Digital Equipment DECsystem-10

MANAGEMENT SUMMARY

Digital Equipment has provided a multipurpose system in its DECsystem-10. There are built-in protection features in both the hardware and software to ensure data integrity and system availability. The design of the DECsystem-10 is open-ended permitting the addition of new features and devices. To afford its many DECsystem-10 users increased performance, Digital Equipment Corporation, on December 7, 1981, announced a three-CPU configuration of the DECsystem-10, known as Triple Symmetric Multi Processing (Tri-SMP). Coupling three 1090 CPUs with a single copy of its TOPS-10 operating system, the Tri-SMP system can boost the maximum number of time-sharing users from 175 (on a dual-processor 1090 SMP) to 250, a whopping 43 percent. DEC states that Tri-SMP shares memory resources, provides dynamic CPU reconfiguration if a CPU fails, and achieves its maximum performance through dynamic and automatic load balancing. In December 1982, Digital Equipment announced support for its 1091 Symmetric Multi Processor for dual- and tri-processor configurations. The 1091 is based on the KL10-E CPU, while the 1090 is based on the KL10-D.

The DECsystem-10 family includes the 1091, which uses MOS memory, and the 1090 and 1090 SMP systems, which use core. All systems support interactive time-sharing, batch, and realtime remote, sensor-based applications, and compete primarily in the time-sharing marketplace with Burroughs, Control Data, and Sperry.

PROCESSORS AND PERIPHERALS

The DECsystem-10, originally introduced in September 1971, is today based on the KL10 processor. The KL10 can directly replace the older KA10 and KI10 processors and achieves superior performance over earlier models through ▷

The DECsystem-10, a multipurpose, multi-tasking system, is designed to offer users interactive time-sharing, batch processing, realtime, and distributed processing. With its triple processor Symmetric Multi-Processing (SMP), the DECsystem-10 can support up to 250 active jobs or terminals. Digital Equipment Corporation has over 600 DECsystem-10 installations worldwide. The system is used primarily in service bureaus and other organizations that require high-performance time-sharing facilities.

MODELS: DECsystem 1090, 1090 SMP (two or three CPUs), and 1091, 1091 SMP (two or three CPUs).
CONFIGURATION: One to three CPUs, 256K to 4096K words (36 bits) of memory, up to 49 billion bytes of on-line disk storage, and up to 512 communications lines.
COMPETITION: IBM 303X, 308X, and 4341 Series, Honeywell DPS 8, Control Data 170/825 and 170/835, and Sperry 1100/60 through 1100/80 Series.
PRICE: Purchase prices start at $496,000 to $694,800.

CHARACTERISTICS

The DECsystem-10 is a family of large sale interactive computers that comprises four models: the 1090, 1090 SMP, 1091 and 1091 SMP. Designed to offer users support for up to 250 jobs operating concurrently, the system may be configured with up to three processors. The DECsystem-10 is a popular choice of large time-sharing users.

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▷ the use of cache memory, a four-word-wide data path between main memory and the cache memory, and the use of emitter-coupled logic (ECL) circuitry. The KL10 also includes a set of business-oriented instructions that provide double-precision addition, subtraction, division, and multiplication of fixed-point operands and a string manipulation instruction that performs decimal/binary conversions and editing functions. The cache has a 160-nanosecond access time, which, according to DEC, allows an effective memory cycle time of 334 nanoseconds.

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

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

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

A special version of the DECSYSTEM-20, a model 2020, can also run under the TOPS-10 monitor. This system is based on the KS10 CPU.

The DECsystem models 1090 and 1091-S can support up to 120 time-sharing users, and the 1090 SMP can handle up to 175 users as a dual-CPU system and 250 in a triple-CPU configuration. Up to 30 batch jobs can be run concurrently with interactive and real-time jobs on each system. The model 1090 can be field upgraded to the multi-processor 1090 SMP, and the 1091-S can now be upgraded to the 1091 SMP configuration.

The DECsystem models 1090 and 1090 SMP use MH10 core memory modules, and the 1091-S uses MF20 MOS memory. The 1091 SMP uses either MH10 core memory or external MOS memory. A previous model of the 1091, the 1091-P, used core memory. The 1090 and 1090 SMP can have from 256K words (1 megabyte) of memory up to 4,096K words (16 megabytes), in 64K- and 256K-word increments. The 1091-S can have from 256K words up to 3,072K words (12 megabytes) in 256K-word increments. A triple-SMP system requires a minimum 1,536K words (6 megabytes) and can be expanded to 4,096K.

Input/output devices are controlled via a number of specific systems in the DECsystem-10 family. In all models disk and tape subsystems are connected to the KL10 via the RH20 Massbus. The RH20 is the integrated controller and ▷

▶ **CURRENT MODELS:** DECsystem-10 Models 1090, 1091, and two- or three-processors 1090 SMP and 1091 SMP.

DATA FORMATS

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

FIXED-POINT OPERANDS: Either 36-bit words or 18-bit halfwords for add and subtract instructions. The multiply instruction produces a double-word product, and the divide instruction uses a double-word dividend. There are also integer multiply and divide instructions which involve only single words. All arithmetic operations are performed in binary mode.

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

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

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

MAIN STORAGE

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

CAPACITY: See Table 1.

CYCLE TIME: See Table 1.

