words at a time, thereby providing an instruction look-ahead feature.

DEC estimates that data being written to or read from main memory is typically found in the cache from 90 to 95 percent of the time, resulting in an effective access time of 174 nanoseconds for the KL10 processor. The cache uses a

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They won't, however, be calling on the typical batch-oriented computer user whose processing requirements are concentrated on conventional business applications. Instead, Digital's DECsystem-10 market target includes "the top manufacturing and service companies" where a DECsystem-10 can complement the processing capabilities of an already existing large computer installation.

In addition to the above criteria, DEC observes that a typical DECsystem-10 user will:

- Have already gained a respect for DEC's products and service through use of its minicomputers (scientific laboratory and industrial control environments are good examples); and/or
- Have experienced some degree of exposure to on-line environments, particularly through the use of a time-sharing service bureau using DECsystem-10 equipment; and/or
- Have an application requirement that falls into one of DEC's industry specialties, whether or not the user has dealt directly with DEC in this specialized area (e.g., typesetting applications); and/or
- Require the establishment of a network of high-level applications-oriented terminals that may come from a variety of vendors (e.g., large-scale R&D organizations employing instrumentation or lab monitoring equipment).

The 1080 and 1088 computers are expected to spearhead DEC's thrust into new markets. Along with their commercial instruction sets and software enhancements, they can be equipped with a selection of new disk and tape drives, a fast-access swapping disk, and a PDP-11-based universal synchronous/asynchronous communications controller. Although DEC has demonstrated a gradually increasing reliance upon internal peripheral development during recent years, it continues to market a number of peripherals which are purchased from other suppliers. The newly announced RHP06 Disk System, with a capacity of 176 million characters per spindle, and DEC's TU70 1600-bpi and TU72 6250-bpi Magnetic Tape Drives are purchased from Storage Technology Corporation. DEC has also announced the low-performance TU16 1600-bpi tape system and a 1200-lpm chain printer. The RHS04 high-speed fixed-head disk provides up to two million words of swapping storage for program swapping and virtual memory operations. The new peripherals are available for all processor models in the DECsystem-10 product line.

Communications capabilities of the DECsystem-10 have been enhanced by the addition of the DN87 Universal Synchronous/Asynchronous Front End. Each DN87 is capable of terminating up to 128 asynchronous terminals (including ASCII or IBM 2741-compatible terminals) or up to 12 synchronous links to the DN80 Remote Batch Stations. The synchronous links operate using DEC's DDCMP message-oriented communications protocol, which was designed especially for computer-to-computer communications. The PDP-11 based DN87 off-loads some functions from the host central processor, such as echoing and line speed synchronization. DEC also offers an

least-recently-used algorithm to identify the oldest cache entry, and that entry is removed to provide space for new data. 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 KI10 and 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 addresses 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 4096 physical page numbers. The referenced physical page number is concatenated 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 1080 or 1090). The KI10 processor uses an associative memory-mapping unit to perform address translation, while the KL10 maintains a 512-word hardware version of the entire page table. 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 KA10 processor used in the DEC-system 1040, 1050, and 1055 has two modes: User Mode and Executive Mode. The Monitor operates in the Executive Mode, in which addresses are not relocated and all memory locations are accessible. User programs execute in the User Mode, and are relocatable and subject to memory protection restrictions.

IN KI10 and KL10 processors, the Exec Mode is further 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 Exec Mode.

User Mode on the KI10 and KL10 permits the execution of all instructions except those which would cause interference with other users or the integrity of the DECsystem-10 Monitor. 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 KA10 has seven standard prioritized channels associated with the I/O bus that transfers interrupt signals between system devices and the I/O Bus. Twenty-one additional channels can be added for a maximum of 28. Assignment of the channels to specific devices is under user program control, and may 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. Any number of devices can be connected to a single channel, and some devices may use two channels to transfer interrupts identifying different conditions, such as device ready for data transmission or error condition encountered.

In addition to the seven-level interrupts available on the KA10, the KI10 and KL10 use up to 135 Programmed Trap

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extensive range of low-cost interactive video terminals and the LA36 DECwriter hard-copy terminal.

In addition, DEC provides a wide variety of "standard" interfaces to "nonstandard" products, in the sense that each of these devices has already been interfaced to the DECsystem-10 a number of times. Indeed, many of the products available from the DEC Advanced Systems Group, although not yet offered as part of the DEC standard product line with publicly available prices, provide an inkling of what's coming next in DECsystem-10 development. Here are two examples:

- The DAS78 Synchronous Communications System permits a DECsystem-10 (terminating or emulating an IBM 2780 remote batch station) to operate in a computer network with IBM System/360 and System/370 computers and IBM 2780-compatible devices.

- The DAS79 Synchronous Communications System provides a high-speed communications link between DECsystem-10 processors and large Control Data 6000 Series and Cyber Series computer systems using a modified version of the CDC Import/Export communications protocol. In network configurations including Control Data computer systems, programs developed on the DECsystem-10 can be submitted for execution in batch mode on the Control Data central processor, with conversion from DEC 7-bit ASCII code to CDC display code performed by the DAS79 software.

Aside from these applications utilizing specialized software, compatibility for the DECsystem-10 is limited primarily to its PDP-6 and PDP-10 forerunners. There is no current object-level compatibility between the DECsystem-10 and other popular computer systems, although DEC's COBOL, FORTRAN IV, ALGOL-60, and BASIC source-level language specifications all conform closely to industry standards. The DECsystem-10 is currently being utilized in customer installations for development of COBOL programs for execution on IBM System/370 computers. Incompatibilities between DEC's ASCII internal representation and the IBM EBCDIC are resolved by source program editing, although DEC plans future enhancements to improve compatibility between the two compilers. In addition, DEC has simulators for IBM 1401 and 360/20 systems, but has revealed no plans for utilizing the writable control storage facilities of its newest KL10 central processor for emulating competitive systems.

Early in 1976, concurrently with the introduction of the DECsystem-20 computer family, DEC modified the marketing policy for the current DECsystem-10 models in order to implement a standardized marketing policy for its large-scale computer product line. The DECsystem-10 computers are now 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 Virtual Memory Monitor Expansion, the GALAXY Batch System, loader, assembler, editor, utilities, and a Compiler Package which includes FORTRAN-10, ALGOL-10, BASIC-10, and COBOL-10. The "system package" price also includes installation of the system, software documentation, and a

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 KI10 and KL10 are decoded with one instruction.

INPUT/OUTPUT CONTROL

I/O CHANNELS: The DECsystem-10 uses DF10 and DF10C Data Channels to control the transfer of data between high-speed device controllers and memory ports via the memory bus, and a multiplexed I/O Bus to attach controllers for slower peripherals. DF10 Data Channels interface with the MX10 Memory Port Multiplexer and utilize 18-bit address logic with the capability to address 256K words of main memory. DF10C Data Channels utilize 22-bit address logic and interface with the MX10C Memory Port Multiplexer, with the capability to address up to 4 million words of main memory.

Up to 126 I/O devices can be connected to a DECsystem-10. Each DF10 Data Channel can interface up to eight controllers or special devices, but provides only one path through the memory bus directly to an assigned memory port, thus requiring other devices connected to the DF10 to wait until data transfer has been completed before being serviced. A DECsystem-10 can have up to 24 DF10's, each capable of handling its own I/O simultaneously with that of other DF10's. Any device connected to memory through a DF10 is also connected to the processor thru the I/O bus to allow for testing of device status.

Each memory module (with the exception of the MG10 Module) has four MC10 Memory Access ports to provide direct access to any combination of four processors and/or high-speed data channels. The 256K word MG10 Memory Module has up to eight ports and supports four-way interleaving. The capacity of each MC10 port can be increased by seven additional channels with an MX10 Memory Port Multiplexor. Thus, full expansion with the addition of an MX10 Multiplexor on each port gives 32 channels to each memory module for high-speed data access and/or processor connection. The memory bus for KA10, KI10, and KL10 processors, which gives access to memory both for high-speed DF10 Data Channels and the arithmetic processors, allows 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.

Controllers for slow-speed devices can be attached to the Multiplexed I/O Bus, which provides a full 36-bit-word 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 200,000 words per second.

SIMULTANEOUS OPERATIONS: Each controller is capable of transferring data to or from only one of the devices attached to it at a time. Swapping disk or drum devices have two paths to memory, allowing direct transfer of data to memory while control information is passed through the I/O bus. The I/O bus, memory bus, and processor can each operate independently with simultaneous computing. Up to four-way memory interleaving is possible, which causes consecutive addresses to be stored in alternate physical memory banks. Overlap of memory accesses is thus provided. 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 the KI10 and KL10 processors, where the next sequential instruction is decoded during execution of any given instruction.

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limited amount of software maintenance and customer training.

