Digital Equipment DECsystem-10

MANAGEMENT SUMMARY

The DECsystem-10 product line is an evolutionary outgrowth of the PDP-10, which was introduced by DEC in 1967. However, the true origins of this popular time-sharing system lay even farther back with the PDP-6. At the time of its 1964 introduction, the 36-bit PDP-6 was the first commercially available computer system with manufacturer-provided software for general-purpose time-sharing. At that time, other time-sharing systems had been implemented, but no others were supported by the system manufacturers.

The PDP-10 was program-compatible with the PDP-6 and offered twice the internal performance. It was designed to perform conversational time-sharing, batch processing, and real-time applications equally well and simultaneously. An equally important feature of the PDP-10 was the significant improvement of user accessibility to the system, largely through interactive operations, a feature that has continued to be an important consideration in the design of the DECsystem-10 and its successor product, the DECsystem-20 (Report 70C-384-03).

The DECsystem-10 was introduced in September 1971. The product line initially consisted of five models: the 1040, 1050, 1055, 1060, and 1070. A year later, in September 1972, DEC added the 1077, a dual-processor version of the 1070.

The early DECsystem-10 product line was based on two processors, the KA10, which was the same processor used in the PDP-10, and the KI10, an enhanced version of the KA10. The 1040, 1050, and dual-processor 1055 systems were based on the KA10 processor, while the 1060 and 1070, as well as the later-introduced dual-processor 1066 and 1077 systems, incorporated the enhanced KI10 processor. The KI10 processor provided faster execution speeds, improved memory utilization, and a higher degree ➢

Although the DECsystem-10 line still includes the most powerful systems produced by DEC's Large Computer Group, it is gradually being superseded by the newer-technology DECsystem-20. Already one model of the DECsystem-20 line can run under either the TOPS-10 or TOPS-20 operating system. The DECsystem-10 is still superior to the DECsystem-20 in real-time applications and will continue to be marketed until these functions are enhanced in the newer product line.

CHARACTERISTICS

MANUFACTURER: Digital Equipment Corporation, Large Computer Group, 200 Forest Street, Marlborough, Massachusetts 01752. Telephone (617) 481-9511.

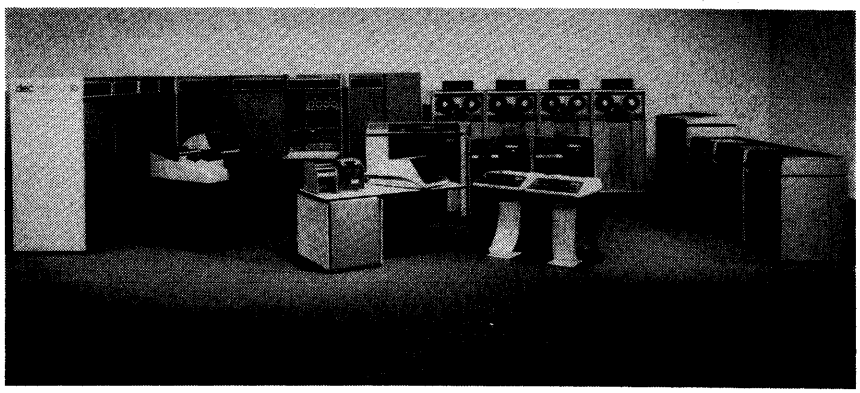
MODELS: DECsystem-10 Models 1090, 1091, and 1099. Model 1099 is a dual-processor system consisting of two 1090's. Former members of the DECsystem-10 Series include the 1040, 1050, 1055, 1060, 1066, 1070, 1077, 1080, and 1088.

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

FLOATING-POINT OPERANDS: The DECsystem-10 Series is currently based on the KL10 processor. Former models were based on the KA10 and KI10 processors. Standard floating-point hardware is included on the KI10 ➤



The DECsystem-10 and several of the available peripherals are shown here. The large CPU complex (cabinetry at left rear) includes separate cabinets for I/O channels. The new-technology DECsystem-20 incorporates the same system functionality in about half the cabinetry required by the DECsystem-10.

REFERENCE EDITION. This is a mature product line, and no significant further developments are anticipated. Because of its importance, coverage is being continued, but no future update is planned.

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of overlap between processing functions. Specific improvements included instruction lookahead, expanded register stack, improved adder, double-precision floating-point hardware, and paging registers.

Distinctions between the early DECsystem-10 models were based largely on configuration rules and marketing strategy. The Model 1040 had from 64K to 256K 36-bit words of core memory and used an I/O bus and a memory bus to attach up to 128 peripheral devices. The 1050 differed from the 1040 only in the addition of a fixed-head swapping disk subsystem, and the Model 1055 was a dual-processor version of the 1050.

The 1060 had similar memory and I/O configurability to the 1040 but employed the higher-performance KI10 processor. The 1060 also had a dual-processor counterpart, the 1066. The 1070 bore the same relationship to the 1060 as the 1050 had to the 1040—the addition of the fixed-head swapping disk subsystem—and there was a dual-processor version, the 1077.

In October 1974, a new chapter began with the introduction of the Model 1080, which was based on a new processor, the KL10. Later, in September 1976, a dual-processor version, the Model 1088, was introduced, thereby maintaining the policy of dual-processor versions of each basic model.

The KL10 processor can directly replace the KA10 and KI10 processors and achieves superior performance over the earlier models through the use of cache memory, a four-word-wide data path between main memory and the cache memory, and the use of emitter-coupled logic (ECL) circuitry. The KL10 also includes a set of business-oriented instructions that provide double-precision addition, subtraction, division, and multiplication of fixed-point operands and a string manipulation instruction that performs decimal/binary conversions and editing functions. According to DEC, the cache hit rate is typically between 85 and 90 percent, producing an effective memory cycle time of 334 nanoseconds.

The KL10 also incorporates a PDP-11 minicomputer to function both as a console processor and as a diagnostic processor. Included in the KL10 processor is a separate diagnostic bus that permits the PDP-11 to perform diagnostics on the central processor control logic and data paths either in local or remote mode.

In November 1976, DEC announced the Model 1090 and the dual-processor Model 1099—two of the three DECsystem-10 models that are currently being marketed. The 1090 was initially based on an enhanced version of the KL10 processor, designated the KL10-B. This new processor was actually the same one that originally formed the basis for the DECsystem-20 Models 2040 and 2050. Its most significant feature was the addition of integrated high-performance mass storage controllers (tape or disk) identical to the RH20 controllers that are incorporated into the DECsystem-20 Models 2040, 2050, and 2060. The addition of these integrated controllers made the

and KL10 processors. The KI10 and KL10 have both single- and double-precision floating-point, while the KA10 had only single-precision and a "long mode," which approximated double-precision through the use of software subroutines. Single-precision floating-point on all three processors uses one word, consisting of a 27-bit-plus-sign fraction and 8-bit exponent. The KA10 "long mode" consisted of two words with a 54-bit fraction, half of which was 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 were not used for floating-point number representation. KA10 floating-point operations were performed in a double-word register, only the most significant word of which was 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 KI10 and KL10 include storage protection as a standard feature. 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 located in contiguous memory locations, thus eliminating the need to shuffle program segments in memory to counteract checkboarding. The paging registers effectively permit addressing of 4 million words of memory through use of special hardware. Three bits are used to denote the type of access possible for each page, such as read/write, read-only, proprietary, or denial of access.