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

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

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TABLE 1. CHARACTERISTICS OF THE DECSYSTEM-10 COMPUTERS

	1091E	1090PH	1090 SMP	1091 SMP
SYSTEM CHARACTERISTICS				
Date of introduction	June 1979	November 1976	July 1979	December 1982
Date of first delivery	July 1979	March 1977	December 1979	March 1983
CPU type	KL10-E	KL10-D	KL10-D	KL10-E
No of CPUs	1	1	2 or 3	2 or 3
Basic system purchase price	$496,000	$694,800	$1,134,800	$836,000
Basic system monthly maintenance	$2,470	$3,275	$4,435	$4,045
Relative performance level, approximate	1.0	1.2	2.5	2.5
Average no. of users per system	30-120	30-120	50-250	50-250
MAIN STORAGE				
Type	MOS	Core	Core	Core or MOS
Read cycle time, nanoseconds	735	735	735	735
Effective cycle time, nanoseconds	334	334	334	334
Minimum capacity, words	256K	256K	256K to 1,536K	256K to 4,096K
Maximum capacity, words	3,072K	4,096K	4,096K	4,096K
Increment size, words	256K	64K, 256K	64K, 256K	64K, 256K
No. of memory ports/module	8	8	8	8
Interleaving	2-way or 4-way	2-way or 4-way	2-way or 4-way	2-way or 4-way
Error correction	Yes	Yes	Yes	Yes
CACHE MEMORY				
Type	Bipolar	Bipolar	Bipolar	Bipolar
Cycle time, nanoseconds	160	160	160	160
Capacity, words	2K	2K	2 x 2K or 3 x 2K	2 x 2K or 3 x 2K
PROCESSOR				
Cycle time, nanoseconds	360	360	360	360
Dynamic address translation method	Page table	Page table	Page table	Page table
No. of page entries	512	512	512	512
Accumulators	8 sets of 16	8 sets of 16	8 sets of 16	8 sets of 16
No. of instructions	398	398	398	398
I/O CONTROL				
No. of hard-copy controls, max.	3	3	6	6
No. of Massbus controllers, max.	8	8	16	16
I/O bus data rate, words per second	370K	370K	370K	370K
Memory bus data rate, words per second	4,000K	4,000K	4,000K	4,000K
COMMUNICATIONS CONTROL				
No. of comm. processors, max.	3	3	4	4
No. of asynchronous lines, max.*	512	384	512	512
No. of synchronous lines, max.*	36	36	36	36

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

▷ the Massbus is the channel. Up to eight RH20s can be configured in single-processor systems and up to 16 RH20s can be attached to a 1090 SMP or 1091 SMP. Each RH20 can accommodate up to eight disk drives, depending on the unit selected, or up to eight tape drives, (TU72 and TU78 systems) per RH20. One RH20 must be reserved for disk, and the remaining seven RH20s can be designated for either tape or disk storage. DEC recommends that minimum systems be configured with at least one RH20 each for disk and tape systems. The 1090 SMP and 1091 SMP requires a minimum of one RP06 disk drive per CPU. A maximum of 24 billion bytes of on-line disk storage can be configured on the models 1090 and 1091, while the 1090 SMP and 1091 SMP can handle up to 49 billion bytes of storage.

Unit record devices can be connected via an I/O Multiplexer Bus or the PDP-11 Unibus depending on the processor and the system configuration. Each DECsystem-10 can support up to three line printers (six in the 1090 SMP or 1091 SMP) and two card readers. ▷

▶ **CENTRAL PROCESSORS**

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

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

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

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DECsystem-10 users can select from several high-speed drum or charaband printers, with speeds up to 1200 lines per minute possible. Card readers are available in 300- or 1200-cpm models. Tape drives are available in 125-ips systems, with recording densities of 800, 1600, and 6250 bpi. There are three disk drives available, and recommended, by Digital. Users have a choice of the 220-megabyte RP06, the 498-megabyte RP07 or the newer RTP20, with 1,200 megabytes per unit. A large variety of DEC terminals is available to support a user's needs.

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

SOFTWARE AND SUPPORT

All members of the DECsystem-10 family and a version of the DECSYSTEM-2020 operate under control of the TOPS-10 operating system, of which the latest release is Version 7.02. A multi-purpose operating system, TOPS-10 permits concurrent execution of interactive timesharing, local and remote batch, realtime, remote, sensor-based, and transaction-oriented processing. Time-sharing on the DECsystem-10 is classified as "general-purpose," that is, time-sharing users have access to all system facilities, such as the command language, I/O facilities, and data files, under operating system control. Any input character or character string can be either data or commands to the TOPS-10 operating system. TOPS-10 is designed to service up to 512 time-sharing terminals, and time-sharing users have access to the Cobol, Fortran, Basic, APL, Algol, CPL (an interactive PL/1 subset), BLISS-36, and AID (a version of JOSS) languages plus a wide variety of interactive debugging and program preparation aids.

A separate module of TOPS-10 version 7.02 is provided (unbundled) in multi-processor 1090 SMP systems or 1091 SMP systems. The SMP (symmetric multiprocessing) option permits sharing of memory and I/O devices between the two CPUs and offers greater system availability and performance.

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

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

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

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

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

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

PAGING: The KL10 processors provide a mapping capability from physical memory addresses of up to 4 million words (which require 22 bits for representation) to shorter effective addresses contained in 18 bits. The most significant half of the 18-bit effective addresses is used as an index to a page table which contains up to 8,192 physical page numbers. The referenced physical page number is linked with the low-order 9 bits of the effective address (which indicates one of the 512 words on a page) to produce a 22-bit main memory

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▷ Digital's GALAXY-10 Batch System is designed to greatly enhance DECsystem-10 production throughput, and can be used in interactive as well as production batch processing environments. At least 30 batch jobs can be run concurrently with time-sharing and realtime activities.

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

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

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

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

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

One key reason why the DECsystem-10 models are less expensive than functionally comparable IBM systems is that DEC competes only in system environments which favor the DECsystem-10's particular strengths. Those strengths are largely derived from the excellent applicability of the DECsystem-10 operating system to a "multimode" environment, including on-line processing plus local batch plus remote batch plus computer network requirements. Interactive time-sharing is 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. ▷

▶ address that can reference any of the 4 million words (maximum memory size of the 1090 and 1090 SMP and 1091 SMP). The KL10 processor maintains a 512-word hardware version of the entire page table to perform address translation. In the KL10, the high-order bits of the virtual address are used to perform a table look-up to locate the 13-bit most significant portion of the resulting 22-bit physical address.