The currently marketed DECsystem-10 product line now includes the 1060, 1066, 1080, and 1088 models. The 1060 System Package includes a KI10 Central Processor, a Real-Time Clock, Data Channel for either a TU10, TU16, or TU70 Magnetic Tape System, DL10 Communications Interface, 128K words of core memory, and the System Software Package. The 1066 is a dual-processor configuration that includes a 1060 System Package with a Data Channel for either a TU10 or TU70 Magnetic Tape System, and an additional KI10 Central Processor.

The 1080 System Package includes a KL10 Central Processor, Real-Time Clock, Data Channel for either a TU10, TU16, or TU70 Magnetic Tape System, DL10 Communications Interface, 256K words of core main memory, one RHP04-H Disk System, and the System Software Package. The new top of the DECsystem-10 product line, the dual-processor 1088, includes two KL10A Central Processors, 256K words of core storage, DL10 Communication Interface, Data Channel for a TU70 Magnetic Tape System, two RHP04 Disk Drives, and the System Software Package.

Purchase prices for the basic System Packages range from $290,000 for the 1060 System Package to $1,025,000 for the 1088 System Package. Operating configurations that include a full complement of peripheral units in addition to the basic System Packages will be priced considerably higher. As an example, the minimum DECsystem-1088 configuration, including two KL10 Central Processors; 512K words of main memory; two RHP04 Disk Subsystems, each including two dual-port disk drives; two Data Channels, each with two TU70 Magnetic Tape Drives; two communications channels and two DN87 Communications Systems; two 1200-lpm printers; and two 1000-cpm card readers, has a purchase price of $1,760,680.

Some of the earlier systems in the DECsystem-10 product line are now marketed only on a limited basis by DEC. These include the 1040, 1050, and 1055 systems, which incorporate the older KA10 Central Processor. The KI10 Central Processor, which forms the nucleus of the 1060 and 1066 system, will be available only as refurbished equipment after June 1976, while the newer KL10 Central Processor is still in new production. In addition, DEC has discontinued the use of the 1070 and 1090 designation for processor models that incorporate fixed-head swapping storage. Although the RHS04 Swapping Systems are still available for time-critical applications, DEC states that the availability of high-performance disk drives plus the optimization of DEC software for operation with the newer moving-head drives make the use of fixed-head diks unnecessary for efficient virtual memory operation.

Many potential customers in DEC's targeted market segments are conditioned to acquiring their computers through rental agreements. Although the overwhelming majority of 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. Full-payout lease prices are estimated at

MASS STORAGE

RHS04 SWAPPING DISK SYSTEM: Provides up to 2 million words of high-speed swapping storage for DECsystem-10 time-sharing and real-time systems. Each disk has a capacity of 256,000 36-bit words, an average rotational delay of 8.5 milliseconds, and a transfer rate of 250,000 words (1.25 million 7-bit characters) per second. Each track consists of 64 sectors with 128 words per sector. The basic subsystem includes an RHS04 Controller, either a DF10 (18-bit) Data Channel or a DC10C (22-bit) Data Channel, and a single fixed-head disk drive. A maximum of eight drives can be attached to a single controller to provide the maximum of 2 million words of swapping storage per subsystem. One or two RHS04 subsystems can be connected to a DECsystem-10.

RP02C DISK SYSTEM: Provides up to eight on-line RP02 Disk Pack Drives, an RP10C Disk Control, and a DF10 Data Channel. Each RP02 Disk Drive uses an RP02P Disk Pack and can store 5.12 million 36-bit words (25.6 million 7-bit characters) with an average transfer rate of 66,667 36-bit words (333,333 7-bit characters) per second. The average access time of 47.5 milliseconds includes a 12.5-millisecond average rotational delay at 2400 rpm and a 35-millisecond head-positioning time. The industry-standard 11-high RP02P Pack is physically interchangeable with the IBM 2316 Pack, although not logically compatible with it. Timing notches cut into the base plate of the RP02P Pack facilitate presenting of addresses on the pack. Data is organized on 20 recording surfaces with 128 words/sector, 10 sectors/track, 20 tracks/cylinder, and 203 cylinders/pack. The disk packs are preformatted at initialization time so that all physical reads and writes are for 128-word data blocks.

The minimum RP02C Disk System consists of one RP02 Disk Drive and can be expanded in increments of one drive to the eight-drive maximum capacity of 40.96 million 36-bit words (240.8 million 7-bit characters). A maximum of 4 eight-drive RP02C single-channel systems can be connected to a DECsystem-10 to provide up to 163.84 million words of on-line storage.

RP03C DOUBLE-DENSITY DISK SYSTEM: Provides up to eight on-line RP03 Disk Pack Drives, an RP10C Control, and a DF10 Data Channel to give twice the storage capacity of the RP02C System described above at up to 32 percent lower cost. The RP03 Double-Density Disk Drives use the industry-standard RP02P Packs described above, preformatted with 400 cylinders, to store 10.24 million 36-bit words (51.2 million 7-bit characters) with an average transfer rate of 66,667 36-bit words (333,333 7-bit characters) per second. RP02P packs initialized for the RP03C system can be read only on the RP03C. Average access time is 41.5 milliseconds, which includes a 12.5-millisecond average rotational delay and a 35-millisecond head-positioning time.

The minimum RP03C Disk System consists of one RP03 Disk Pack Drive and can be expanded in one-drive increments to the maximum of eight drives on-line. The total storage capacity of the full RP03C is twice that of a full-size RP02C system: 81.92 million words (409.6 million 7-bit characters). RP02 Disk Drives can be substituted for RP03 Disk Drives or used in combination with them on the single-channel RP10C Controller to form an entry-level disk system for new users or a compatibility approach for current PDP-10 users with installed (purchased) RP02 drives. A maximum of four RP03C system can be connected to a DECsystem-10, providing up to 327.68 million words of on-line storage.

RHP04 DISK SYSTEM: Provides large-capacity random-access storage. Includes a controller and from one to eight RP04 Disk Drives, each with a storage capacity of 20 million 36-bit words. A maximum of four controllers, each with a maximum of eight disk drives, can be connected to a DECsystem-10 for a total of 640 million 36-bit words (or 3.2 billion 7-bit characters). Average seek time is 28 milliseconds, average rotational delay is 8.8 milliseconds, and data transfer rate is 178,571 million 36-bit words (or 892,855 7-bit characters) per second. Rotational speed is 3600 rpm.

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approximately 2.5 percent of the system purchase price per month, and five-year rental rates average approximately 3.2 percent of the system purchase price per month. Exact rental prices, however, are not available from DEC, and rental and lease agreements are negotiated individually with each customer.

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 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 steady if not rapid growth for DEC's large-scale systems business. In this regard, DEC's current business plan remains essentially unchanged from previous years, and the company's realistic approach seems likely to yield continued market acceptance of the DECsystem-10 at a pace satisfactory to DEC.

USER REACTION

The responses from 25 users of DEC PDP-10 and DECsystem-10 systems received in Datapro's 1975 survey of general-purpose computer users confirmed the successes achieved by Digital Equipment Corporation with its family of large-scale time-sharing computers. For the second consecutive year, the DECsystem-10 and its predecessor PDP-10 models topped all other computer systems represented in the survey by achieving the highest weighted average in the key category of Overall Satisfaction. The ratings supplied by these 25 DEC users were as follows:

	Excellent	Good	Fair	Poor	WA*
Ease of operation	15	9	0	0	3.6
Reliability of mainframe	10	14	0	0	3.4
Reliability of peripherals	5	14	5	0	3.0
Maintenance service:					
Responsiveness	11	9	2	0	3.4
Effectiveness	7	12	3	0	3.2
Technical support	3	9	8	1	2.7
Operating system	12	9	1	0	3.5
Compilers and assemblers	7	14	1	0	3.3
Applications programs	1	8	2	1	2.9
Ease of programming	14	10	0	0	3.6
Ease of conversion	10	10	1	0	3.4
Overall satisfaction	10	14	0	0	3.4

*Weighted Average based on 4.0 for Excellent.

The 25 responses from DEC users represented a total of 34 systems. The average main memory size for all 34 systems was 151K words, and the average number of months in use for all systems was 35.

Of the 25 respondents, 16 indicated that their systems were purchased, 4 specified that their systems were rented from DEC, and 5 stated that their systems were acquired through a third-party lease. The largest number of systems, 17 in all, were performing scientific and engineering data processing, while 11 were performing

The RHP04 Disk System uses an industry-standard IBM 3336-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 411 cylinders per pack. Error detection and correction circuitry permits detection and correction of bursts up to 11 bits in length under control of the operating system. Instruction retry is also supported. In addition to a rotational position-sensing capability, the RHP04 Controller also permits overlapped head positioning on two or more disk drives under control of the operating system software. Additional reliability features include an offset head capability to facilitate read recovery and the ability to dynamically eliminate track sectors with unrecoverable errors from use by the system.