CENTRAL PROCESSORS

REGISTERS: All DECsystem-10 processors have sixteen 36-bit general-purpose 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 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

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CHARACTERISTICS OF THE DECSYSTEM-10 COMPUTERS

	1060/1070	1077	1080	1088	1090	1091	1099
SYSTEM CHARACTERISTICS							
Date of introduction	Sept. 1971	Sept. 1972	Sept. 1974	March 1976	Nov. 1976	—	Nov. 1976
Date of first delivery	Dec. 1972	—	July 1975	May 1976	Mar. 1977	—	Mar. 1977
CPU	KI10	KI10	KL10-D	KL10-D	KL10-D	KL10-E	KL10-D
No. of CPU's	1	2	1	2	1	1	2
Basic system purchase price	Not marketed	Not marketed	Not marketed	Not marketed	$620,000	$540,000	$1,010,000
Basic system monthly maintenance	—	—	—	—	$2,397	$2,580	$3,703
Relative performance level, approximate	1.0	1.6	2.2	3.0	2.2	—	3.0
Average no. of users per system	30-80	40-100	50-127	75-150	50-127	50-127	75-150
MAIN STORAGE							
Type	Core	Core	Core	Core	Core	Core	Core
Cycle time, nanoseconds	1200	1200	1200	1200	1200	1200	1200
Effective cycle time, nanoseconds	1200	1200	334	334	334	334	334
Minimum capacity, words	131,072	131,072	131,072	131,072	131,072	131,072	131,072
Maximum capacity, words	4,194,304	4,194,304	4,194,304	4,194,304	4,194,304	4,194,304	4,194,304
Increment size, words	64K, 128K, 256K	64K, 128K, 256K	64K, 128K, 256K	64K, 128K, 256K	64K, 128K, 256K	64K, 128K, 256K	64K, 128K, 256K
No. of memory ports	4 to 64	4 to 64	4 to 64	4 to 64	4 to 64	4 to 64	4 to 64
Interleaving	2-way or 4-way	2-way or 4-way	2-way or 4-way	2-way or 4-way	2-way or 4-way	2-way or 4-way	2-way or 4-way
Error correction	No	No	No	No	No	No	No
Memory port multiplexer:							
No. of ports per multiplexer	2	2	2	2	—	—	—
No. of multiplexers per system	2	2	2	2	—	—	—
CACHE MEMORY							
Type	None	None	Bipolar	Bipolar	Bipolar	Bipolar	Bipolar
Cycle time, nanoseconds	—	—	160	160	160	160	160
Capacity, words	—	—	2,048	2 x 2,048	2,048	2,048	2 x 2048
PROCESSOR							
Cycle time, nanoseconds							
Dynamic address translation method	Assoc. memory	Assoc. memory	Page table	Page table	Page table	Page table	Page table
No. of page entries	32	32	512	512	512	512	512
Accumulators	4 sets of 16	4 sets of 16*	8 sets of 16	8 sets of 16*	8 sets of 16	8 sets of 16	8 sets of 16*
Index registers	4 sets of 15	4 sets of 15*	8 sets of 15	8 sets of 15*	8 sets of 15	8 sets of 15	8 sets of 15*
No. of instructions	378	378	398	398	398	398	398
I/O CONTROL							
No. of hard-copy controls, max.	2	2	2	2	1	1	1
No. of data channels, max.	9	9	9	9	5	5	5
No. of Massbus controllers, max.	8	16	8	16	8	8	16
I/O bus data rate, words per second	370,000	370,000	370,000	370,000	370,000	370,000	370,000
Memory bus data rate, words per second	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000
COMMUNICATIONS CONTROL							
No. of comm. multiplexers, max.	4	4	4	4	8	8	8
No. of data line scanners, max.	2	2	2	2	None	None	None
No. of asynchronous lines, max.	576	576	576	576	896	896	896
No. of synchronous lines, max.	48**	48**	48**	48**	48**	48**	48**

* Indicates the number of registers per CPU.
**Mutually exclusive with asynchronous lines. Each synchronous line réduces the maximum number of asynchronous lines.

KL10-B processor a bridge product between the previously disparate DECsystem-10 and DECsystem-20 product lines, because the KL10-B could also utilize the older-style external data channels, thus achieving a common replacement processor that was usable in both product lines.

The integrated controllers included 16-word buffers that help to reduce the overhead caused by multiple direct memory access requests. The older controllers do not have these buffering capabilities. Diagnostic capabilities are also included in the integrated controllers. Up to eight

memory, the effective execution time for the high-speed registers ranges between 70 and 200 nanoseconds.

The KL10 processor used in the 1080/1090 and 1088/1099 dual 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 500 nanoseconds for the KL10. One register block also can be assigned for the exclusive use of a time-critical real-time program.

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RP04 (20-million-word) or RP06 (40-million-word) disk pack drives or up to four magnetic tape units can be connected to each integrated controller. A dual-controller arrangement can also be implemented, allowing up to eight tape drives on a single CPU. By incorporating the controllers into the CPU cabinets, DEC reduced the basic system package cost by about 25 percent.

The DECsystem 1090 can support more than 128 users engaged in general-purpose time-sharing activities, such as development and multiple applications programs, or over 1000 transaction processing users. System prices for practical DECsystem 1090 configurations start at about $700,000 and can extend beyond $2,000,000.

In addition to the mass storage controllers, the KL10-B processor employed a specialized control for data communications subsystems called the DTE Data Link. Each Data Link can interface up to four data communications front-end subsystems, and the KL10-B processor can accommodate up to three Data Links.

The latest processor employed in the DECsystem-10 series is the KL10-D, an enhanced version of the KL10-B processor that was introduced in the Model 1090 and the dual-processor 1099. The enhancements take the form of backplane changes that permit other future improvements to be implemented. Like the KL10-B, the KL10-D can accommodate both the external channel controls used in earlier DECsystem-10 models and the integrated channel controls that mark the most significant difference between the original DECsystem-10 and its successor series, the DECsystem-20. The KL10-D processor has replaced the KL10-B in the DECsystem-10 Models 1080, 1088, 1090, and 1099 systems. The KL10-D processor is also employed in the DECsystem-20 Models 2040, 2050, and 2060, and is now the unification system that welds the DECsystem-10 and DECsystem-20 product lines together.

The DECsystem-10 series also includes the Model 1091, which is based on the KL10-E processor. The KL10-D and KL10-E processors are identical except for external cabinetry; the KL10-D is mounted in standard 19-inch cabinetry, and the KL10-E is packaged in the wider DEC "corporate cabinetry."

Memory for the DECsystem-10 has evolved almost independently of CPU developments. During the course of its product lifetime, several memory products have been released for use with the system. This extensive development has resulted in decreases in main memory prices averaging about 30 percent per year. The various memory subsystems are all compatible across the range of KI10- and KL10-based systems. The primary difference between the successive memory subsystems has been in the storage capacity of each standard module. The currently available memories and their maximum module and system capacities are as follows:

	MF10	MG10	MH10
Words per module, max.	65,536	131,072	262,144
Words per system, max.	1,048,570	2,097,152	4,194,304

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

INSTRUCTION REPERTOIRE: The DECsystem-10 instruction set evolved in three distinct phases. The KA10 processor (DECsystem 1040, 1050, and 1055) had 366 instructions, including 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 KI10 processor (1060, 1070, and 1077) added 11 more instructions: 8 for double-precision floating-point arithmetic and 3 for conversion between fixed-point and floating-point formats.

The KL10 processor used in the 1080, 1088, 1090, and 1099 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. In addition, the processor provides 64 "programmable operators" that are used as monitor or user calls.

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 systems permit execution of two instructions simultaneously.

	1060/1070, 1077	1080/1090, 1088/1099
Fixed-point add/subtract	1.6	0.52
Fixed-point multiply	4.6	2.4
Floating-point add/subtract (single-precision)	2.7	1.8
Floating-point add/subtract (double-precision)	3.9	2.2
Floating-point multiply (double-precision)	8.1	4.8
Floating-point divide (double-precision)	16.0	10.2
Increment and move byte	5.6	1.4
Move from memory	1.6	0.48
Unconditional jump	1.1	0.36

CACHE: The KL10 processor includes a fast-access MOS cache memory with a 160-nanosecond access time. The cache, which is 2,048 words in size, actually consists of four caches, each with a capacity of 512 words (or one page) that operate in parallel. Each cache is a two-dimensional array consisting of 128 horizontal lines and 4 vertical columns containing one word of data each. 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 85 to 90 percent of the time, resulting in an effective access time of 334 nanoseconds for the KL10 processor. The cache uses a 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.