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

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

User Mode on the KL10 permits the execution of all instructions except those which would cause interference with other users or the integrity of the DECsystem-10 Monitor. User Mode is subdivided into the Public Submode and the Concealed Submode. Concealed Submode protects any program in that category from being copied or modified, even by the program itself, and is normally used for proprietary software. Concealed Submode programs can read, write, execute, and transfer to any Public location, while Public programs can access addresses in Concealed programs only by transferring to locations which have ENTRY instructions. In User Mode, a program can access up to 256K words.

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

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

SIMULTANEOUS OPERATIONS: Each controller is capable of transferring data to or from only one of the devices attached to it at a time. Disk or tape drives have several paths to memory, such as the RH20 Massbus and the ▶

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TABLE 2. MASS STORAGE

Subsystems	RP06	RP07	RP20
Cabinets per subsystem	1	1	2
Disk packs/HDAs per cabinet	1	1	2
Capacity, megabytes	176* per drive	498* per drive	483* per spindle
Tracks/segments per drive unit	19 per cylinder (1)	537 per inch	957 per inch
Average access time, milliseconds	28.5	31.3	25.0
Average rotational delay	8.33	8.33	—
Data transfer rate: Bytes/second Words/second	806KB	2.2MB	2.0MB
Controller model	RH20	RH20	RH20/DX20
Comments	Disk pack drive (1) 815 cylinders per pack	Winchester disk drive	Winchester disk drive

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

COMPETITIVE POSITION

Digital Equipment enhanced their competitive position by expanding their Symmetric Multi-Processing capability to allow up to three tightly-coupled systems to be utilized. Competition for the DECsystem-10 includes IBM 4341 Series, IBM 303X Series, IBM 3083X, Control Data Cyber 170/825 and 170/835, and Sperry 1100/60, -70, and -80 Series.

The IBM 303X and the Control Data Cyber 170 Series can be configured with only up to two processors; however, the IBM 303X is currently not in new production.

In competing with the Honeywell DPS 8 Series, DECsystem-10 is able to accommodate up to 36 synchronous lines and between 384 to 512 asynchronous communications lines depending on the line mix. The Honeywell DPS 8 Series 8/20 through 8/62 can also accommodate up to 512 communications lines.

UNIBUS, allowing direct transfer of data to memory while control information is passed through the bus. The I/O bus, memory bus, and processor can each operate concurrently with asynchronous computing. Up to four-way memory interleaving is possible, which causes consecutive addresses to be stored in alternate physical memory banks. Aggregate maximum data transfer rates for the I/O bus and memory bus are 1.2 million and 20 million 7-bit characters per second, respectively. Instruction look-ahead is provided on KL10 processors, where the next sequential instruction is decoded during execution of any given instruction.

INPUT/OUTPUT CONTROL

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

Controllers for slow-speed devices in the Models 1090 and 1090 SMP can be attached via the BA10 interface to the Multiplexed I/O Bus, which provides a full 36-bit-word parallel path between the processor and the devices. Data can be transferred in words or blocks of up to 256K words by a single instruction at a maximum rate of 370,000 words per second. Slow-speed devices can be connected to the PDP-11 front end in the 1091 or 1091 SMP, as well as the BA10. DEC indicates the PDP-11 method provides better performance with slow-speed devices, particularly printers.

CONFIGURATION RULES

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

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TABLE 3. INPUT/OUTPUT UNITS

Magnetic Tape Units	Number of Tracks	Recording Density, Bits/Inch	Encoding	Tape Speed Inches/Sec.	Transfer Rate, Bytes/Sec.
TU72	9	1600	PE	125	200,000
TU72	9	6250	GCR	125	750,000
TU78	9	1600	PE	125	200,000
TU78	9	6250	GCR	125	781,250

Printers	Printing Speed	Print Positions	Horizontal Spacing, Chars./Inch	Vertical Spacing, Lines/Inch	Form Size, Inches
LP07 (with LP200)	900 or 1200 lpm	132	10	6 or 8	5.25 to 18.75 wide (up to 6 parts)
LP14 (with LP20 and LP100)	660 or 900 lpm	132	10	6 or 8	4.0 to 16.75 wide
LP27	800 or 1200 lpm	132	10	6 or 8	3.5 to 18.75 wide
LP26 (with LP20)	450 or 600 lpm	132	10	6 or 8	4.0 to 16.75 wide

Punched Card Equipment	Columns	Speed Cards/Min.	Input Hopper Capacity	Output Stacker Capacity	Options
CD20AA/AB (tabletop)	80	300	1000	1000	—
CD20CA/CB (freestanding)	80	1200	2250	2250	—

▷ ADVANTAGES AND RESTRICTIONS

One key advantage of the DECsystem-10 is that it is a system which has proven its reliability and is supported by a major computer manufacturer in the marketplace. It is a system which has been designed to execute many different types of jobs concurrently and which is periodically enhanced. The DECsystem-10 has good communications capability and is often selected by service and time-sharing users. The system will support from 384 to 512 asynchronous and 36 synchronous connect points. Another advantage of the system is its flexibility and ease of expandability, affording attachment of a variety of peripheral devices. The system functions well where there is a requirement for high performance time-sharing facilities.

Many users view a restriction to the DECsystem-10 is the announcement by Digital Equipment that the project, referred to as Jupiter, which was to provide a follow on to the DECsystem-10 family of computers, is abandoned.

This was considered by some to be the intended growth path. Digital Equipment is said, however, to intend to integrate the DECsystem-10 into the Corporate System Interconnect and Information architectures while continuing to provide enhancements to the KL-10 hardware and software.

USER REACTION

Fourteen users of Digital Equipment's DECsystem-10 responded to Datapro's 1983 Computer System User Survey, with 10 users having purchased system installed, three users having leased their systems and one no response. ▷

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

Up to eight Massbus controllers can be connected to 1090 and 1091 systems. The first Massbus is designated for disk units only, the second is recommended for tapes, and the last six can be designated for either. Up to eight RP06 or RP07 disk drives can be connected to a Massbus. A tape transport and a line printer must be included within a basic system configuration.