INPUT/OUTPUT UNITS

TD10G DECTAPE SYSTEM: This inexpensive but slow magnetic tape system reads forward or reverse on up to four TU56 Dual DECtape Units. The single-channel TD10 Controller transfers data to the central processor over the I/O bus at a peak rate of 2,777 36-bit words (13,885 7-bit characters) per second at 97 ips. The TU56 reads and writes fixed-length blocks of 128 words each on pocket-sized, 3/4-inch wide, 260-foot-long reels of magnetic tape which are 3-3/4 inches in diameter, at a recording density of 172 six-bit characters per inch. The DECtape unit has a directory on tape which is indexed to a special track on the tape marked with physical tape position information. This special track is read to provide the user with the ability to position the DECtape directly at the beginning of a given 128-word block. DEC describes the tape as a "linear file" which can read or write single words within any block and is used either as a very slow direct-access device or as a substitute for punched-card equipment. Redundant recording of each bit on two separate tracks increases reliability of the TD10G DECtape System. The simplicity of the transport mechanism, which uses drive motors to control tape movement instead of capstant or pinch rollers, helps reduce maintenance requirements. One or two TD10G systems can be connected to a DECsystem-10.

TU10C MAGNETIC TAPE SYSTEM: Available in 9- and 7-track NRZI versions, which record on standard 1/2-inch tape in ANS standard formats. Up to eight TU10 Tape Units can be interfaced to the I/O bus via the single-channel TM10A. Control in any combination of 9- and 7-track units. The 7-track TU10A-F Unit records data at densities of 200, 556, or 800 bpi with peak transfer rates of 9,000, 25,020, or 36,000 characters per second at 45 ips. The 9-track TU10A-E reads and writes tape at 45 ips with a density of 800 bpi to transfer data at a peak rate of 36,000 characters per second. The TU10A-E/F drives, manufactured by DEC, replace the earlier plug-compatible TU20 Magnetic Tape Unit which was purchased OEM by DEC. The TU20 will continue to be supported on the DECsystem-10 for upward migration by PDP/10 customers with purchased TU20's. One TU10C system can be connected to a DECsystem-10. The TU10C is not available for KL10 processors.

RHP06 DISK SYSTEM: A double-density version of the RHP04 Disk System, each RHP06 Disk Drive has a storage capacity of 38 million 36-bit words (or 176 million characters). A maximum of four channel subsystems, each with up to eight disk drives, can be connected to a DECsystem-10, for a total of 32 disk drives and 1.2 billion words. Average seek time is 28 milliseconds, average rotational delay is 8.8 milliseconds, and data transfer rate is 178,571 36-bit words (or 892,855 7-bit characters) per second. A dual-port capability on each drive permits overlapped head positioning to occur on two or more drives. The RHP06 Disk Drive is fully compatible with the RHP04 controller, permitting RHP04 and RHP06 Disk Drives to be intermixed on the same control unit.

TU16 MAGNETIC TAPE SYSTEM: Originally introduced for the DEC PDP-11 computers in May 1975, the TU16 Magnetic Tape System uses industry-standard ½-inch, 9-track tape units with program-selectable recording densities of 800 or 1600 bits per inch. The recording

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business data processing, 6 were engaged in real-time processing, 8 in data communications, 4 in data base management, and 10 were performing applications in the "other" category; most of the latter systems were being used in educational institutions. The average number of batch terminals per system was 3, and the average number of interactive terminals was 35.

Fourteen of the systems represented in this survey replaced earlier computer equipment, including an RCA 70/45 (two), an IBM 1401/1620 combination, an IBM 1620, an IBM 1130, an IBM System/3, a DEC PDP-6, an IBM 360/44, an NCR Century 200 (two), and a Control Data 3300.

These DEC users were profuse in their praise of the DECsystem-10 as a time-sharing system. In their evaluation of the principal advantages of the system, respondents described the DECsystem-10 as an "excellent time-sharing system" and a "beautiful time-sharing machine." The operating system software was also singled out for praise. It was described by one respondent as "very powerful but easy to use" and by another as "friendly time-sharing software." Programmers in one DECsystem-10 installation were estimated to be three to five times as productive as they had been in the previous batch processing environment.

Some areas in which these users thought the DECsystem-10 could be improved included software technical support, a larger selection of peripherals (including the large-capacity disk drives that DEC has since introduced), and a larger library of program products. However, the average rating of 3.4 supplied by these users for the category of Overall Satisfaction—the highest achieved by any mainframe vendor in Datapro's 1975 user survey—underscores DEC's success with the DECsystem-10 computer systems. It would be difficult to refute the words of one highly satisfied customer who put it this way: "It's the best time-sharing computing system on the market."□

method for the 800-bpi version is NRZI, while phase encoding is used for the 1600-bpi version. The tape speed is 45 inches per second, and the maximum data transfer rate is 72,000 characters per second. A basic TU16 Magnetic Tape System consists of a control unit that includes the master tape control electronics, and one magnetic tape drive. Up to seven additional tape drives can be added to the controller.

TU40C/TU41C MAGNETIC TAPE SYSTEM: Includes a DF10 Data Channel, a TM10B Control, and one 9-track TU40 or 7-track TU41 Tape Unit. The TM10B Controller handles up to eight units consisting of any combination of 9- or 7-track TU40's, TU41's, TU10's or TU20 Magnetic Tape Units. Data is transferred between the single-channel control and a main memory port via the DF10 Data Channel. Control information and device status are transferred between the controller and main memory through the I/O bus. Both the TU40 and TU41 record on industry-standard 1/2-inch tape at 200, 556, or 800 bpi with a tape speed of 150 inches per second to produce peak transfer rates of 30,000, 83,400, or 120,000 characters per second. One or two 8-drive TU40C systems can be connected to a DECsystem-10.

TU70 MAGNETIC TAPE SYSTEM: These high-speed tape units are available in 7- and 9-track versions with program-selectable recording densities of 800 ot 1600 bits per inch for 9-track tape drives and 200, 556, or 800 bits per inch for 7-track transports. The recording method for the 1600-bpi tapes is Phase Encoding, while NRZI is utilized for the 800-bpi 9-track transports and for all 7-track tape transports. Tape speed is 200 inches per second, resulting in a maximum data transfer rate of 320,000 characters per second. A TU70 Magnetic Tape System consists of a channel controller and one 9-track tape drive. Up to seven 9-track or 7-track add-on tape drives can be added to a controller for a maximum subsystem of eight tape drives per controller. The TU70 Magnetic Tape Drives feature an automatic reel hub to facilitate tape loading, analog capstan control, vacuum tape buffers, power windows, and radial attachment to the controller.

PC10 PAPER TAPE READER/PUNCH: Reads paper tape at 300 characters per second using a photo-electric paper tape reader, and punches tape at 50 characters/second. The PC10 is included as a standard I/O device on all DECsystem-10 models.

CR10D AND CR10E HIGH-SPEED CARD READERS: The CR10E reads 80-column cards from a 2,250-card input hopper at 1200 cpm, while the CR10D reads from a 1000-card input hopper at a rate of 1000 cpm. In each machine a vacuum picker and riffle air-stream help feed worn or damaged cards to a jam-resistant mechanism. Each reader uses light-emitting diodes (LED) and photoelectric cells for high reliability. Both card readers have built-in controllers. Up to two CR10D's and two CR10E's can be connected to a DECsystem-10.

CR10F CARD READER AND CONTROL: Reads 80-column cards at a rate of 300 cpm from an input hopper with a 600-card capacity. Although the CR10F uses the same card input techniques and jam-resistant read mechanism employed in the high-speed CR10D and CR10E Card Readers, the slow speed and table-top size of this Documation-built unit make it most effective for remote batch entry applications. One or two CR10F units can be connected to a DECsystem-10.

CP10D CARD PUNCH: Punches cards at the rate of 100 80-column cards per minute. The CP10D includes its own controller. Input hopper and output stacker capacities are 1000 cards each. Only one CP10D can be connected to a DECsystem-10.

LSP10 LINE PRINTER: Prints at 300 lpm using a 64-character drum with 132 print positions per line and at 200 lpm using a full 96-character set. A single-channel controller that connects the LSP10 to the I/O bus is included. A paper-tape carriage control mechanism permits selectable forms control at optional densities of 6 or 8 lines per inch.

LP10F AND LP10H LINE PRINTERS: Print at 1250 lpm with a 64-character drum or at 925 lpm with a 96-character drum, respectively. These drum printers have 132 print positions per line and connect through the I/O bus to a processor via a built-in controller. The print feed mechanism is advanced by a paper tape control carriage, and can be set to print 6 or 8 lines per inch. Both models can be equipped with either a scientific or commercial character set.