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All DECsystem-10 memory modules employ the same-sized printed-circuit cards and are interchangeable in the 16 memory slots. Thus, as new denser memory modules have been developed, the maximum memory size of the system has increased accordingly. The MH10 memory is suggested for current systems, although the earlier ME10, MF10, and MG10 memory is still available for expansion of installed systems. DEC encourages users to upgrade their system memory for offering allowances toward the purchase of the newer modules. These and other upgrade allowances are detailed in the Pricing section of this report.

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, TOPS-10 permits concurrently 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.

Interactive time-sharing has been the area in which the DECsystem-10 has clearly been most successful, and DEC has a significant share of the market for computers in independent time-sharing utilities already under its belt. The company has also expanded its marketing efforts into commercial general-purpose data processing environments. Significant steps in this direction include the DBMS-10 data base management system (providing access to the data base from both COBOL and FORTRAN programs) and the MCS-10 Message Control System, a general-purpose communications monitor designed to ease the development of communications software for on-line applications.

DBMS-10 is a new version of the DEC data base management system that contains all the features of DEC's earlier CODASYL-compatible DBMS packages plus some new capabilities. The new features include a simultaneous-update facility, which permits multiple jobs to update one file simultaneously, and a new data base format designed to improve system performance. The DBMS package also includes a utility called DBINFO that can be used to generate cross-reference listings, visual maps, and system statistics, such as the amount of free space available.

As a complement to the DBMS package, the Interactive Query Language (IQL) processes DBMS files through

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 earlier DECsystem 1040, 1050, and 1055 provided 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 originally provided 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 could be added for a maximum of 28. Assignment of the channels to specific devices was under user program control, and could be altered during processing. The processor itself was treated as a device, and internal overflow or priority checks could cause signals to be sent to the user program. Any number of devices could be connected to a single channel, and some devices used 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 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 primary difference between the KL10-B and KL10-D processors (used in the DECsystem

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operator-initiated queries. IQL is a retrieval and report-writing system that includes condition processing, computational expressions, built-in summary statements, and formatting capabilities for the generation of multiple reports.

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 is estimated to surpass the internal performance of an IBM System/370 Model 158 or the newer Model 3031 in scientific processing environments and to approximately equal the performance of these systems in business-oriented processing.

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 operating system 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.

DEC's 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 has always offered high-performance peripheral equipment for the DECsystems in order to reduce I/O overheads and minimize system response times. Two types of disk pack drives, the 20-million-word RP04 and the 40-million-word RP06, use 11-platter disk packs similar to the IBM 3336-11 packs. The TU70 and TU72 magnetic tape drives provide data transfer rates from 320 to 1250 KBS, and the LP10 line printer provides print speeds of up to 1250 lines per minute.

Communications capabilities of the DECsystem-10 are currently provided by 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

1090's) and the earlier KA10 (1040's and 1050's), KI10 (1060's and 1070's), and the early KL10 processors (1080's) is in the I/O channel configurations. Until the introduction of the KL10-B processor in the DECsystem 1090 and dual-processor 1099 systems, I/O channels were mounted in separate cabinets. The KL10-B processor incorporates up to eight RH20 integral I/O channels, which are more cost effective and also help to reduce the amount of floor space required for the system. The KL10-B and -D processor can also utilize the external I/O channels used with the KA10 and KI10 processors.

The external I/O channels are the DF10 and DF10C data channels. Both are used 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.

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 14 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 through the I/O bus to allow for testing of device status.

The DECsystem-10 also includes the high-performance Massbus, a high-speed data path that connects the RH20 integrated channel controllers and mass storage devices, primarily disk and tape units. It operates synchronously or asynchronously and transfers data between devices and their respective controllers. Massbus controllers can each control up to 8 devices and can buffer up to 16 data words. The Massbus controllers have an integral channel command word register and a control word location counter that functions as a channel program counter and permits channel command chaining. Each channel controller can execute channel programs that have been previously set up in main memory.

Each DECsystem-10 memory is multiported; the earlier MA10, ME10, and MF10 memory subsystems have four ports and the newer MG10 and MH10 subsystems have eight ports. Each port provides 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 multiplexer. Thus, full expansion with the addition of an MX10 multiplexer 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 370,000 words per second.

SIMULTANEOUS OPERATIONS: Each controller is capable of transferring data to or from only one of the

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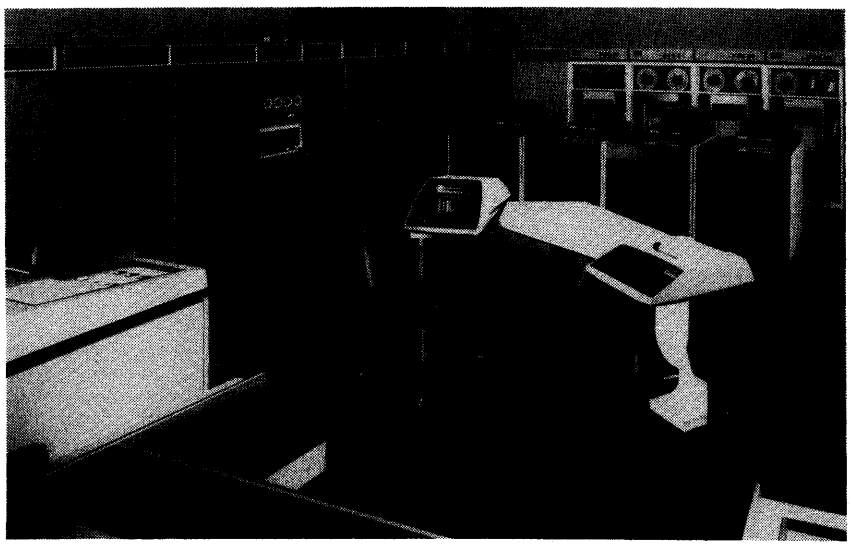

This medium-to-large-scale DECsystem-10 configuration includes 200-ips TU70 magnetic tape units and 20-million-word RP04 disk pack drives. Partially shown in the foreground are two 1250-lpm line printers. The DECsystem-10 product line is being superseded by the newer, more cost-effective DECsystem-20.

line speed synchronization. DEC also offers an extensive range of low-cost interactive video terminals and versions of 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 DAS61 IBM 2780/3780 Front End permits these IBM remote job entry stations to interface to the DECsystem-10 or permits the DECsystem-10 to simulate an IBM 2780/3780 RJE terminal to a System/360 or System/370 host computer.

- The DAS62 IBM HASP Multi-Leaving Front End allows these workstations to interface to the DECsystem-10 or allows the DECsystem-10 to simulate a HASP multi-leaving workstation.

Aside from these specialized applications, 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

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.

MASS STORAGE

RHP04 DISK SYSTEM: Provides large-capacity random-access storage. Includes a controller and from one to four RP04 disk drives, each with a storage capacity of 20 million 36-bit words. A maximum of two controllers, each with a maximum of four disk drives, can be connected to a DECsystem-10 for a total of 160 million 36-bit words (or 800-million 7-bit characters). Average seek time is 28 milliseconds, average rotational delay is 8.3 milliseconds, and data transfer rate is 178,571 36-bit words (or 892,855 7-bit characters) per second. Rotational speed is 3600 rpm.

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. The RP04 drive is manufactured by ISS.