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

The TU72 and TU78 tape systems can be connected to the Massbus. Each TU78 tape master can have a maximum of four TU78-AF/AJ tape drives. Systems can be varied in configuration but must not exceed eight tape drives per RH20 channel. On a second channel up to eight TU72 tape drives can be connected to a TX02 tape controller.

Up to three line printers and two card readers can be connected in single-processor systems. Up to six printers can be connected to the 1090 SMP or 1091 SMP.

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

Up to 512 asynchronous lines can be connected to a 1091 system via the PDP-11 (DC20 subsystem; 128 lines maxi- ▶

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▷ Eight of the users indicated they had not converted to the DECsystem-10 from another system. Ten of the respondents classified their industry as Education, with Health Care/Medical, Retail/Wholesale, and Service Bureau following next. Most of the DEC-10 sites were single computer central processing installations. Four of the users indicated they were involved in distributed processing with three of the six requiring 10 or more remote locations. All users indicated that they had terminals and/or remote workstations. Six users indicated they had 16 to 30 such workstations/terminals, one user had 31 to 60, and six users required over 60 workstations/terminals. Only one user indicated his requirement was in the area of 1 to 5 workstations/terminals.

In terms of system size, most of the respondents' DEC-10s had memory ranging from 4096K to 8192K with disk storage over 1200 megabytes. Seven respondents currently use a data base management system, while three respondents plan to use one this year. Four users did not respond to the question. Six respondents also indicated they use a communications monitor. Six respondents also said they had integrated word processing functions on their DECsystem-10s, while two others were planning to integrate them in 1983. The most popular language choice for DEC-10 respondents was Fortran followed by Cobol. Interest in disaster recovery planning is growing, and 10 DECsystem-10 users either have or plan to have a disaster recovery plan in place in 1983.

DECsystem-10 users appear satisfied with the performance of their system, with 12 of the respondents stating they do not plan to replace their DEC-10s, while the remaining two plan to migrate to another Digital Equipment system.

In total, overall user ratings by DECsystem-10 respondents to the Datapro survey are summarized in the following table. There are 14 respondents to the survey. The number of responses does not always total 14, however, because not all users answered every question.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	10	3	0	0	3.7
Reliability of mainframe	7	6	1	0	3.4
Reliability of peripherals	3	7	4	0	2.9
Maintenance service:					
Responsiveness	5	5	1	1	3.2
Effectiveness	4	7	0	1	3.2
Technical support:					
Trouble-shooting	2	3	6	1	2.5
Education	3	4	2	2	2.7
Documentation	1	7	2	2	2.6
Operating systems	10	4	0	0	3.7
Compilers and assemblers	5	6	3	0	3.1
Applications programs	1	6	1	1	2.8
Ease of programming	9	4	0	1	3.5
Ease of conversion	3	6	1	1	3.0
Overall satisfaction	5	8	1	0	3.3

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

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

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

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

On all DECsystem-10 processors, hardware internally is EIA with support for EIA lines and terminals only. All 20mA current loop terminals must be converted to EIA for use with the DECsystem-10. For asynchronous speeds up to 2400 bps, cabling must not exceed 1000 feet; for asynchronous speeds up to 9600 bps, cabling must not exceed 250 feet.

MASS STORAGE

See Table 2.

INPUT/OUTPUT UNITS

MAGNETIC TAPE UNITS: See Table 3.

PRINTERS: See Table 3.

CARD READERS: See Table 3.

TERMINALS

LA38 DECWRITER IV HARD-COPY TABLE-TOP TERMINAL: The LA38 is designed for entry-level applications with a maximum print speed of 30 characters per second. This model is an addition to the DECwriter IV series and features serial printing by 9-by-7 dot matrix, a 128-character buffer, and communication speeds of 110 or 300 bps. In the LA38, paper movement is by use of tractor feed. The unit prints 128 ASCII upper- and lower-case characters. The LA38s also have a 19-key pad for rapid entry of numerical data. Like other terminals from DEC, the LA38 is microprocessor-based and incorporates a self-check feature as standard.

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

LA120-RA DECPRINTER RECEIVE-ONLY TERMINAL: The LA120-RA is a serial impact printer that prints ▶

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To qualify our findings, we contacted several users by telephone for their comments and observations on the DECsystem-10. One Data Processing Manager indicated his organization was in the medical field and his DECsystem-10 was installed about one year ago. He was pleased with his system, and felt that it met all of his requirements. Combining both local and remote terminals, this user was utilizing something less than 60 terminals total with his DEC-10. These users appeared happy with their response time, and his plans for the future include integrating word processing functions and also developing a disaster recovery plan. When asked if his system performed as expected, he said yes and would recommend it to another user.

Another phone call made was to a college in the northeast. In addition to their DEC-10 system, the school also had installed different manufacturers' microcomputers and word processors, and had integrated word processing functions on their DEC-10 system. Their DEC-10 system was used not only with students but for administrative work as well. All of their application programs were developed in-house using Fortran. The school felt their users were happy with the response time and that the productivity aids available with the system helped them to keep programming costs down. Since their system performed as expected, they would recommend it to another user.

A call to the Operations Director of a midwestern company revealed they are a large DEC-10 user with 14 DEC-10s configured into nine different systems. A sister site in the northeast also has nine systems. This company offers remote computing services for financial institutions and corporations. The Director stated that he feels that Digital Equipment's TOPS-10 is an outstanding operating system. When questioned about the support DEC supplied, he noted his organization did not take advantage of DEC support since they have their own maintenance staff. One reason for this is to provide good maintenance turnaround since they are a mixed vendor site. It was stated that their organization had reviewed Digital Equipment's expansion plans for DEC-10 users, and he felt satisfied that his requirements would be satisfied in the future. This organization gave a high rating to DEC as a manufacturer.□

at the rate of 180 characters per second. It is a matrix unit that prints the full 128-character ASCII set using a 7 x 7 dot matrix. It also prints rows of 132 characters. Horizontal spacing is 10 characters per inch, and vertical spacing is 6 lines per inch. The LA120-RA will accept data at standard rates between 110 and 9600 bps. Operation can be full duplex, half duplex, or echoplex. The LA120-RA is manufactured by DEC.