XY10 PLOTTER CONTROL: Provides an interface for the CalComp 500 and 600 Series Digital Incremental Plotters. The single-channel XY10 can connect one plotter device directly to a DECsystem-10 memory port. Only one plotter system can be attached to a DECsystem-10.

XY10A INCREMENTAL PLOTTER AND CONTROL: Consists of a single-channel XY10 Controller and CalComp Model 565 drum-type plotter. Plots up to 300 0.01-inch steps per second on a chart up to 12 inches wide and 120 feet long.

XY10B INCREMENTAL PLOTTER AND CONTROL: Consists of a single-channel XY10 Controller and a CalComp Model 563 drum-type plotter. Plots up to 200 0.01-inch steps per second on a chart up to 31 inches wide and 120 feet long.

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COMMUNICATIONS EQUIPMENT

DC10 DATA LINE SCANNER: Provides on-line servicing of up to 64 communications lines with accommodation of any device that uses 8- or 5-level serial Teletype code at speeds to 2400 bits/second. Full-duplex with local copy or half-duplex mode is available on each line serviced. The DC10 System includes a DC10A Control Unit which houses the scanner and contains I/O interface and control logic, as well as providing 4 units of cabinet space and power supplies for various combinations of line equipment. Half-duplex or full-duplex interfacing to data sets is accomplished in 2 units of cabinet space by the DC10C 8-line Telegraph Relay Assembly and DC10D Power Supply. The minimum 8-line capability of the DC10 system can be expanded with the 1-unit DC10B 8-line group up to the 64-line maximum. Eight additional units of cabinet space are available with the DC10F Expander Cabinet if required.

DS10 SYNCHRONOUS LINE UNIT: Provides a single synchronous line that can handle data transmission rates up to 9,600 bits per second when equipped with a high-speed modem. The DS10 is used with the DC72 Remote Station to interface a remote batch terminal, a high-speed display, a remote job entry station, or another computer. Up to two DS10 units can be attached to a DECsystem-10 to handle an aggregate data rate of 9,600 bits per second.

DC72 REMOTE STATION: Uses full-duplex lines to provide both remote job entry capability and interactive terminal facilities for general time-sharing use. The basic DC72A, B, and C synchronous stations provide a PDP-8/E communications processor, 10-cps teletypewriter, 300-cpm card reader, and one of the following printers, respectively: 165-cps strip printer, 245-lpm (132-position) line printer with 64-character set, or 173-lpm (132-position) line printer with 96-character set. Eight additional 110-to-2400-bps synchronous ASCII transmit or 110-to-300-bps receive terminals can be attached to a DC72 station through a DC72L Teletype Concentration or terminal expansion package. Up to eight DC72 remote stations can be connected through full-duplex modems to DS10's or a DC75.

DC75 SYNCHRONOUS COMMUNICATIONS SYSTEM: Consists of up to four PDP-11 programmable controllers, a multiplexer, and eight communications lines. The full-duplex DC75 can interface 64 2400-bps lines or 16 9600-bps lines directly to the DECsystem-10 memory bus. The main function of the DC75 is to serve as a synchronous data communications multiplexer. Other functions include character formatting, line control, and error checking.

DC76 ASYNCHRONOUS COMMUNICATIONS SYSTEM: Consists of up to 4 PDP-11/40 processors for multiplexer control and up to 128 full-duplex asynchronous communications lines per multiplexer. A DC76 equipped with 4 multiplexers can thus handle a maximum of 512 full-duplex communications lines. The PDP-11/40 processor/multiplexers are interfaced directly to the DECsystem-10 memory through the DL10 PDP-10/PDP-11 interface. The total aggregate line speed for each multiplexer is 1500 characters per second. The maximum individual line speed is 9,600 bits per second, but the standard software support restricts incoming line speeds to 2,400 bits per second. The DC76 supports automatic recognition for lines with speeds of 110, 134.5, 150, and 300 bits per second. Other line speeds from 50 to 9,600 bits per second and a split-speed operation are program-selectable. The DC76 supports asynchronous terminals that operate in eight-level ASCII code or IBM 2741-compatible terminals that utilize seven-level EBCDIC, APL, or Correspondence character sets. The DC76 software supports the full-duplex and full-duplex with local copy transmission modes, but not two-way alternate simplex or polled operations.

DN87 UNIVERSAL SYNCHRONOUS/ASYNCHRONOUS COMMUNICATIONS FRONT-END PROCESSOR SYSTEM: This PDP-11-based front-end communications processor combines the synchronous communications handling capability of the earlier DC75 or DAS85 Communications Systems and the asynchronous communications capability of the DC76 Communications System into one communications processor capable of handling mixed-mode data transmission. The DN87 has a maximum capacity of 96 asynchronous and 12 synchronous lines, and a maximum aggregate data rate of 40,800 bits per second. The asynchronous throughput rate is 1,500 characters per second. Installed DC76 and DAS85 Communications Systems can be upgraded to the DN87 with the addition of required termination interfaces. The DN87 replaces the DC10, DS10, DC75, DC76, and DAS85, which are no longer offered on new DECsystem-10 systems.

LA36 DECWRITER II KEYBOARD TERMINAL: Provides electromechanical impact printing at a rate of 30 characters per second in a "60-character-per-second mode." Printable characters are stored in a buffer during carriage return and line feed, allowing subsequent bursts at 60 characters per second while multiple characters are stored in the buffer. Prints in rows of 132 print positions on forms ranging from 3 to 14-7/8 inches in width. Up to six-part forms can be handled. The LA36 keyboard generates a set of 128 ASCII characters, including 96 upper and lower case letters and numbers and 32 control characters. Characters are formed in a 7-by-7 dot matrix and are printed at a horizontal pitch of 10 characters per inch and a vertical spacing of 6 lines per inch. The keyboard layout conforms to the most recent ANS standard. The LA36 features quietized operations to enhance its suitability for office environments.

GT40 GRAPHIC DISPLAY SYSTEM: This multipurpose graphic display system incorporates a PDP-11 processor with 8K words of memory that allows it to operate as an interactive terminal or a stand-alone system. An additional 256-word read-only memory contains routines required for loading a program or initiating dialogue with a central computer in a communications network. The GT40 features a 12-inch (diagonal) display of 31 72-character lines, for a total of 2,432 characters per display. The 96-character ASCII character set includes both upper and lower case characters and 31 special symbols. Control characters include those for carriage return, line feedback, backspace, and bell. Each character is represented by a 6-by-8 dot matrix. Vector generation capabilities include both relative and arbitrary vectors in solid, long dash, short dash, and dot/dash vector types. The nominal point plotting speed is 20 microseconds per point; approximately 200 microseconds are required for a full-screen vector. A light pen, free-standing ASCII keyboard, and separate eight-key function pad are included in the system. Data transmission is asynchronous at rates of from 300 to 9600 bits per second. Standard PDP-11 peripherals also can be attached to the system.

VB10C GRAPHIC DISPLAY SYSTEM: Provides both alphanumeric and graphic display capabilities to represent information as straight lines, vectors, curved lines, characters, or single random-position points. The basic VB10C system features a Parameter Mode, allowing use of a standard light pen with display intensity and coordinate zoom (scaling) controls. Both I/O bus and memory bus interfacing is available to handle control information and data transmission on a full 36-bit-plus-parity data path. The ASCII 128-character set and graphic capabilities are supported by the I/O Handler available through DECUS, and by diagnostics provided by DEC. Each character is represented by a 5-by-7 dot matrix. A maximum character plotting rate of 1,500 characters per second or 6,000 inches of short or long vectors is made possible by the refresh buffer, which regenerates the display 30 times per second. Nominal point plotting speed is 20 microseconds per point, with less than 0.6 microsecond per point required in vector mode for incremental plotting of contiguous points. The 21-inch-diagonal-screen VB10C system is built by DEC and can optionally include a function box, keyboard or Rand Tablet input, color display, and larger screen sizes.

VT05 ALPHANUMERIC DISPLAY TERMINAL: This solid-state CRT terminal, built by DEC, provides a buffered 10-1/8" by 7-5/8" display of twenty 72-character lines, for

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a total of 1,440 characters per display. Displayable upper-case ASCII characters are generated in a 2,240-bit-read-only memory. Each character is represented with a 5-by-7 dot matrix. The 9,816-bit refresh buffer regenerates the display 60 times per second. The 64-character-set keyboard is supported by a nondestructive, blinking cursor and erase controls. The alphanumeric character set can be superimposed on a background video image derived from a closed-circuit TV or video player. The VT05 is Teletype-compatible and communicates in half- or full-duplex mode over standard telephone lines, using data sets, at rates up to 2,400 bps.