RHP06 DISK SYSTEM: A double-density version of the RHP04 Disk System, each RHP06 disk drive has a storage capacity of 40 million 36-bit words (or 200 million 7-bit characters). A maximum of two channel subsystems, each with up to four disk drives, can be connected to a DECsystem-10 for a total of eight disk drives and 312 million words. Average head-positioning time is 28 milliseconds, average rotational delay is 8.3 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

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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 limited amount of software maintenance and customer training.

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 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 its large-scale systems at a pace satisfactory to DEC.

USER REACTION

As in previous years, the DECsystem-10 received very high ratings in the category of Overall Satisfaction in the latest Datapro survey of general-purpose computer users (Report 70C-010-50), published in December 1977. We received 22 responses from users representing a total of 23 systems. The system population was nearly evenly divided among the KA10, KI10, and KL10 processors.

positioning to occur on two or more drives. The RHP04 controller permits RHP04 and RHP06 disk drives to be intermixed on the same control unit. The RP06 drive is manufactured by ISS.

Two earlier disk subsystems, the RHS04 Fixed-Head Disk Subsystem and the RP03C Disk Pack Subsystem are described in the following paragraphs, although these subsystems are no longer marketed.

RHS04 FIXED-HEAD DISK SUBSYSTEM: 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. This subsystem is no longer marketed.

RP03C DISK SUBSYSTEM: Provides up to eight on-line RP03 Disk Pack Drives, an RP10C Disk Control, and a DF10 Data Channel. Each RP02 Disk Drive uses an RP02P Disk Pack and can 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. The average access time of 42.5 milliseconds includes a 12.5-millisecond average rotational delay at 2400 rpm and a 30-millisecond head-positioning time. The industry-standard 11-high Disk Pack is is physically interchangeable with the IBM 2316 Pack, although not logically compatible with it. Timing notches cut into the base plate of the disk 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 400 cylinders/pack. The disk packs are preformatted at initialization time so that all physical reads and writes are for 128-word data blocks. This subsystem is no longer marketed.

INPUT/OUTPUT UNITS

TU45 MAGNETIC TAPE SUBSYSTEM: The RU45 is a 9-track, 75-ips magnetic tape unit that features program-selectable recording densities of 800 bpi (NRZI) or 1600 bpi (phase encoded). The TU45 transports employ vacuum-column tape buffers and dual-gap heads that enable writing and data checking on each pass. "On-the-fly" error correction of single-track dropouts is provided in the 1600-bpi phase-encoded recording mode. The unit can read data in both the forward and reverse directions. Up to eight TU45 magnetic tape units can be connected to a controller.

TU70 MAGNETIC TAPE SUBSYSTEM: These high-speed tape units are available in 7- and 9-track versions with program-selectable recording densities of 800 or 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 subsystem 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.

TU72 MAGNETIC TAPE SUBSYSTEM: The TU72 high-performance magnetic tape units are 125-ips units that feature the 1600-bpi phase-encoded and the 6250-bpi group-coded recording modes. Data transfer rates for the two modes are 200,000 and 780,000 characters per second,

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The survey population characterized DEC's target markets for the DECsystem-10. Among the 22 respondents were seven educational organizations and six scientific/engineering users, including three pharmaceutical companies. The remaining nine users consisted of five remote computing service companies (another market target), two management information service organizations, and two financial institutions.

Of the 14 users who specified their systems' installed life spans, 8 had been using their systems for periods ranging between 43 and 87 months. The average system installed life was 43 months, and the youngest system had been installed for just over 10 months.

Memory sizes in the 23 systems ranged from 80K to 512K words. Half of the users had 256K-word systems. Disk storage sizes averaged 562 million bytes and ranged from one commercial bank's 25 megabytes to a time-sharing vendor's 2000-megabyte system. The respondents also reported using from one to five magnetic tape units per system, with about half the systems having two units.

Altogether, there were 71 remote terminals attached to these 23 systems. The vast majority of the terminals were of the interactive type; very few were remote batch terminals. More than half of the 71 terminals were connected to one KA10 system belonging to one of the financial institutions.

The following table contains the ratings supplied by these users.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	14	8	0	0	3.6
Reliability of mainframe	10	9	3	0	3.3
Reliability of peripherals	5	10	7	0	2.9
Responsiveness of maintenance service	7	11	4	0	3.1
Effectiveness of maintenance service	6	12	4	0	3.1
Technical support	3	4	13	1	2.4
Operating systems	12	7	2	0	3.5
Compilers and assemblers	7	12	3	0	3.2
Applications programs	0	7	9	0	2.4
Ease of programming	14	8	0	0	3.6
Ease of conversion	10	9	2	0	3.4
Overall satisfaction	8	11	2	0	3.3

*Weighted average based on 4.0 for Excellent.

The survey results show that the DECsystem-10 users continue to find the system exceptional in its Ease of Operation and Ease of Programming, two characteristics that DEC has always stressed as principal design goals. The TOPS-10 operating system also received high marks, and this undoubtedly contributed to the high ratings for Ease of Operation and Ease of Programming.

Although the DECsystem-10's Mainframe Reliability was generally well rated, it drew a weighted average rating two-tenths of a point below the 3.5 rating it received in Datapro's 1976 user survey. And the categories of Reliability of Peripherals, Responsiveness of Maintenance Service, Technical Support, and Applica- respectively. In all other features, these units are identical to the TU70 magnetic tape units described above.

TU10C MAGNETIC TAPE SUBSYSTEM: 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 TU10C subsystem is not available for use with KL10 processors.

LP100D AND LP100E LINE PRINTERS: These are both versions of the Dataproducts 2230 line printer, a drum-type printer featuring a choice of either a 64- or 96-character drum. Each printer includes a controller. Using the 64-character drum, the printer operates at 300 lpm, but when the 96-character drum is specified, the printing speed becomes 240 lpm. Both models are 132-position printers that feature programmable vertical format units. Switches on the units permit line spacing of either six or eight lines per inch. Users have a choice of either EDP or scientific character fonts for both the 64- and 96-character models.

LP10F AND LP10H LINE PRINTERS: These printers are versions of the Dataproducts 2240 line printer, which is a drum-type unit featuring a choice of 64- or 96-character drums. Using the 64-character drum, the printer operates at 1250 lpm, and with the 96-character drum, at 925 lpm. Both models are 132-position printers with standard 12-channel tape-controlled vertical format units. Switches on the units permit line spacing of either 6 or 8 lines per inch. Users have a choice of either EDP or scientific character fonts for both the 64- and 96-character models. These drum printers connect through the I/O bus to a processor via a built-in controller.

LP100B LINE PRINTER: A Dataproducts 2250-Charaband-type unit, this printer provides the flexibility and interchangeability of the train printer mechanism but is said to eliminate the problems caused by the metal-to-metal friction inherent in that design. The Charaband is composed of a number of rods mounted on a steel-clad polyurethane belt. The assembly looks like a machine gun cartridge belt. A replaceable cap, with two print characters, is placed on the ends of each rod to make a two-character print head. The entire Charaband passes horizontally past the paper in the same manner as a train printer. The second set of replaceable print caps can serve as spares, or they can have a different character font. The Charaband mechanism is less expensive than a drum and can be refurbished merely by replacing the print caps. In addition, the Charband enables greater printing speeds than those attainable from drum printers.

The LP100B printer is a 1220-lpm unit that includes a controller and either a 64- or 96-character font. Users have a choice of four Charabands, and both the 64-character and the 96-character set can be included on the same Charaband. Other features include a 12-channel paper tape-controlled vertical format unit and operator-selectable line spacing (6 or 8 lines per inch). Users may optionally specify special character fonts.

CR10D CARD READER AND CONTROL: The CR10D reads 80-column cards from a 1000-card input hopper at a rate of 1000 cpm. A vacuum picker and riffle air-stream help feed worn or damaged cards to a jam-resistant mechanism. The reader uses light-emitting diodes (LED) and photoelectric cells for high reliability, built-in controller. Up to two card readers 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 mech-

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tions Programs were all rated somewhat below the overall industry average ratings for these categories. Several users noted on the returned questionnaires that DEC's documentation was either inadequate or unavailable.