VT100 VIDEO DISPLAY TERMINAL: This performance-oriented family of terminals contains a 12-inch screen with either an 80 characters by 24 lines or 132 characters by 14 lines display and a detachable keyboard with an 18-key numeric/function keypad. The VT100 displays a 7 x 9 dot matrix character font on a 10 x 10 space, and includes a large variety of standard and optional features. Data rates range from 50 to 19,200 bps. The asynchronous terminal is equipped with an EIA RS-232-C or 20ma current loop interface. All operating parameters are established via the keyboard in the Set-Up mode. The VT100 is manufactured by DEC. For more details, refer to Report 70D2-384-01.

COMMUNICATIONS EQUIPMENT

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

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

DN20 DATA COMMUNICATIONS FRONT END: One basic processor, the DN20-MC/MD, is available with 128K words of MOS memory. Up to three DN20-MC/MD units can be connected to the 1090 and 1091 systems, and up to six units can be attached in a 1090 SMP or 1091 SMP. The DN20-MC/MD can support up to eight low-speed and four high-speed DECnet lines. A separate DN20-MC/MD must be established when operating in bisync (2780/3780) mode, and up to six bisync lines can be connected to this unit. ANF-10 software is the primary communications product used in the DN20.

DECnet-10 software can also be used when communicating with other DECnet host systems. The DN20 can support up to 128 asynchronous lines and up to 12 synchronous lines, in various configurations.

DN87 DATA COMMUNICATIONS FRONT END: Based on the PDP-11 processor, this subsystem supports various configurations of synchronous and asynchronous lines. The DN87 has been eclipsed by the DN20 but is still supported in the field by DEC. The two models available, the DN87 and DN87S, have 16K and 32K bytes of memory, respectively. Each can support up to 112 asynchronous and 12 synchronous lines in various configurations, and can support DECnet-10 and ANF-10 software. Up to three DN87 front ends can be connected to a DECsystem-1090, and a maximum of four in the 1090 SMP.

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

SOFTWARE

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

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

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> • Shareable Resource Allocator: Distributes system resources to individual users in accordance with messages from the service request handler. Includes two cyclic programs: the Scheduler and the Swapper. The Scheduler determines which user program is to be run during a given time-slice, using a round-robin queued monitor. The Scheduler is activated by the system clock 60 times per second, and user jobs are given time-slices of 1/2 second for execution. Jobs which do not issue I/O requests during their 1/2-second time-slice are considered to be compute-bound, and are placed in a different queue where they get 2-second time-slices at less frequent intervals. The Swapper transfers jobs between disk and main memory after determining which user programs must be present in core for a job to run and which programs must be removed from core in order to make room for the run.

- I/O Service Routines: These routines process user program requests for I/O devices, and consist of three non-cyclic routines. The Programmed Operator Handler traps user service requests to the operating system and is the only means by which the user can switch to Exec Mode for operating system service. Input/Output routines are initiated by the Programmed Operator Handler to manage data transfers between peripheral devices and user programs in core memory. The I/O System permits the use of symbolic device names and allows the user to have device independence. The File Handler permits users to define protected output files for permanent storage.

TOPS-10 allows five basic concurrent modes of operation: interactive time-sharing, realtime processing, batch, multiprogramming and remote communications. Up to 512 interactive terminals associated with 250 active jobs can be handled by the Monitor, with multiple remote batch stations multiplexed through the DN20 and DN87 Communications Systems.

The most recent release of TOPS-10, Version 7.01, has been enhanced to include improvements in reliability and availability. These improvements include an enhanced monitor dump process, improved error logging, diagnostics, memory configuration and improved network management routines. TOPS-10 Version 7.01 supports the multiprocessor 1090 SMP, and I/O requests are handled by a queued I/O protocol which assures prompt CPU attention. TOPS-10 Version 7.01 has Dual Processor Extension (DPE) and Multi Processor Extension (MPE) options for multiprocessor support on older KI10- and KL10-based systems.

Symmetric Multi-Processing (SMP) software supports two or three 1090 CPUs or 1091 CPUs. Memory is shared among processors with a single copy of TOPS-10 supporting the overall system. The monitor is re-entrant, and, according to DEC, all monitor calls can be executed on all CPUs. SMP can dynamically reconfigure the operational CPU(s) in the event of a CPU failure. Automatic and dynamic load balancing is managed by SMP, and all CPUs operate from a single job queue and a common queued I/O protocol to maximize performance.

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

The non-resident portion of TOPS-10 is stored on disk and includes the language processors, debugging programs, and operating system support programs. Standard languages available for the DECsystem-10 include Cobol, Fortran-77,

Algol-60, Basic, APL, BLISS-36, and the Macro Assembler. Each language processor consists of a "pure" or reentrant portion and a user portion which contains parameters defining a specific user job. The language processors produce sharable, re-entrant user programs.

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

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

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

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

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

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

Remote communications hardware and software capability on the DECsystem-10 permits simultaneous use of multiple remote stations with other DECsystem-10 modes of operation. Synchronous full-duplex communication between small remote computer stations allows remote users to send or receive data typically at speeds up to 9600 bits/second. The remote batch terminals (such as the DN200) can have printers, card readers, etc., locally attached, and can 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 can change their logical addresses to back up or copy file functions of a different remote station.

VIRTUAL MEMORY: The Virtual Memory Feature (VMSER) provides an optional virtual-memory mode of operation for DECsystem-10 installations with a KL10 processor and at least Release 7.01 of TOPS-10. The VMSER ▶

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

GALAXY-10 BATCH PROCESSING: The GALAXY-10 Multistream Batch and Spooling System permits concurrent execution of multiple batch jobs with time-sharing jobs. It uses the same command language as that used in timesharing, contains a centralized queue manager and job scheduler, and simplifies the execution of a batch job via a time-sharing terminal. GALAXY-10 requires a KL10 processor with a minimum 256K words of memory, TOPS10 Version 7.01 or later, VMSER Version 7.01, one disk unit, and one tape unit.