VT50 DECSCOPE INTERACTIVE VIDEO TERMINAL: A solid-state CRT terminal, built by DEC, that provides an 8.7" by 4.3" display of up to 12 lines of 80 characters each, for a total of 980 characters. The displayable characters, consisting of upper-case ASCII characters and punctuation symbols, are represented with a 5-by-7 dot matrix. The 64-character set keyboard uses a typewriter keyboard format and is supported by a nondestructive blinking cursor that serves as a position indicator. The cursor can be moved to the top left-hand corner, to the right or left by one character position, and up or down one line. The VT50 operates in either an off-line or on-line mode. The transmission code is teletypwriter-compatible ASCII in full-duplex or full-duplex with local copy mode. Transmission rates are switch-selectable and range from 75 to 9,600 bits per second in the full-duplex mode and from 110 to 9,600 bits per second in the full-duplex with local copy mode.

VT52 DECSCOPE VIDEO DISPLAY TERMINAL: Announced in August 1975, the VT52 is upward-compatible with the VT50 Interactive Video Terminal and incorporates a number of enhancements. The VT52 has an 8.3 by 4.1-inch display screen of up to 24 lines of 80 characters each, for a total of 1920 characters. The displayable characters consist of a 96-character upper and lower case, numeric, and punctuation ASCII subset. The terminal includes a 63-key typewriter keyboard plus an auxiliary 19-key keypad for entering numerals, controlling cursor movement, and invoking up to three user-defined functions. The cursor can be moved up or down one line, right or left by one character, to home position, or to fixed tab stops every eight spaces. The cursor can also be moved to any position on the screen under program control. Other functions include: erase the display from the cursor position to the end of the screen, scroll up, and scroll down. Transmission is in ASCII in either full-duplex or full-duplex with local copy mode. Transmission speeds are switch-selectable and can be 75, 110, 150, 300, 600, 1200, 2400, 4800, or 9600 bits per second.

SOFTWARE

OPERATING SYSTEM: A single operating system and Command Control Language is provided for all DECsystem-10 models. The DECsystem-10 Monitor 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.

- Sharable 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 queue monitor as well as the Core Allocator (to provide access to sharable system resources) and the Context Switcher (for saving and restoring program conditions when swapping). The Scheduler is activated by the system clock 60 times per second, and user jobs are given time-slices of ½ second for execution. Jobs which do not issue I/O requests during their ½-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 drum/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 disk I/O service routine includes optimization techniques for disk accesses, which according to DEC result in 25-50% faster disk throughput than would otherwise be possible under the same loading conditions where the controller is saturated with transfer requests. 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.

The resident Monitor requires from about 20K to 40K words of main memory, depending upon processor model.

Non-resident DECsystem-10 Monitor software is usually stored on drum or disk and includes the language processors, debugging programs, and operating system support programs. 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.

The DECsystem-10 Monitor allows four basic concurrent modes of operation: interactive time-sharing, real-time processing, batch, multiprogramming and remote communications. Up to 512 interactive terminals can be handled by the Monitor, with multiple remote batch stations multiplexed through the DC75 Synchronous Communication System.

The DECsystem-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.

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 his exclusive use on a given job, or he 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. Control information is passed through the I/O bus to initiate swapping or memory transfers. This device attachment scheme permits independent overlapped operation between the swapping of one program and the execution of another program in memory. The re-entrant or sharable nature of many monitor segments, as well as the sharable code segments

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produced by the sharable DECsystem-10 compilers, results in additional core utilization by minimizing swapping.

Multiprogramming performance of the KI10 and KL10 processors is improved over that of the KA10 processor through hardware features such as additional high-speed registers and fast interrupt handling, which speed up switching between programs.

Multiprogramming batch mode allows operation of up to 14 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. EBCDIC card input will automatically be handled by the stacker program and passed through a code conversion. Tapes, however, are currently required to be ASCII and must be converted through a DEC "Filter" program prior to input. The Stacker program collects batched input data in the job stream and accumulates it onto different individual files depending upon data type. Individual alternating inputs resulting from multiple data acquisition processes cannot be gathered by the system on a common input spool for subsequent processing by applications programs.

The batch controller system accepts parameters specified by the user, such as start and deadline times, which then are used by the queue manager to modify the basic round-robin scheduling algorithm inherent in the system. At monitor generation time, default conditions can be established providing standard parameters to be inserted unless otherwise specified by individual users. 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.

Real-time applications are handled by the DECsystem-10 Monitor using the system facilities available for time-sharing and multiprogramming, as well as the additional features of guaranteed residence, where user programs are locked into core, and the programmable interrupt system, which can link a real-time sensor or activator device to one or more assigned priority interrupt levels. The DECsystem-10 provides seven standard priority levels, with up to 135 additional levels available through the use of programmed traps on the KI10 and KL10.

Real-time 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 real-time device before the interrupt program is executed. In either mode, execution of the interrupt program causes the status of all DECsystem-10 operations to be preserved and restored upon completion of the interrupt processing.

Remote communciations hardware and software capability on the DECsystem-10 permits simultaneous use of multiple 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 at speeds up to 9600 bits/second. The remote batch terminals 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 the functions of a different remote station.

VIRTUAL MEMORY: The Release 6.04 Virtual Memory Feature (VMSER) provides an optional virtual-memory mode of operation for DECsystem-10 installations with a KI10 or KL10 processor and at least Release 5.07 of the Monitor. The VMSER option supplies a system Page Fault Handler that works in conjunction with the central processor hardware 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. As an alternative, a user-written Page Fault Handler can be embedded in a user program to provide optimized demand paging based upon its specific characteristics.

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 KI10 or KL10 Processor with 128K words of main memory, two RP02, RP03, or RHP04 Disk Drives, one Swapping Disk System, a DC10 or DC76 Communication System, and two magnetic tape drives. VMSER occupies 5K words of main memory, and the sharable system Page Fault Handler occupies 1K words.

The new GALAXY Batch System was designed specifically for operation with the VMSER Virtual Memory Feature. According to DEC estimates, GALAXY provides a 50 percent increase in throughput in both batch and real-time operation in comparison to the previous batch processing facility supported under TOPS-10. The software has been optimized for operation in a virtual memory environment, and, according to DEC measurements, achieves a 75 to 90 percent reduction in disk accessing in comparison to the previous TOPS-10 batch processing manager. The GALAXY Batch System, along with VMSER, is included in the basic system price of the new Model 1088 system. Current DECsystem-10 users can add the GALAXY system to the TOPS-10 monitor for a one-time charge of $3,500.

MESSAGE CONTROL SYSTEM (MCS-10): Announced in October 1974, the Message Control System provides the facilities for developing tailored communications-oriented programs using the DC75 Synchronous Communication System and the DC76 Asynchronous Communications System. MCS-10 consists of four major software components. The MCS Generation Program accepts user-supplied parameters that define the communications network and the terminals operating in the network, define the message types, establish queue structures, and define the message processing programs in the communications network. The output of the MCS Generation Program is an installation-tailored MCS Kernel module that operates with MCS Message Control Program as a user-specified communications control program. The Message Control Program contains the generalized logic that performs message handling and acts as a message queue mechanism for queuing and routing messages to user message processing programs. The COBOL Communications Facility is an extension to the COBOL compiler that provides the COBOL communications verbs SEND, RECEIVE, ENABLE, DISABLE, and ACCEPT COUNT, and a communications description section that can be accessed by message processing programs written in COBOL. In addition, each COBOL user message processing program includes a LIBOL Communications Module, which provides extensions to DECsystem-10 COBOL programs that enable them to execute the extended verb complement and provides an interface to the MCS communications control program.

Message processing functions performed by the MCS-10 software include initiation and termination of message processing programs, activation of identical copies of message processing programs in cases where additional messages require immediate processing, and logging of activities that occur between message processing programs and the MCS control program. The message handling functions include message routing; queuing (in first-in/first-out order or in four-level tree structures to permit priority access between message types); a roll-down/roll-up

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feature that automatically transfers messages to direct access storage queues when main memory queues are filled and restores them to main memory when space is available; and a fail-soft capability that permits optional copying of messages in main memory queues to direct-access storage as a basis for recovery in event of a system malfunction. Other activities performed by the MCS software include keeping audit trails, time-stamping of input messages, message buffering, and the enable-disable function which controls access by terminals in the network to input message queues. The MCP Control program and multiple message processing programs operate concurrently with DECsystem-10 time-sharing and batch processing operations.

DATA BASE MANAGEMENT SYSTEM: DBMS-10 is a full-scale data base organization and management system that uses both COBOL and FORTRAN as its host languages and provides a data management language (DML) based largely upon 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 application 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, DBMS-10 allows multiple subschemas to 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 Version II was announced in October 1974 and is a separately priced program product.