It must be noted that DEC markets the DECsystem-10 to users who are expected to be reasonably self-sufficient, and who will typically generate nearly all of their own applications software. Thus, despite ratings four-tenths of a point below the overall industry averages in the two categories of Technical Support and Applications Programs, the DECsystem-10 drew a weighted average rating of 3.3 in the "bottom-line" Overall Satisfaction category, an impressive two-tenths of a point *above* the overall industry average.□

anism employed in the high-speed CR10D card reader, 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.

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.

COMMUNICATIONS EQUIPMENT

DN87 UNIVERSAL SYNCHRONOUS/ASYNCHRONOUS COMMUNICATIONS FRONT-END PROCESSOR SYSTEM: This flexible communications subsystem is based on a DEC PDP-11 minicomputer and can support mixtures of synchronous and asynchronous communications lines. It is a successor product to the earlier DC75 Synchronous Communications Subsystem and the DC76 Asynchronous Communications Subsystem, having the functionality of both these products.

The basic DN87 front end processor has 16K bytes of memory. The expanded-capability DN87S includes 32K bytes of memory. Each version can control up to 96 or 112 asynchronous or up to 10 or 12 synchronous lines according to the following limitations:

	No. of Synchronous Lines	No. of Asynchronous Lines
DN87	0	96
	2	64
	6	32
	10	0
DN87S	0	112
	4	64
	8	32
	12	0

The basic DN87-A includes the DL10-A memory interface and the DN87-D front end, which consists of the PDP-11 minicomputer and its memory, and mounting space for up to four DN81-H or -J single-line synchronous control units. Asynchronous lines are available in 16-line groups and must be housed in the DN81-EA cabinet, which has space for up to four 16-line groups. Additional synchronous lines are mounted separately from the asynchronous lines in a DN81-EE cabinet, which has space for up to eight DN81-H synchronous line controls.

The DN87 subsystems connect to the DECsystem-10 through a DL10 data channel on the KA10 and KI10-based systems and also on the KL10-based 1080 systems. Up to four DN87 front-end subsystems can be connected to each DL10 data channel.

The later DECsystem-10 models, the 1090 and 1099, which are based on the KL10-B and KL10-D processors, can also attach communication subsystems through the DL10 data channel as described above. In addition, these systems can attach communications subsystems through integrated data links that are incorporated into the processor cabinet. A processor can have up to three data links, each capable of interfacing one DN87 communications subsystem.

Six types of asynchronous line interfaces are offered with the DN87 subsystems, and four of these are offered in 8-line groups:

- DN81-FA: 8-line current-loop interface
- DN81-FB: 8-line EIA interface
- DN81-FC: 8-line EIA interface with modem controls
- DN81-FD: 8-line interface for auto-answer modems
- DN81-FF: Controller for two Bell 801-type automatic calling units (ACU's)
- DN81-FG: Expander for two additional Bell 801-type ACU's.

The DECsystem-10 Model 1091 is a Model 1090 housed in smaller cabinetry. It employs the DN20 Universal Synchronous/Asynchronous Front-End subsystem that is functionally equivalent to the DN87S subsystem. The only difference between the DN20 and DN87 communication subsystems is that the DN20 line interfaces are exclusively EIA. Lines that require a current-loop termination must employ an external adapter.

DAS61 IBM 2780/3780 FRONT-END COMMUNICATIONS SUBSYSTEM: The DAS61 allows IBM 2780 and 3780 emulation and termination, permitting these units to be used as RJE stations with the DECsystem-10. The DECsystem-10 can also simulate an IBM 2780/3780 remote batch entry system and pass data to any IBM System/360 or 370 computer system. The DAS61 can control up to 12 synchronous lines, each operating independently with any combination of 2780 or 3780 emulation or termination. The maximum aggregate data rate of the DAS61 is 100,000 bps. The unit connects to the DECsystem-10 through the DL10 channel control.

DAS62 IBM HASP MULTI-LEAVING FRONT-END COMMUNICATIONS SUBSYSTEM: The DAS62 combines the functionality of the DAS61 with support for IBM HASP multi-leaving work stations as RJE stations to the DECsystem-10. It also allows the DECsystem-10 to simulate a HASP multi-leaving work station to an IBM System/360 or 370 host computer. Like the DAS61, the DAS62 can control up to 12 synchronous lines, each operating independently with any combination of 2780, 3780, or HASP multi-leaving emulation or termination. The maximum aggregate data rate of the DAS62 is 100,000 bps.

LA36 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

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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. A specialized version of the LA36, the LA37, has been adopted for use with the APL programming language.

LA35 RECEIVE-ONLY TERMINAL: Essentially an LA36 without a keyboard, this unit is intended for use as a hard-copy printer attached to a CRT display terminal.

LA180 RECEIVE-ONLY TERMINAL: An impact printer that uses a mechanism similar to that of the LA35 terminal but can print characters at the rate of 180 characters per second. The LA180 is a matrix unit that prints the full 128-character ASCII set using a 7-by-7 dot matrix. It prints rows of 132 characters and can accommodate 6-part forms in widths from 3 through 14-7/8 inches. Horizontal spacing is 10 characters per inch, and vertical spacing is 6 lines per inch. A switch permits the operator to select 11 different forms lengths.

VT50 DECSCOPE INTERACTIVE DISPLAY TERMINAL: A solid-state CRT terminal, built by DEC, that provides an 8.7-by-4.3-inch 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 teletypewriter-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 DISPLAY TERMINAL: Announced in August 1975, the VT52 is upward-compatible with the VT50 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.

VT61 DECSCOPE INTERACTIVE DISPLAY TERMINAL: The VT61 is an upper and lower case ASCII terminal with a 1920-character display, 19-key function pad, and 12 user-defined function keys. The VT61 can transmit in either block or character mode. It also features direct cursor addressing and built-in editing commands that permit character and line insertion and deletion, text justification, reverse video, and protected forms plus other editing features not available on the VT50 and VT52 terminals. The VT61 displays a 128-character set using a 7-by-8 dot matrix. 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. TOPS-10 consists of a resident portion and a nonresident portion. The resident operating system, in turn, consists of the following components:

- Service Request Handler: Accepts requests for allocation of system resources such as main memory, processor time, and I/O device availability. Includes the cyclic Command Decoder, which is responsible for validity checking and interpreting user requests and passing them to the appropriate system program.

- 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 portion of TOPS-10 requires from about 20K to 40K words of main memory, depending upon the processor model.

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

TOPS-10 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 DN87 Communications System.

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

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

Multiprogramming performance of the KI10 and KL10 processors has been 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 TOPS-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 communications 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 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 TOPS-10. 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 disk drives, one swapping disk system, a communications system, and two magnetic tape drives, VMSER occupies 5K words of main memory, and the sharable system Page Fault Handler occupies 1K words.

The 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 Model 1090, 1091, and 1099 systems. Current DECsystem-10 users can add the GALAXY system to the TOPS-10 monitor for a one-time charge of $3,300.

MESSAGE CONTROL SYSTEM (MCS-10): Announced in October 1974, the Message Control System provides the facilities for developing tailored communications-oriented programs using the DN87 Universal Synchronous/Asynchronous Front-End 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,

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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 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.

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

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 of 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 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.

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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.

PRICING

EQUIPMENT: The following systems are representative of the types of DECsystem-10 configurations which are normally used and supported by TOPS-10.