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

DECnet-10 COMMUNICATIONS SOFTWARE: Tops-10 Version 7.02 supports DECnet-10 Phase III. Network command terminals, full message routing, and network file facilities are supported between DECsystem-10s and other DECnet nodes. In addition, Tops-10 users have the ability to use ANF-10 to communicate with the DECsystem-10 nodes. A DECystem-10 that acts as a host in a DECnet network can maintain its place in a ANF-10 network, experiencing no limitation on previous functionality. DECnet-10 and ANF-10 require separate DN20 front-ends if they coincide on the same system.

DATA BASE MANAGEMENT SYSTEM: DBMS-10 is a full-scale data base organization and management system that uses both Cobol and Fortran as host languages and provides a data management language (DML) based largely on the April 1971 CODASYL Data Base Task Group (DBTG) specifications. DBMS-10 supports hierarchical data structures in simple tree format or in more complex network structures and provides a high degree of data independence from physical devices as well as user applications programs. A detailed analysis of DBMS-10 can be found in Report 70E-384-01.

IQL-10: The DEC Interactive Query Language is an information retrieval and report writing system that uses English-like requests to read a file or group of files and process data contained in those files. IQL-10 extracts, summarizes, reorganizes, and copies file information, and produces reports in specified formats. The language interfaces both the file management system of the operating system and DBMS-10. Data files can be sequential DBMS data bases, or index-sequential with fixed and/or variable record length.

COBOL-68, COBOL-74: A complete implementation of American National Standard Cobol X3.23 (Level 4). Both the 1968 and 1974 versions are implemented. 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 can be used for line-by-line compilation or for batch compilation. The latest Cobol update, Version 12B, includes support for Record Management Service (RMS) Version 1.0, conforms to federal specifications FIPS Pub. 21-1, and includes a flagging capability to highlight errors in syntax.

FORTRAN-77: Fortran-77 contains both extensions to the ANS Fortran-IV standard and global and local optimization capabilities for improving execution times. It requires a minimum memory area of 35K words, Version 7.01 of TOPS-10, and executes in either batch or interactive mode. An interactive debugger, FORDDT, is provided.

ALGOL-10: An implementation of the Algol-60 language that consists of a one-pass, single-phase compiler with a full range of diagnostics, extended-precision floating-point representation, byte-string manipulation capability, "while" and "for" statements for iterative procedures, and independent program and procedure compilation. Use of the compiler requires a 14K-word re-entrant segment in memory and a non-sharable user segment consisting of 2K words plus an amount of core dependent upon the size of the user's Algol program.

APL: A conversational programming language that is particularly well suited for operating on numeric and character array-structured data, the DEC APL system runs under the DECsystem-10 time-sharing Monitor. Two versions are available: APL-BASIC version 2.0 and APL-SF Version 2.0. APL-BASIC requires a minimum of 30K words of storage space, and APL-SF requires a minimum of 50K words of storage and at least 45K words of user space.

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

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

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

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

MACRO ASSEMBLER: This two-pass symbolic assembler is device-independent, allowing the user to select I/O devices for source program entry, program listing output, and object code storage. Powerful macro capabilities permit creation of user-defined language extensions for frequently used coding sequences. The pure, re-entrant code for the macro assembler occupies 7K words of main storage, and each user's portion of the assembler requires a minimum of 1K words.

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

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

TECO (Text Editor and COrrector) is used to edit individual ASCII characters in an input file. The file is read into a memory buffer from any device except a user terminal, where 30 TECO editing commands of two types may be applied to the data.

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

PRICING

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

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

USER GROUP: The worldwide DEC Users' Society (DE-CUS) was founded in 1961 and currently has about 30,000 members in over 40 countries. This group is directly supported by DEC and schedules two international meetings annually in addition to publishing a bi-monthly newsletter DECU-SCOPE. DECUS is composed of four chapters (listed below), special interest groups (such as the DECsystem 10/20 Group), local users groups, and national users groups. Symposia are held throughout the year in each of the DECUS chapters. The DECUS Program Library Catalog lists more than 2,600 programs written by DEC users, most of which are available at no charge, or in some cases for a nominal handling fee. DECUS Membership is limited to DEC users, although some meetings are open to general attendance. Inquiries should be directed to:

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

DECUS Canada
P.O. Box 11500
Ottawa, Ontario

K2H 8K8 Canada
613-592-5111 Ext. 2115

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

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

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

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

Digital's Software Products Services group provides multiple levels of service, including DECsupport, Basic Service, and Self-Maintenance Service for Software. DECsupport makes regular on-site service calls to monitor systems and to eliminate potential problems. Basic Service for Software features a toll-free 800 number, which gives immediate access to Digital software specialists, seven days a week. Self-Maintenance Service for Software features software product and documentation updates.

Self-Maintenance Service for Software (post-warranty) is available on a yearly contractual basis. This program includes software Product and Documentation updates, which are sent automatically during the contract period. They include Software Dispatch, a monthly newsletter with information about new software developments and programming enhancements, and Software Performance Reports (SPRs), a more detailed publication on software problem diagnosis. The annual price for Self-Maintenance Service when using TOPS-10 is $2,720.

In addition to the Software Notebook Set provided with the system, an additional set may be purchased, including a one-year update capability, for $1,100. A one-year update service on the original Notebook can be purchased for $559. An additional Software Dispatch subscription in hardcopy costs $330, and in microfiche costs $285 annually. Additional consulting services are available on a per-call basis.