COBOL: A complete implementation of American National Standard COBOL X3.23 (Level 4) with compilation speeds, according to DEC, which vary from 2,000 to 6,000 statements per minute. DEC also claims sort speeds of 1,000 to 5,000 records per minute for the COBOL Sort statement, which uses the disk as intermediate storage by default but may assign intermediate files to tape or drum. An ISAM package is also included in the compiler to allow access to data files which may employ a variety file organizations. The COBOL Compiler may be used for line-by-line compilation or for batch compilation. The standard recording mode for DECsystem-10 COBOL is ASCII, in either 6-bit or 7-bit bytes; however, IBM-compatible EBCDIC code may also be read or written on magnetic tape after a code conversion to or from the internal ASCII code representation. The COBOL Compiler has 7K words of "pure" (re-entrant) code and a minimum of 10K words for each user's portion.

A separately priced QSORT package for use with COBOL can reduce sort times for disk data sets with more than 1000 records by about half.

FORTRAN IV: Provides full ANS FORTRAN IV capabilities, plus additional features such as mixed-mode expressions, unlimited subscript dimensions, zero or negative DO loop parameters, and literal text and constants. The re-entrant compiler requires 10K words of main storage plus 2K words for a non-sharable user segment, and runs under either time-sharing or batch processing. The DECsystem-10 FORTRAN IV library contains 110 functions, any number of which can be loaded into the system at monitor generation time.

FORTRAN-10: FORTRAN-10 is a new FORTRAN compiler that contains both extensions to the ANS FORTRAN-IV standard and global and local optimization capabilities for improving execution times. DEC estimates that even without the global optimization capability, FORTRAN-10 object code executes 5 to 10 percent faster than that compiled with DEC's earlier FORTRAN IV compiler, and that compilations require only half of the CPU time required by DEC FORTRAN IV. When global optimization is invoked, DEC estimates that compilation speed will decrease slightly but that the resulting object code will execute up to 40 percent faster than unoptimized code.

Language extensions in FORTRAN-10 include OPEN and CLOSE file statements, list-directed READ and WRITE statements, INPUT and OUTPUT statements, multiple ENTRY subprograms, a multiple form of RETURN statements, implied DO loops in DATA statements, floating-point variables for DO loop control, ENCODE and DECODE statements, SKIP RECORD and SKIP FILE statements, and APPEND mode I/O. Error detection facilities available at the user terminal include compile-time error messages (including the erroneous line of code), detection of uninitialized variables, and optional invocation of array-bounds checking for each subscript in a multiple-subscripted array. FORTRAN-10 executes under Release 5.06 (or a subsequent version) of the Monitor, occupies 19K words of re-entrant code plus 4K words for a non-sharable user segment, and runs in either batch or time-sharing mode.

FORTRAN-10 supports FORDDT, an interactive debugging aid allows breakpoints to be set on any line, allows array elements to be referenced by name, and permits interactive run-time recovery of file and device selection errors.

ALGOL-60: Consists of a one-pass, single-phase compiler capable of processing up to 5,000 ALGOL lines per minute, according to DEC; this speed assumes disk I/O with 24 unpacked significant symbols per line. Advanced features of DECsystem-10 ALGOL include 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 a 13K-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. DEC's APL closely resembles the IBM APL/360 implementation, but provides additional features. DEC offers both basic and extended versions of APL, each of which can have double-precision arithmetic facilities. Extended APL includes the Divide-Quad, Execute, Quote, and Dyadic Format for performing matrix inversions, solving linear equations, and evaluating character strings, plus 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.

Extended APL, with or without double-precision arithmetic, occupies 24K words of re-entrant code plus 7,500

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characters of user code area and a 5K or 6K user workspace. Basic APL, with or without double-precision arithmetic, requires 20K words of re-entrant code plus 7500 characters of user code area and a 5K to 6K user workspace. APL is a separately priced program product.

BASIC: Provides 13 commands for full BASIC language capabilities plus enhancements in four areas:

- Editing facilities for adding or deleting lines, renaming files, resequencing line numbers, combining two files, and listing any portion of a file on the line printer or a user terminal.
- User-controlled peripheral assignments for input or output files, including disk.
- Output format controls allowing terminal output to include tabs, spaces, and columnar headings.
- Expanded command set including matrix manipulation operators and a macro capability.

The pure, re-entrant code for BASIC occupies 12K words of main storage, and each user's portion requires a minimum of 2K words.

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.

AID (Algebraic Interpretive Dialog) is DEC's version of JOSS. AID output is device-independent, allowing the user to create files for storage of routines and data on any available medium specified by the user. AID performs line-by-line compilation without producing an object version of the program. This language is generally used for one-shot computational problems as an alternative to BASIC, and requires a minimum of 9K words of core for sharable code plus a minimum of 2K words of user code area.

LINED (LINe EDitor) is used to create files of numbered command statements at a terminal. LINED may 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. LINED uses 1K words for re-entrant code and a minimum of 2K words for non-sharable user code.

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. The pure re-entrant code for TECO occupies 3K words of main storage, and each user's portion of TECO requires a minimum of 2K words.

EDITS is a page- and line-oriented file editor that permits blocks of data to be transferred within files and allows lines or complete pages of data to be copied from one file to another. Other facilities provided by EDITS include string searches and substitutions, the capability to modify text within a line and to complete a line, and the ability to save edited material by issuing one command. EDITS requires 8K words of main storage, and each user's portion requires a minimum of 5K words.

INTERACTIVE TEXT PREPARATION SYSTEM (ITPS-10): Announced in April 1976, ITPS-10 is a text preparation package that operates under the TOPS-10 operating system and can be used for photocomposition, typesetting, and word processing applications. The system is modular in design and contains separate routines for text entry and editing and for text processing. The system supports interactive text editing on CRT terminals and can produce output suitable for teletypewriter terminals, line printers, or photocomposition equipment. ITPS-10 is available for a one-time charge of $15,000.

SOUP (SOftware Updating Package) is a system programming utility provided by DEC to facilitate the revision of other DEC software. A string of changes to source code is processed against a master copy of the program to be updated by SOUP to produce a current master copy of the source version.

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. The user may (1) name the resulting output file(s), (2) edit the input data files, (3) define the mode of transfer, (4) manipulate the file directory if one is present, (5) control magnetic tape and card punch functions, and (6) recover from errors during processing. The pure, re-entrant code for PIP occupies 4K words of main storage, and each user's portion requires a minimum of 1K words.

Other systems utilities supplied by DEC include RUNOFF, which formats TECO or LINED files for printed manuscripts; CREF, a cross-reference listing program which aids debugging efforts by producing assembly listings with sequence-numbered statements and cross-reference tables for user programs; DDT (Dynamic Debugging Technique), with 50 different commands for on-line checkout and testing of individual Macro Assembler program segments in a minimum of 2K words of sharable code; FILEX to convert files to various formats; and COBDDT (COBOL Dynamic Debugging Technique) for on-line checkout and testing of individual program segments. A file backup system which copies disk files on tape for subsequent restoration to disk is also available.

USER GROUP: The worldwide DEC Users' Society (DECUS) was founded in 1961 and currently has more than 10,000 members in over 40 countries. This group is directly supported by DEC and schedules two meetings annually in addition to publishing a bi-monthly newsletter, DECUSCOPE. The DECUS Program Library Catalog lists more than 500 programs written by DEC users, most of which are available at no charge, or in some cases for a $5.00 handling fee. DECUS Membership is limited to DEC users, although some meetings are opened to general attendance. Inquiries should be directed to:

DECUS Executive Director
Digital Equipment Corp.
146 Main Street
Maynard, Mass. 91754

DECUS European Secretary
DECUS International Office
81 Route de L'Aire
1227 Carouge
Geneva, Switzerland

PRICING

EQUIPMENT: The following systems are representative of the types of DECsystem-10 configurations which are normally used and supported by the DECsystem-10 Monitor. All necessary controllers, processor features, and interfaces are included in the indicated prices.

MINIMUM DECSYSTEM-1060: Consists of a central processor with 96K words of MF10 core memory, an operator console with KSR-35 Teletypewriter and paper tape reader/punch (300/50 cps), one RP03 Disk Drive, one TU40 Tape Unit (120KC), a CR10-F Card Reader (300 cpm), an LSP10-V Line Printer (300 lpm), and a DC76-A 16-line Asynchronous Communications Multiplexer. Purchase price is $475,085.

TYPICAL DECSYSTEM-1060: Consists of a central processor with 192K words of MF10 core memory, two

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RHP04 Disk Drives, three TU70 Tape Units (120KC), one LP10-F Line Printer (1250 lpm), one CR10-E Card Reader (1200 cpm), and a DC76-A Asynchronous Communications Multiplexer (16 lines) plus an additional DC76-E 16-line group. Purchase price is $826,175.