MINIMUM DECSYSTEM 1090: A typical DECsystem-1090 starter system includes the KL10-D CPU with 256K words of main memory and two LA36-C console terminals; a disk storage subsystem consisting of one 40-million-word RHP06 disk pack drive; a 320KBS magnetic tape subsystem consisting of two 200-ips TU70 magnetic tape units; a 1250-lpm LP10-F line printer; a 300-cpm CR10-F card reader; a 32-line asynchronous communications subsystem consisting of one DN87 front end and two DN81 16-line groups, and the TOPS-10 operating system, compilers, and utilities. Purchase price is $831,610, and maintenance service is priced at $3,711 per month.

MEDIUM DECSYSTEM 1090: A DECsystem-10 configuration capable of serving up to 96 users includes a KL10-D CPU with 1024K words of main memory and two LA36-C console terminals; a disk storage subsystem consisting of three 40-million-word RHP06 disk pack drives; a magnetic tape subsystem consisting of four 320KBS TU70 magnetic tape units; one 1250-lpm LP10-F line printer; one 1200-cpm CR10-H card reader; a 96-line asynchronous communications subsystem consisting of one DN87 front end and six DN81 16-line groups; and the TOPS-10 operating system, compilers, and utilities. Purchase price is $1,242,550, and maintenance service is priced at $7,610 per month.

LARGE-SCALE DECSYSTEM-1090: Includes a KL10-D CPU with 2048K words of main memory and two LA36-C console terminals; a disk storage subsystem consisting of eight 40-million-word RHP06 disk pack drives; a magnetic tape subsystem consisting of six 320KBS TU70 magnetic tape units; three 1250-lpm LP10-F line printers; two 1200-cpm CR10-11 card readers; a communications subsystem consisting of DN87 front ends and controllers for 256 asynchronous lines and 4 synchronous lines; and the TOPS-

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10 operating system, DBMS-10 data base management system, compilers, and utilities. Purchase price is $2,685,150 including a one-time license fee for the DBMS-10 package. Monthly maintenance charge is $21,928.

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 Software Prices section of this report.

DECUS-supplied software is subject to a copying charge that ranges from $32 to $128, depending on distribution media. The vast majority of the DECUS software is distributed on DECtape for $32 per copy.

SUPPORT: Each DEC software package includes one of three support categories in the license fee. The most comprehensive, Category A, provides on-site remedial coverage during 90 days following installation and Software Problem Report (SPR) service during one year after installation. Only two software packages, the MCS-10 Message Control System and the DBMS-10 data base management system, are provided with Category A support. Category B, the support category provided with most of the software packages, consists of only the SPR service for one year following installation. Category C provides no service; the software package is licensed on an "as is" basis. Older compilers and maintenance packages are in Category C.

DEC currently offers two software support services, the Software Distribution Service and the Customer Software Maintenance Service. It must be noted that the first service, Software Distribution, will be discontinued in July 1979.

The Software Distribution Service supplies monthly copies of software modifications and updates plus regular distribution of general software "fixes," and is priced at $1,820 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 $4,000 per year. 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 above 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.

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.

CONTRACTS: DEC offers the DECsystem-10 computer systems for purchase, installment purchase, or lease. There is no warranty period with any of the agreements, and maintenance is contracted separately.

The Installment Sales Agreement allows users to purchase systems over a one- to seven-year period. Two types of Installment Sales Agreements are offered, one for commercial users and one for municipalities. The commercial agreement is taxable, and the payment terms are generally higher than those for lease agreements. The municipal agreement is tax-exempt and has payment terms lower than for comparable-length leases. Both versions provide for a $1 transfer of ownership at the end of the contracted period.

There are also two types of lease agreements. Both are full-payout contracts with one- to seven-year periods, and both offer an end-of-contract purchase option. One version of the DEC lease agreement is a "true" lease with terms to minimize tax exposure. Its purchase option is based on the fair market value of the system at the end of the lease period. Users with the "true" lease can also choose whether or not to take the investment tax credit. The second version of the full-payout lease offers an end-of-contract purchase option at a stipulated value or percentage of the system purchase price. It does not have the provisions for investment tax credit.

Both types of lease agreements can be extended for three 1-year periods. The extension terms are based on the purchase option originally selected and use that purchase price as the basis of the new leasing agreements. Lease cancellation penalties are determined by standard termination tables that are too extensive for presentation in this report.

For federal government customers, DEC offers the Federal Financing Program, a lease-to-purchase agreement that passes ownership of the system to the customer at the end of the lease term in return for a $1 payment.

Regarding educational discounts, it is not DEC's policy to discount computer equipment other than through quantity discounts, the terms of which are available upon request. However, DEC does have programs to encourage educational customers to purchase systems packages that have a variety of software languages. These programs are a function of inventory and shipment loading and vary from time to time. By purchasing these multiple-language packaged systems, educational users can realize savings of 5 to 8 percent over the prices of the individual system components.

MAINTENANCE: The standard maintenance fees provide 12-hour, 5-day DECservice, which includes four-hour response to calls received within the contracted hours, continuous remedial service until the system is fully operational, and scheduled preventive maintenance outside normal working hours. The 12-hour period is 8 a.m. to 8 p.m. There is no charge for corrective maintenance services performed outside the contracted 12-hour period provided that the service call was placed during the contracted 12-hour period. DECservice is available only to users within a 50-mile radius of a DEC service office.

Extended coverage is also available at extra cost. Charges for maintenance of equipment beyond the 12-hour standard period are calculated by adding a percentage premium to the basic DECservice rates. The percentage increases for various coverage periods are as follows:

	12-hour	16-hour	24-hour
Monday-Friday	Base	3.8%	11.5%
Saturday, Sunday, holidays	9.2%	10.8%	13.1%

DEC also provides BASIC maintenance coverage for approved situations that require less than DECservice coverage. Each request for BASIC coverage must be approved by DEC field service management and by the product-line representative. Two coverage periods are offered under BASIC maintenance: 12-hour, 5-day, priced at 86.9 percent of the standard 12-hour, 5-day DECservice rate; and 8-hour, 5-day, priced at 76.9 percent of the DECservice rate.

The standard DECservice Agreement stipulates that the user provide an environment in which the temperature is maintained between 65 and 75 degrees Fahrenheit (18 to 24 degrees Celsius) and does not vary more than 3.6 degrees Fahrenheit (2 degrees Celsius) per hour. Humidity should be between 40 and 60 percent, non-condensing.

DEC also provides per-call service for users without maintenance agreements. The charge for this service is $48.00 per hour for service between the hours of 8:00 a.m. and 5:00

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p.m., Monday through Friday, and $56.00 per hour at all other times. Travel expenses are also charged at the hourly rate.

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.

Upgrade allowances are as follows:

RP03	**10.24-MW Disk Drive**	**$ 5,000**
RP04	**20-MW Disk Drive**	**8,000**
DF10-A	**Data Channel with 18-bit addressing**	**5,000**
DF10-C	**Data Channel with 22-bit addressing**	**6,000**
DC10-A	**Scanner and Control Unit**	**3,000**
DC10-B	**Eight-line group for DC10-A**	**1,500**
MF10-G	**64KW Memory**	**8,000**
ME10	**16KW Memory**	**2,000**
MG10-H	**128KW Memory**	**20,000**
TU70	**200-ips Magnetic Tape Unit**	**9,000**
RH10	**Data Channel Control**	**10,000** ■