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

The DECservice agreement for hardware provides on-call remedial maintenance between 8 a.m. and 5 p.m. and preventative maintenance between 8 a.m. and 8 p.m., both Monday through Friday. There is no additional charge for remedial service begun during the contracted hours of coverage but which must extend beyond these coverage hours. There is a guaranteed four-hour response for service calls placed during the contract period and on-call maintenance ▶

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► on a best-effort basis at per call rates with no charge for materials outside the contract period. The following table gives premiums to be added to regular rates (Monday-Friday, 8 a.m.-8 p.m.) for service outside the standard contract period.

	16 hours	24 hours
Daily Mon. through Fri.	3.8%	11.5%
Saturday or Sunday	10.8%	13.1%

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

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

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

UPGRADE POLICY: DEC offers a trade-in policy giving credits toward the purchase of more advanced DECsystem devices. Older PDP-10 equipment or slower DECsystem equipment can be upgraded to higher-performance devices. Traded-in equipment must be in generally good condition

(ie., DEC-maintained by Field Service) or is subject to a refurnishing charge. Allowances depend upon device type and vary widely from about 20 to 50 percent of the original purchase prices.

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

DECsystem-1091: Includes a KL10-E CPU with 512K words (2 megabytes) of MOS memory, a cache memory, one LA120 DECwriter III console, two RH20 Massbus interfaces for disk or tape drives, 16 asynchronous communications lines, one RP06 disk unit and two RP07 totalling 1.2GB of storage, two TU78 tape drives with controller, one LP200 Charaband printer (1200 lpm), one CD20 card reader (300 cpm), TOPS-10 operating system, GALAXY batch system, installation with 90-day warranty, and 50 days of applications software consulting. The purchase price is $733,300 and monthly maintenance is $4,220.

DECsystem-1090: Includes a KL10-D CPU with 512K words (2 megabytes) of core memory, a cache memory, one LA120 DECwriter III console, two RH20 Massbus interfaces for disk or tape drives, 16 asynchronous communications lines, two RP06 disk drives and three RP07 totalling 1.9GB of storage, four TU78 tape drives with controller, one LP100 Charaband printer (650 lpm), TOPS-10 operating system, GALAXY batch system, installation with 90 day warranty, and 50 days of applications software consulting. The purchase price is $1,067,260 and monthly maintenance is $6,043. ►

Digital Equipment DECsystem-10

EQUIPMENT PRICES

		Purchase Price	8 hr./5-day Maint. Service
SYSTEM PACKAGES			
1090-PH	1090 System Package; includes KL10-D CPU with cache memory, 512K-words of core memory, RP06 disk system, one RH20 I/O channel communications subsystem, LA 120 DECwriter III Console Terminal, and system software package including TOPS-10 operating system; requires one 800/1600- or 1600/6250-bpi magnetic tape subsystem and one line printer	$694,800	$3,275
1091-SE	1091 System Package; includes KL10-E CPU with cache memory, 512K-words of MOS memory, RP06 disk system, 2 RH20 I/O channels communications subsystem with 16 asynchronous lines, I/O bus, LA 120 DECwriter III Console Terminal, and system software package including TOPS-10 operating system; requires one 800/1600- or 1600/6250-bpi magnetic tape subsystem and one line printer	496,000	2,470
PROCESSOR OPTIONS			
1090-FA/FD	1090 Upgrade Package, upgrades KA10 or KI10 systems to KL10-based processor	426,070	1,112
1090-S	1090 SMP Upgrade Package, includes second or third KL10-D processor and SMP software	440,000	1,168
1091-S	1091 SMP Upgrade Package, includes second or third KL10-E processor and SMP software	340,000	1,575
DIB-20	Internal I/O bus interface for 1091 system	6,490	50
MAIN MEMORY			
MH10-LA/B	Core Memory; 256K words, 1.2-microsecond, includes 8 memory ports (includes MH10-HA and two MH10-E's):	50,400	565
MH10-E	Expansion Module for MH10-HA, 64K words; two required to upgrade MH10-HA memory unit to MH10-L memory unit	25,000	131
MF20-LA/LB	MOS Expansion controller (first backplane) with 256K-word memory module	50,400	565
MF20-LC/LD	MOS Expansion unit (second backplane) with 256K-word memory module	50,400	368
MF20-LH/LJ	MOS External expansion controller (first backplane) with 256K-word external memory module	50,400	565
MF20-LK/LL	MOS External expansion unit (second backplane) with 256K-word external memory module	50,400	368
MF20-E	MOS memory modules (two max. per backplane)	30,000	224
MASS STORAGE			
RH20	Massbus Controller for disk or tape	19,000	33
RP06-AA/AB	176-megabyte Add-On Single-Access Disk Drive	34,000	273
RP06-BA/BB	176-megabyte Add-On Disk Drive, dual-access version of RP06-A above; max. 7 per subsystem	39,140	302
RP06-C	Dual-access kit; converts one RP06-A single-access drive to RP06-B dual-access drive	5,150	29
RP07-AA/AB	498-megabyte Add-On Single Access Disk Drive	38,000	214
RP07-BA/BB	498-megabyte Add-On Disk Drive, dual access version of RP07-AA, above	43,140	248
RTP20-EA/EE	Disk Drive Subsystem includes controller and one RP20 1.2 gigabyte disk drive	149,000	649
RP20-AC/AD	1.2 gigabyte Add-On Single Access Disk Drive; max. 3 per RTP 20 subsystem	51,000	308
RTP20-EC/EH	Dual-channel option	68,000	151
MAGNETIC TAPE EQUIPMENT			
TX02-EC/ED	Magnetic Tape Controller and DX20 Channel for TU72 Series Tape Drives; requires RH20	96,800	619
TU72-EC/ED	Tape Drive for TX02-E; 125 ips, 1600/6250 bpi, PE/GCR	35,300	205
TX03-A	Two Channel Switch for TX-2-EE/EF	7,040	14
TX03-EE/FF	Two channel switch option and DX20 channel for TX02-E	54,600	257
TX03-FB	Two channel switch option for two TX02-E	12,800	27
TX05-EC/ED	Two control unit tape switch option and one TX02-E; requires one TX02-E	74,400	390
TX05-FB	Two control unit tape switch option; requires two TX02-E	25,700	27
TA78-BF/BJ	Master Tape Drive; dual access, 2 STI intercabinet cables 1600/6250 bpi, 125 ips	52,000	405
TA78-UG	Upgrade kit TU78-AB/AD to TA78-BF/BJ	15,000	—
TU78-AB/AD	Single Access Magnetic Tape Subsystem including formatter and 1 master tape drive, 125 inches per second, 1600/6250 bits per inch expandable to maximum of 4 tape drives/formatter	48,000	364
TU78-AF/AJ	Add-on Magnetic Tape Drive, 125 inches per second, 1600/6250 bits per inch	25,500	221