MINIMUM DECSYSTEM-1080: Consists of a central processor with 256K words of core memory, operator console with KSR-35 Teletypewriter and paper tape reader/punch (300/50 cps), two RHP04 Disk Drives, one TU70-C Tape System, one LP10-F Line Printer (1250 lpm), one CR10-F Card Reader (300 cpm), and one DC76-A 16-line Asynchronous Communications Multiplexer. Purchase price is $739,590.

TYPICAL DECSYSTEM-1080: Consists of a central processor with 256K words of core memory, three RHP04 Disk Drives, four TU70 Tape Units, two LP10-F Line Printers (1250 lpm), one CR10-E Card Reader (1200 cpm), and one DC76-A 16-line Asynchronous Communications Multiplexer with four DC76-E Incremental 16-line Groups and one DC76-EC Incremental 16-line Group with Expander Cabinet. Purchase price is $969,455.

DECSYSTEM-1088: Consists of two central processors, 256K words of main memory, LA36 operator console, four RHP04 Disk Drives, four TU70 Tape Units (320KC), two CR10-E Card Readers (1200 cpm), two LP10-P Line Printers (1250 lpm), and two DN87 Communications Front-End Processors. Purchase price is $1,760,680.

SOFTWARE: A System Software Package is included at no additional charge with the Basic System Package for each DECsystem-10 central processor. The System Software Package includes the TOPS-10 Operating System, Virtual Memory (VMSER), loader, assembler, editor, and basic utilities; and a Compiler Package with FORTRAN-10, ALGOL-10, BASIC-10, COBOL-10, and the GALAXY-10 Batch System. The charges for separately purchased system software, language processors, and DEC-supplied program products are listed in the price list that follows. In addition, DECUS-supplied software is subject to a $5 copying charge.

SUPPORT: Ninety days of installation support are provided at no charge following delivery of a system. 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 most basic support package, the Software Distribution Service, supplies monthly copies of software modifications and updates plus regular distribution of general software "fixes," and is priced at $1,500 per year. The Customer Software Maintenance Service, in addition, provides remedial action for software bugs occurring at participating installations plus limited on-site support for critical malfunctions, and is priced at $3,500 per year. The On-Site Customer Maintenance Service offers, in addition to the above services, scheduled monthly visits of up to one full day by a DEC software support representative for consultation on software plus seminars on new Monitor releases, and is priced at $7,000 per year.

Customized software support beyond that supplied in the three support packages is charged for at $45 per hour, with a $75 minimum per call. The charge for a "resident" DEC Systems Engineer spending 40 hours per week at a customer site is $4,800 per month on a six-month term and $4,300 per month on a twelve-month term. A monthly consulting arrangement that provides the services of a DEC Systems Engineer for 160 hours during a four-week period is available for $6,000 per month.

EDUCATION: Each DECsystem-10 user is entitled to 13 man-weeks of training. On-site training, including course materials, is provided for specialized customer requirements at individually arranged rates.

CONTRACT TERMS: DEC offers a purchase agreement for immediate ownership of the DECsystem-10, and full-payout accrued-equity lease contracts. The most common of these 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. 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. Liberal educational discounts are given to qualified institutions.

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

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.* 12-hour	24-hour
PROCESSORS AND MAIN MEMORY				
KA10S	Primary Central Processing Unit for 1040, 1050, and 1055 (includes DK 10 Real-Time Clock and operator console)**	130,000	410	503
KA10	Additional Central Processing Unit for 1055 (includes operator console; DK 10 Real-Time clock additional)**	100,000	410	503
KI10S	Primary Central Processing Unit for 1060, 1070, and 1077 (includes DK 10 Real-Time Clock and operator console)	200,000	599	758
KI10	Additional Central Processing Unit for 1077 (includes operator console; DK 10 Real-Time Clock additional)	200,000	555	680
KI10A	Central Processing Unit for 1080 and 1090 (includes operator console)	250,000	814	1,030
DK 10	Real-Time Clock; 10-microsecond crystal oscillator resolution	3,000	12	16
MD10E	Additional 32K-word core memory module for 64K-word MD10G Mass Memory System; 1.8 microseconds (Note that MD10G is out of new production; for use with KA10 and KI10 processors.)**	42,000	147	180
MF10A	Core Memory; 32K words, 1.0 microsecond, including memory ports	40,000	316	400
MF10E	Core Memory; 32K-word expansion module, 1.0 microsecond	30,000	136	172
MF10G	Core Memory; 64K words, 1.0 microsecond, including memory ports	60,000	452	572
MF10L	Core Memory; 128K words, 1.0 microsecond, including memory ports	110,000	904	1,144
MG10L	Core Memory; 256K words, 1.0 microsecond, including memory ports	180,000	1,197	1,502
MX10	Memory Port Multiplexer (direct memory access for eight additional DF 10 Data Channels)**	4,500	18	22
MX10C	Memory Port Multiplexer (direct memory access for eight additional DF 10C Data Channels; 22-bit addressing)	6,500	21	27
MC10	Memory Port for add-on memory (separately priced only when ordered for already-installed memory)	1,000	8	10
DF10	Data Channel (included in RP02C, RP03C, and TU40/41C)	14,000	75	94
DF10C	Data Channel; 22-bit addressing	20,000	87	110
SYSTEM PACKAGES				
1060-F	Includes KI10 central Processor with DF10 Data Channel for TU10 Tape System, Real-Time Clock, DL10 Communications Interface, MG10-H Memory Module (128K), and System Software Package	290,000	1,476	1,868
1060-X	Includes 1060 System Package with Data Channel for TU70 Tape System	290,000	1,476	1,868
1066-F	Includes 1060 System Package with Data Channel for TU10 Tape System and second KI10 Central Processor	430,000	2,075	2,626
1066-X	Includes 1060 System Package with Data Channel for TU70 Tape System and second KI10 Central Processor	430,000	2,075	2,626
1080-F	Includes KL10 Central Processor, Real-Time Clock, Data Channel for TU10 Tape System, DL10 Communications Interface, two MG10-H Memory Modules (256K), RHP04-H Disk System, and System Software Package	660,000	2,884	3,650
1080-X	Includes 1080 System Package with Data Channel for TU70 Tape System	660,000	2,884	3,650
1088-F	Includes two KL10A Central Processors, two MG-10-H Memory Modules (256K), Data Channel for TU70 Tape System, Communications Channel, RHP04-H Disk System and one RP04-B Disk Drive, and System Software Package	1,025,000	3,935	4,979
1088-X	Includes 1080-X System Package, one additional KL10 Central Processor, RP04-H Disk System and one RP04-B Disk Drive, and System Software Package	1,025,000	3,935	4,979
1088-H	Includes 1080-H System Package, one additional KL10 Central Processor, and RP06 Disk Drive	1,043,000	3,935	4,979
1088-Y	Includes 1080-Y System Package, one additional KL10 Central Processor, and RP06 Disk Drive	1,043,000	3,935	4,979
MASS STORAGE				
RHS04H	Swapping System; 256K words, includes DF10 Data Channel, controller, and one fixed-head disk	62,000	301	380
RHS07J	Swapping System; 256K words, includes DF10C Data Channel, controller, and one fixed-head disk	68,000	313	396
RHS04D	Fixed-Head Disk Drive; 256K words	18,000	73	93
RHS04C	Add-On Fixed-Head Disk Drive; 256K words	18,000	73	93
RHS04G	Fixed-Head Disk Subsystem; includes controller and two fixed-head disks	48,000	226	286
RP02C	Disk System: 5.12M words (includes RP10C Control, 1 RP02 Drive, DF10 Data Channel)**	55,000	287	367
RP02	Additional Disk Drive; 5.12M words**	15,000	141	183
RP03C	Double-Density Disk System; 10.24M words (includes RP10C Control, one RP03 Drive, and DF10 Data Channel)	60,000	341	432
RP03	Additional Disk Drive; 10.24M words	20,000	180	227
RP02-P	Disk Pack for RP02/RP03 Disk Drives	295	NC	NC
RHP04A	Disk System; 20 million words; includes controller and RP04A single-access disk drive	55,900	390	493
RHP04B	Disk System; 20 million words; includes controller and RP04B dual-access disk drive	60,800	412	522
RHP04D	Disk System; includes DF10 Data Channel, controller, and RP04A single-access disk drive	69,900	464	588
RHP04E	Disk System; includes DF10 Data Channel, controller, and RP04B dual-access disk drive	74,800	487	616
RHP04F	Disk System; includes DF10C Data Channel, controller, and RP04A single-access disk drive	75,900	477	603

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** Offered on an as-available basis.