EQUIPMENT PRICES

		Purchase Price	12-hr./5-day Maint. Service
PROCESSORS AND MAIN MEMORY			
KL10-D	Central Processor for 1090 system; includes TOPS-10 Virtual Memory Monitor license and console terminal; maximum of 8 controllers and 3 communications subsystems may be added	395,000	929
MH10-HA	Core Memory; 128K words, 1.2-microsecond, includes 8 memory ports	60,000	575
MH10-L	Core Memory; 256K words, 1.2-microsecond, includes 8 memory ports (includes one MH10-HA and two MH10-E's):		
	1 unit	100,000	835
	2 units	160,000	1,670
	3 units	220,000	2,505
	4 units	280,000	3,340
MH10-E	Expansion Module for MH10-HA, 64K words; two required to upgrade MH10-HA memory unit to MH10-L memory unit	60,000	260
MC10	Memory Port for MA10, ME10, and MF10 memory	1,100	9
MC10-G	Memory Ports, two for MG10 memory	2,200	19
MB20-G	Memory Expansion for 1091 system; 64K; 1.2-microsecond	31,510	169
MB20-E	Additional Memory for MB20-G expansion; 64K, 1.2-microsecond; two required per each MB20-G	31,510	130
MB20-H	First 128K expansion for 1091 system beyond 256K	60,000	260
MB20-L	256K expansion for 1091 system beyond 256K	100,000	520
SYSTEM PACKAGES			
1090-H	1090 System Package; includes KL10-D CPU, one 256K-word memory module, disk system, synchronous/asynchronous communications subsystem, LA36-C maintenance terminal and console terminal, and system software package; requires one 800/1600- or 1600/6250-bpi magnetic tape subsystem and one line printer	620,000	2,397
1091-B	1091 System Package; includes KL10-E CPU with cache memory, 256K words memory, RP06 disk system, communications subsystem with 8 asynchronous lines, I/O bus, LA36-C console, and system software package; requires one 800/1600- or 1600/6250-bpi magnetic tape subsystem and one line printer	513,000	2,580
1099-H	1090-H with additional KL10-D CPU and dual-access RP06 disk drive; requires one 800/1600/6250-bpi magnetic tape subsystem and one line printer	1,010,000	3,703
PROCESSOR FEATURES			
DIB20	Internal I/O bus interface for 1091 system	10,000	50
DF10-C	Data Channel, 22-bit	22,000	100
MX10-C	Memory Port Multiplexer, 22-bit	7,350	25
GP10	General-Purpose Interface to DECsystem-10 I/O bus	6,600	NC
GP10-L	GP10 Interface Logic	4,400	NC
GP10-M	GP10 Power Supplies and Indicators; does not include cables	2,750	NC
H956	Cabinet; requires 844 power control	630	NC
844	Power Control for H956 cabinet	665	NC
MASS STORAGE			
RHP04-A	Disk Subsystem; includes controller and RP04-A 20-million-word single-access disk drive; requires DF10 or DF10-C data channel	58,700	448
RHP04-B	Disk Subsystem; includes controller and RP04-B 20-million-word dual-access disk drive; requires DF10 or DF10-C data channel	63,840	474
RTP04-A	Disk Subsystem for KL10-B system; includes Massbus controller and RP04-A single access, 20-million-word disk drive; 8 drives max.	37,700	280
RTP04-B	Disk Subsystem for KL10-B system; includes Massbus controller and RP04 20-million-word dual-access disk drive; 8 drives max.	42,800	306
RP04-A	Add-on disk drive; 20 million words, single-access; includes one RP04-P disk pack; max. 7 per controller	27,200	248
RP04-B	Add-on disk drive; 20 million words, dual-access; includes one RP04-P disk pack; max. 7 per controller	32,340	274
RP04-C	RP04 Dual-Access Kit for RP04-A disk drive	5,150	26
RTP04-C	Dual-Channel Access Kit; includes Massbus controller and RP04 dual-access kit	15,650	58
RHP06-A	Disk Subsystem; includes controller and RP06-A 39.6-million-word single-access disk drive; 8 drives max.	65,500	448
RHP06-B	Disk Subsystem; includes controller and RP06-B 39.6-million-word dual-access disk drive; 8 drives max.	70,640	474
RTP06-A	Disk Subsystem; includes Massbus controller and RP06-A 39.6-million-word single-access disk drive; 8 drives max.	44,500	280
RTP06-B	Disk Subsystem; includes Massbus controller and RP06-B 39.6-million-word dual-access disk drive; 8 drives max.	49,640	306

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EQUIPMENT PRICES

		Purchase Price	12-hr./5-day Maint. Service
MASS STORAGE (Continued)			
RP06-A	Add-on disk drive, 39.6 million words; single-access, includes RP06-P disk pack; max. 7 per controller	34,000	248
RP06-B	Add-on disk drive, 39.6 million words; dual-access, includes RP06-P disk pack; max. 7 per controller	39,140	274
RP06-C	RP06 Dual-Access Kit for RP06-A disk drive	5,150	26
RTP06-C	Dual-Channel Access Kit; includes Massbus controller and RP06 dual-access kit	15,650	58
INPUT/OUTPUT UNITS			
TTU45-E	Magnetic Tape Subsystem for KL10-D or 1091 systems; includes controller, TU45C tape drive, and Massbus controller	36,900	266
TU45C-E	Magnetic Tape Subsystem; includes controller and TU45C tape drive	26,400	234
TU45C-EE/EF	Add-On Tape Drive; 9-track, 75 ips; maximum 7 drives per TU45C magnetic tape subsystem	14,700	156
TE10N-E	Add-On Tape Drive; 9-track, requires controller; maximum 7 per controller	13,500	110
TE10N-F	Add-On Tape Drive; 7-track, requires controller; maximum 7 per controller	15,500	110
TU70-C	Magnetic Tape Subsystem; includes channel, controller, and TU70-A tape drive; maximum 8 drives per controller	105,000	604
TU70-CC/CD	Magnetic Tape Subsystem (same as TU70-C magnetic tape system, but controller accepts both TU70 and TU72 drives); maximum 8 drives per controller	110,000	684
TU70-J	Magnetic Tape Subsystem; includes controller and TU70-A tape drive; maximum 8 drives per controller	76,650	468
TU70-JC/JD	Magnetic Tape Subsystem (same as TU70-J magnetic tape system, but controller accepts both TU70 and TU72 drives); maximum 8 drives per controller	83,000	546
TU70-A	Add-On Tape Drive; 9-track, 800/1600 bpi, maximum 7 per controller	29,700	191
TU72-C	Magnetic Tape Subsystem; includes channel, controller, and TU72-E drive; maximum 8 drives per controller	110,000	690
TU72-J	Magnetic Tape Subsystem; includes controller and TU72-E drive	83,000	552
TU72-E	Add-On Tape Drive; 9-track, 1600/6250 bpi; maximum 7 per controller	33,000	196
CP10-D	Card Punch, 100 cpm	29,700	250
CR10-H	Card Reader, console model, 1200 cpm	24,500	177
CR10-F	Card Reader, table model, 300 cpm	9,680	103
LP10-F	Line Printer, drum-type, 64-character, 1250 lpm	51,450	265
LP10-FE	EDP Drum for LP10-F printer	1,575	—
LP10-FF	Scientific Drum for LP10-F printer	1,575	—
LP10-H	Line Printer, drum-type, 96-character, 925 lpm	52,400	274
LP10-HE	EDP Drum for LP10-H	2,625	—
LP10-HF	Scientific Drum for LP10-H	2,625	—
LP100-B	Line Printer, 1220 lpm; includes controller, software, and long line interface; requires Charaband	64,250	442
LP07	Charaband for LP100-8 line printer	4,000	—
LP100-D	Line Printer, drum-type, 64-character, 300 lpm	24,150	348
LP100-E	Line Printer, drum-type, 96-character, 240 lpm	26,250	348
LP100-F	Line Printer, drum-type, 64-character, 890 lpm	41,425	342
LP100-H	Line Printer, drum-type, 96-character, 650 lpm	42,475	342
PC10-C	Paper Tape Reader/Punch for 1090 system; includes cabinet and power supplies	15,560	134
PC20-B	Paper Tape Reader/Punch for 1091 system; includes cabinet and power supplies	14,500	140
COMMUNICATIONS EQUIPMENT FOR 1090 SYSTEM			
The DN87-A, DN87-D, and DN87S-A communications subsystems have mounting space for up to four synchronous line units, but there is no available mounting space for asynchronous lines; cables are not included			
DN87-A	Front-End Processor; includes DL10-A communications interface and one DL10-C port; requires DN81-XX synchronous or asynchronous line options	55,000	289
DN87-D	Front-End Processor; includes DL10-C port; requires DL10-A communications interface; requires DN81-XX synchronous or asynchronous line options	27,500	206
DN87S-A	Synchronous/Asynchronous Communications Subsystem for KL10-B systems; requires DN81-XX synchronous or asynchronous line options	33,000	269
Synchronous Line Options			
DN81-E	Synchronous Expansion Cabinet; includes DN81-H controller	10,340	37
DN81-H	Synchronous Line Controller Expansion Line for speeds up to 10K bps	3,570	31
DN81-J	Synchronous Line Controller Expansion Line for speeds up to 40.8K bps	5,450	32
DN83	Null Modem for DN81-H controller; 2.0, 2.4, 4.8, 9.6, and 19.2 Kbps	500	—
Asynchronous Line Options			
DN81-EA	Asynchronous Expansion Cabinet; includes DN81-EC asynchronous, 16-line expansion group; maximum 64 asynchronous lines; required for addition of asynchronous lines; maximum two cabinets per DN87/DN875	10,340	73
DN81-EC	Asynchronous 16-Line Expansion Group; requires two DN81-FX 8-line terminators and DN81-EA cabinet	6,820	67
DN81-FA	8-Line Terminators with 20-ma current-loop local interfaces	950	21
DN81-FB	8-Line Terminators with EIA local interfaces	2,220	21
DN81-FC	8-Line Terminators with EIA full modem control interfaces	2,240	32
DN81-FD	8-Line Terminators with integral auto-answer modems	5,600	110
DN81-FF	Controller for two Bell 801-type Automatic Calling Units	1,380	20
DN81-FG	Expander for two additional Bell 801-type Automatic Calling Units	860	20
H312-A	Modem Simulator for connecting local terminals to DN81-B terminators	115	3