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EQUIPMENT PRICES

		Purchase Price	8 hr./5-day Maint. Service
PRINTERS			
LP20-CA/CB	Line Printer and Controller; 132 positions; 64-character; 900 lpm; 1091 only	36,500	355
LPL20-DA/DB	Line Printer and Controller; 132 positions; 96-character; 650 lpm; 1091 only	37,900	355
LP20-JA	Line Printer and Controller; 132 positions; 96-character; 600 lpm	18,700	196
LP100-FA/FB	Line Printer, drum-type, 64-character, 890 lpm; 1090 only	44,300	360
LP100-HA/HB	Line Printer, drum-type, 96-character, 650 lpm; 1090 only	45,400	360
LP200-BA/BB	Line Printer and Controller; 132 positions; Charaband-type mechanism; includes software, long line interface, and diagnostics, does not include Charaband; 900/1200 lpm; 1091 only	54,600	551
LP07-Y	Charaband for LP100 and LP200 printers; dual-sided; choice of 64- and 96- character EDP fonts, two 64-character EDP fonts, two 96-character EDP fonts, 64- and 96-character OCR-A fonts, two 96-character scientific fonts, 96- character EDP and scientific fonts, two 96-character Swedish/Finnish fonts, 64- and 96-character British fonts, two 64-character open Gothic fonts, or customer specified character fonts	4,300	—
LP27-2A/2B	Band Line Printer with JP20 controller, 800/1200 lpm	30,990	348
PUNCHED CARD EQUIPMENT			
CD20-AA/AB	Card Reader and Controller; tabletop mounting, 300 cpm; 1091 only	7,920	118
CD20-CA/CB	Card Reader and Controller; free-standing, 1200 cpm; 1091 only	27,960	201
COMMUNICATIONS EQUIPMENT			
DC20-AA	Basic Asynchronous Multiplexer; 8 lines, can be expanded to 16 lines with one DEC20-DA expander, max. 7 per system; for 1091 only	6,160	100
DC20-DA	Expansion group for use with DC20-AA above; 8 lines, max. 1 per DC20-AA	1,870	91
DC20-EC/ED	Communications Expansion Cabinet; required for over 64 communications lines, includes one DC20-AA basic 8-line group, max. 1 per system; for 1091 only	12,980	222
DC20-CD	Cables and Distribution Cabinet; for configuration between 32 and 128 lines	2,585	—
DN20-MC/MD	Data Communications Front End; requires DN20-BX synchronous line units and software; for 1090 and 1091	37,620	193
DN20-BA	Synchronous Line Controller; one allowed per DN20-M; includes DN20-BB; for 1090 and 1091	4,235	38
DN20-BB	Synchronous Line Unit; for expansion of DN20-BA; max. of 3 DN20-BB per DN20-BA	1,650	17
DN21-JA	Synchronous Line Controller and Interface for speeds between 19.2K and 56K bps; for 1090 and 1091	9,500	31
DN25-AA	Asynchronous Line Controller and interface for speeds from 2.4K to 9.6K bps; includes eight lines; for 1090 and 1091	5,335	51
DN25-BA	Asynchronous Line Unit, eight lines; for 1090 and 1091	2,035	38
DN200-MA	Remote job entry terminal; connects up to 2 synchronous and/or 32 asynchronous lines	29,200	179
TERMINALS			
LA38-AA	DECwriter IV Hard Copy Table-Top Terminal 30 cps; KSR; 132 position EIA interface, 14 position keypad	1,550	21
LA38-BA	With Universal power supply	1,660	21
LAX34-CL	20mA Current Loop Interface for LA38	120	4
LA120-DA	DECwriter III; 180 cps, numeric pad, EIA interface	2,800	38
LA12X-AL	20mA Current Loop Interface for LA120	140	—
VT100-AA/AB	CRT Terminal with detached keyboard; EIA interface supported in the VT52 compatible mode only	1,945	21
VT1XX-AA	20mA Current Loop Interface for VT100	140	5
VT1XX-AB	Advanced Video Option	180	5

SOFTWARE PRICES

		One-Time License Fee	Monthly Self-Maint. Fee
QH502-XM	Algol-10 binaries and source code supplied	$11,500	$118
QH072-AM	APL; same as APL-SF, but without file I/O; binaries only supplied	11,500	—
QH071-AM	APL-SF; binaries only supplied	23,000	193
QH503-XM	Basic-10; binaries and source supplied	6,900	144
QH099-XM	Cobol-74 plus Sort/Merge; binaries and source supplied	16,500	165
QH060-AM	CPL-10 (ANS-76 PL/1 subset interpreter; binaries only supplied)	6,900	—
QH500-XM	Fortran-10; binaries and source supplied	11,500	165
QH300-XM	Sort/Merge; binaries and source supplied	3,450	59
QH101-AM	DBMS-10; binaries only supplied	34,500	391
QH045-AM	IQL-10; extended with DBMS interface, both ISAM and sequential; binaries only supplied	19,600	198
QH074-AM	APL to APL-SF upgrade	17,300	—
QH302-XM	TOPS-10 Support for 1090 SMP	11,600	—
QH683-AM	DECnet-10, Version 3.0	8,600	—
QH603-XM	IBM 2780/3780 emulator/terminator	8,600	165
QH115-AM	BLISS-36	13,800	144 ∎