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.* 12-hour	24-hour
MASS STORAGE (Continued)				
RHP04H	Disk System; includes DF10C Data Channel, controller, and RHP04B dual-access disk drive	80,800	499	632
RP04A	Add-On Disk Drive; 20 million words, single-access, includes one RP04P Disk Pack	25,900	215	272
RP04B	Add-On Disk Drive; 20 million words, dual-access, includes one RP04P Disk Pack	30,800	237	300
RP04C	RP04 Dual Access Kit	4,900	23	29
RP06A	Disk Drive; 38 million words, single-access, includes one disk pack	34,900	215	272
RP06B	Disk Drive; 38 million words, dual-access, includes one disk pack	39,800	237	300
INPUT/OUTPUT UNITS				
TU40C/TU41C	Magnetic Tape System (includes DF10 Data Channel, one TU40 or TU41 Unit, and TM10B Control)**	59,000	294	372
TU40/TU41	Additional Unit: 30/83.4/120KC, 9-track/7-track**	25,000	158	204
TU10C	Magnetic Tape System (includes TM10A Control and one TU10A-E or TU10A-F Unit); not available for KL10	23,500	128	162
TU10A-E/F	Additional Magnetic Tape Unit; 36KC, 9-track/7-track; not available for KL10	8,500	87	110
TU10J	Magnetic Tape System; includes TM10B controller and TU10A 9-track or 7-track tape drive	28,500	155	196
TU70D	Magnetic Tape System; includes controller and one TU70A 9-track tape drive	73,000	407	515
TD10G	DECtape System; 15KC, 3/4-inch (includes TD10 Control and one TU56 Dual DECtape)	20,800	58	73
TD10C	DECtape Controller	15,300	23	29
TU56	Additional Dual DECtape Unit	5,500	36	46
TU70C	Magnetic Tape System (includes DF10 Data Channel, controller, and one TU70 unit)	100,000	525	665
TU70A	Add-On Tape Drive; 9-track, 800/1600 bpi	27,000	166	210
TU71A	Add-On Tape Drive; 7-track, 200/556/800 bpi	27,000	166	210
TM10A	Tape Controller, for I/O bus attachment	15,000	41	51
CR10D	Card Reader (incl. control); 1000 cpm	14,000	99	128
CR10E	Card Reader (incl. control); 1200 cpm	18,000	112	142
CR10F	Card Reader (incl. control); 300 cpm	8,000	75	94
CP10	Card Punch (incl. control); 200-365 cpm	35,000	113	146
CP10D	Card Punch (incl. control); 100 cpm	27,000	181	229
LSP10V	Line Printer (incl. control); 300 lpm	21,000	123	156
LSP10W	Line Printer (incl. control); 230 lpm	23,000	123	156
LP10F	Line Printer (incl. control); 1250 lpm	47,500	192	243
LP10FF	Scientific Drum for LP10F	1,500	NC	NC
LP10FE	Additional Drum for LP10F; 64 characters	1,500	NC	NC
LP10H	Line Printer (incl. control); 925 lpm	48,500	198	250
LP10HE	Additional Drum for LP10H; 64 characters	2,500	NC	NC
LP10HF	Scientific Drum for LP10H	2,500	NC	NC
XY10	Plotter Control	3,000	12	16
XY10A	Incremental Plotter and Control (consists of Calcomp Model 565 and XY10)	9,000	37	47
XY10B	Incremental Plotter and Control (consists of Calcomp Model 563 and XY10)	13,400	44	56
COMMUNICATIONS DEVICES				
DC10 Data Line Scanner:				
DC10A	Scanner and Control Unit (includes 4 units of cabinet space)**	10,000	22	27
DC10B	Eight-Line Group Unit (uses 1 unit of cabinet space)	5,400	21	27
DC10C	Eight-Line Telegraph Relay Assembly (uses 2 units of cabinet space)	3,000	23	29
DC10D	Telegraph Power Supply for DC10C (no cabinet space required)	500	9	11
DC10E	Expander Data Set Control (uses 2 units of cabinet space)	5,500	23	29
DC10F	Expander Cabinet (provides 8 units of cabinet space)	2,000	NC	NC
DC72 Asynchronous Remote Stations:				
DC72A	Communications Processor (includes PDP-8/E processor, 10-cps Teletypewriter, 300-cpm card reader, 165-cps stripe printer)	24,775	302	382
DC72B	Communications Processor (includes PDP-8/E processor, 10-cps Teletypewriter, 300-cpm card reader, 245-lpm line printer with 64-character set)	29,067	316	400
DC72C	Communications Processor (includes PDP-8/E processor, 10-cps Teletypewriter, 300-cpm card reader, 173-lpm line printer with 96-character set)	31,067	316	400
DC72L	Teletype Concentration Package (includes 8 lines; maximum of 2 DC72L's per DC72 system)	3,000	47	60
DC75 Synchronous Programmable Communications System (communications multiplexer);				
DC75A	Communications Processor (includes PDP-11/20 processor, DS11 Synchronous Modem Interface, DL10 Channel Interface, and 8 lines)	50,000	301	380
DC75D	Expander Option for Multiple Synchronous Modem Interfaces (includes DS11 Synchronous Modem Interface, PDP-11 processor, and 8 lines; maximum of 3 DC75D's per DC75A system)	30,000	228	289
DC75E	Additional 8-Line Group for Synchronous Modem Interface (1 per DC75A or D)	10,000	47	60
DS10	Single Synchronous Line Interface Unit**	12,000	27	33

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EQUIPMENT PRICES

COMMUNICATIONS DEVICES (Continued)		Purchase Price	Monthly Maint.* 12-hour	24-hour
DC76 Asynchronous Programmable Communications System (communications multiplexer):				
DC76A	Communications Multiplexer (includes PDP-11/40 processor, DC76E 16-line group, and DL10A high-speed memory interface	53,390	307	389
DC76D	16-Line Expansion for DC76A (incudes PDP 11/40 processor, DC76E 16-line group, and DL10C Unibus port for DL10A memory interface	29,890	236	299
DC76E	Additional 16-Line Group for DC76A or DC76D (up to 7 per DC76A or DC76D)	6,195	58	73
DC76EC	16-Line Group and Expansion Cabinet (required for over 64 lines)	8,785	63	80
DC76FA	Eight-Line Current Loop Local Interface	860	19	24
DC76FB	Eight-Line EIA Local Interface	1,490	19	24
DC76FC	Eight-Line Full Modem Control Interface	1,720	28	36
DC76FD	Eight-Line Integral Auto-Answer Modem Interface	4,240	94	122
DISPLAYS				
VB10C	Graphic Display System	35,000	NA	NA
VT05B	Alphanumeric CRT Terminal**	2,795	31	48
VT50C	Interactive Video Terminal	1,250	24	30
VT52	CRT Terminal	1,995	20	29
GT40A	Graphic Display System	14,500	210	272
TERMINALS				
LT33A (C)	Teleprinter (KSR-33) for local DC10 (DC68) use**	1,400	36	47
LT33B (H)	Teleprinter (ASR-33) for local DC10 (DC68) use**	1,940	42	54
LT35A (C)	Teleprinter (KSR-35) for local DC10 (DC68) use**	3,240	33	42
LA36C	DECwriter (30-cps teleprinter)	2,175	25	36

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SOFTWARE PRICES

	1-Time Charge*	Annual Maintenance Charge
Virtual Memory Monitor Enhancement	7,000	**
GALAXY-10	3,000	**
DC76 Software (if purchased without hardware)	7,000	700
LINK-10	1,500	**
FORTRAN-10 Version 4; includes FORDDT	7,500	**
FORTRAN-40	5,000	**
ALGOL-10	5,000	**
BASIC-10	5,000	**
COBOL-10	5,000	**
Compiler Package for 1080 and 1060 systems; includes FORTRAN-10, ALGOL-10, BASIC-10, COBOL-10, and GALAXY-10	20,000	**
SORT-10	2,500	**
APL—Basic Version	7,500	500
APL—Extended Version	19,500	1,000
APL—Extended Version with double-precision floating-point	19,500	1,000
CPL—10	5,000	—
PDP-11 Cross Assembler and Linker	7,500	750
IQL Interactive Query Language	12,000	1,200
MCS-10 Message Control System	50,000	5,000
DBMS-10 Version 2	25,000	2,500
MTH Multi-Terminal Handler	2,500	**
CAAP-10 College Administration Application Package	1,000	NA
COGO-10 Problem-Oriented Language and Interactive Programming System for geometric problems	3,000	NA

A System Software Package, supplied with each 1060, 1066, 1080 and 1088 System Package, includes the TOPS-10 Operating System, VMSER, loader, assembler, editor, basic utilities, and the Compiler Package.

* The prices for Software License Agreements apply to one system only. A license agreement for use of the software on two systems in an installation costs an additional 15% of the software price; for three, four, or five systems in an installation, an additional 10% of the software price; and for the sixth system, an additional 5% of the software price.

** Maintenance is provided under DEC's QHK02-K Customer Software Maintenance Service, priced at $3,500 per year.