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EQUIPMENT PRICES

		Purchase Price	12-hr./5-day Maint. Service
COMMUNICATIONS EQUIPMENT FOR 1090 SYSTEM (Continued)			
IBM Communications Interfaces; include hardware, software license, and documentation; synchronous line interface must be ordered separately:			
DN61-A	IBM 2780/3780 emulator or terminator subsystem; includes DL10 port	60,000	289
DN61-D	IBM 2780/3780 emulator or terminator subsystem; requires DL10 port	32,500	206
DN61-S	IBM 2780/3780 emulator or terminator subsystem via DTE communications channel	38,000	269
COMMUNICATIONS EQUIPMENT FOR 1091 SYSTEM			
DN20-C	Front End, universal for 1091 system; requires DN2X options for addition of synchronous and asynchronous lines; cables are not included	28,200	190
Synchronous Line Interfaces			
DN20-D	Synchronous Expansion Drawer; includes one DN20-BA controller	9,980	35
DN20-BA	Low-Speed Synchronous Line Controller; includes one DN20-BB interface	3,580	35
DN20-BB	Low-Speed Synchronous Line Interface for speeds between 2.4 KB and 19.2 KB (RS-232C modem interface)	1,380	15
Asynchronous Line Interfaces			
DN25-E	Asynchronous Expansion Cabinet; includes one DN25-DA expansion drawer	13,800	74
DN25-D	Asynchronous Expansion Drawer; includes one DN25-AA controller	10,980	51
DN25-AA	Asynchronous Line Controller; includes one DN25-AB multiplexer	4,510	46
DN25-AB	8-Line Asynchronous Multiplexer; expandable to 16 lines with addition of DN25-BA expansion multiplexer	2,310	31
DN25-BA	8-Line Asynchronous Expansion Multiplexer	1,710	31
REMOTE STATIONS			
DN80-A	Remote Batch Station; includes one DN81-H controller expansion line, card reader, printer, PDP-11, and software	52,300	373
DN81-A	Remote Concentrator; includes DN81-H controller expansion line, asynchronous expansion cabinet, PDP-11, and software; maximum 32 asynchronous lines	43,850	277
DN82-A	Remote Batch Station and Concentrator; includes card reader, printer, asynchronous expansion cabinet, PDP-11, and software; requires DN81-FX asynchronous interfaces	61,380	440
DN92-A	Remote Station; includes PDP-8, console, and software; requires at least one remote station option; maximum four options	17,000	196
Remote Station Options			
DN92-E	Asynchronous 4-Line Multiplexer; includes line drive; requires cables	1,500	24
DN92-C	Card Reader, 80-column, 300 cpm		
DN92-P	Line Printer, 180 cps		
DN92-V	Line Printer, 300 lpm	11,800	124
DN92-W	Line Printer, 220 lpm	14,050	124
TERMINALS			
LA36-C	DECwriter II teleprinter, 30 cps	2,100	21*
LA35-C	Receive-only version of LA36-C teleprinter	1,900	21*
LA37-C	Teleprinter; same as LA36-C, but includes dual APL/ASCII character set	2,950	25*
LA180-E	DECprinter, serial EIA interface, 180 cps	3,770	62*
LA180-P	DECprinter, parallel interface, 180 cps	3,240	57*
VT52	CRT Terminal	1,900	23*
VT61-A	Buffered CRT Terminal	3,100	37*
DF01-A	Acoustic Telephone Coupler	760	12*
Special VT52 Package			
VT52-AE/AF	"Four-Pack"; consists of four VT52-AE or four VT52-AF terminals	6,000	92

*Maintenance service is not normally provided on terminals; price refers to 12-hour basic coverage.

SOFTWARE PRICES

	One-Time License Fee	Ann Maint Ch
SYSTEM SOFTWARE		
Virtual Memory Monitor Enhancement (VMSER)	7,700	
GALAXY-10	3,300	
DECnet-10 Task-to-Task	10,000	
COMPILERS		
FORTRAN-10; includes FORDDT	9,080	
FORTRAN-40	6,050	
ALGOL-10	6,050	
BASIC-10	6,050	
COBOL-10	6,050	
Compiler Package for 1090 systems; includes FORTRAN-10, ALGOL-10, BASIC-10, COBOL-10, and GALAXY-10	24,200	

**Annual maintenance fee is included in DEC's QHK01 or QHK02 software maintenance services.

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SOFTWARE PRICES

	One-Time License Fee	Annual Maintenance Charge
APPLICATIONS PACKAGES		
IQL Interactive Query Language	13,200	1,100
IQL Extended; includes DBMS Interface, both sequential and ISAM	15,000	1,200
MCS-10 Message Control System	55,000	5,500
DBMS-10 Version 3	27,500	2,750
MTH Multi-Terminal Handler	2,750	NA
SORT-10	2,750	**
APL-101SF; replaces APL-E and -F	22,500	1,500
APL-10 Basic	7,500	900
CPL-10	5,500	**
SITGO; load-and-go FORTRAN compiler	2,640	NA
SITBOL: SNOBOL compiler	2,640	NA
CAAP-10; College Administration Application Package	1,100	NA
COGO-10; Problem-Oriented Language and Interactive Programming System	3,300	NA
LICENSE UPGRADES		
APL-10 Basic to APL/SF	15,000	1,500
IQL-10 to IQL Extended	2,800	1,200
APL-E and APL-F to APL-10/SF	NC	1,500
OTHER SOFTWARE		
1090 Microcode Source License	40,000	NA
TOPS-10 Front-End Source Code	20,000	2,500
DECsystem-10/20 Maintenance Product for KL10-A/13 systems	40,000	NA
DECsystem-10/20 Maintenance Product for KL10-D system	40,000	NA

**Annual maintenance fee is included in DEC's QHK01 or QHK02 software maintenance services.