decsystem10

TECHNICAL SUMMARY

digital

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DECsystem-10 INTRODUCTION

SYSTEM HIGHLIGHTS

. One operating system, one user command language handles:

    Multiprogram Batch
    Remote Batch
    Timesharing
    Real-Time Tasks
    Dual Processors

. Flexible data communications, multi-speed lines, multi-character sets, synchronous, asynchronous

. Remote batch station with 16 terminals

. Real-time task capabilities:

    Guaranteed response to user of 10 microseconds
    Software assignable priority levels
    FORTRAN programming of all real-time capabilities

. Disk optimization system gives highest performance during heavy duty use

. Public and private disk file structures; mountable during operation

. 21 levels of file security including EXECUTE ONLY; READ ONLY

. Timeshared maintenance diagnostics

. Easy system expansion under one operating system

. Asynchronous operation of processors, memories, and peripherals

. 36-bit word length for both arithmetic operations and data transfers

. 378 instruction repertoire hardware, including hardware double precision floating point, variable-length byte manipulation and half-word instructions

. Direct memory addressing to 262,144 words, or 4096K words

. A multiprogram, timesharing system providing simultaneous real-time, batch and remote batch operation

. Real-time jobs or tasks are capable of being "locked" into core by means of a monitor call

. Programs may share a common core area

. Memory partitions are dynamic and change automatically under monitor control as required by system loading

. Hardware protection of user jobs in memory

- A dynamic scheduler positions jobs in various queues that are determined by the job history, current state, and other various system optimization criteria

- Standard I/O devices can be connected to several different priority levels so that each I/O is handled efficiently

- No differences in language specifications and compilers from batch to timesharing systems

- Programs are device independent, that is, peripherals are assignable at run time

DECsystem-10 PHILOSOPHY

The DECsystem-10 family represents a unique concept -- a wide range of computing power and computing capabilities under one operating system with one user command language.

The DECsystem-10 is an integrated system of hardware and an advanced multi-task operating system which provides the computer user with the highest possible performance from his investment. It serves interactive timesharing users, it operates local and remote batch stations, and it performs data acquisition and control functions for on-line laboratory projects.

Each of the five DECsystem-10 configurations is distinguished from the other by its range of performance - more than 10 to 1 - although between systems there are no fixed boundaries. System performance is increased by adding hardware. For the first time in the industry, we require no software changes to expand from our smallest system to our largest. The hardware added in this expansion includes: our swapping devices, memories, central processors, peripheral equipment and data communication systems.

The DECsystem-10 and its forerunners are founded on the principle that an operating system can do a far better job of allocating resources dynamically than any system staff can do of predicting the proper allocation.

All DECsystem-10 resources, such as processor time, memory space, file storage space, shareable hardware and shareable software, are allocated dynamically as directed by changes in the system load. Most -10 systems have been and will be used in environments where this dynamic allocation of resources is appreciated and often required. We believe that the user of the 70's has come to expect that computer systems will be available for his job at his convenience, independent of what the system may already be doing.

Through the DECsystem-10 monitor, the system can simultaneously service a wide range of job types and response requirements. The monitor allocates memory, storage, peripherals, and processing time among system users, employing an adaptive scheduling algorithm to dynamically adjust system operation.

The DECsystem-10 provides many features for each class of user. The timesharing user has a powerful command language and a choice of language processors including FORTRAN, ALGOL, COBOL, BASK and MACRO. Utility programs include on-line editing, debugging, and file copying programs. Files can be shared and/or protected against unauthorized access. Also, software is reentrant to save user core space.

The multiprogram batch user has the same services available to interactive users and can operate his programs from local batch stations, remote batch stations, or

interactive terminals. In addition, the user can specify many processing parameters, including start and complete dates, order of program execution, and recovery action in case of errors. Through an operator's console, jobs can be started, stopped, deleted or restarted. Throughput of batch jobs is also optimized by a large number of DECsystem-10 features.

The real-time DECsystem-10 user has a choice of response modes. One provides microsecond response to interrupts while another provides millisecond scheduling of jobs in high priority run queues. On-line data acquisition, for example, might be performed in the first, while reduction of the data -- a less critical task -- could be handled by the second. Multiple real-time users can be accorded other privileges by the system manager -- such as the ability to lock a job in core for fast response. By granting privileges, the manager preallocates system resources to assure required response for each user. Real-time programs may be written in either FORTRAN or assembly language.

For remote users, the DECsystem-10 introduces the concept of remote stations. In this concept, peripherals normally located at the main site can communicate with the DECsystem-10 from remote locations. These peripherals, which operate through a PDP-8/I or similar computer, appear to the user to be directly connected to the DECsystem-10. Under this scheme, the remote processor in a batch processing station not only services a line printer and card reader, but it can also serve as a terminal concentrator for up to 16 devices. In another station arrangement, the remote processor can perform data acquisition through an A/D converter.

All DECsystem-10 users benefit from the advanced file handling features. The DECsystem-10 file organization is completely independent of both the devices and the access method. In fact, different users can access a shared file by different methods. Allocation is also flexible. File space can be allocated upon user demand or preallocated, and a file can extend over more than one like device. DECsystem-10 also provides many features to optimize file access and allows the user to specify file protection codes including EXECUTE ONLY.

The DECsystem-10 has features for every user -- timesharing, multiprogram batch, real-time, remote station. Thus, the modern, growing computer center can offer a full complement of computing services to meet a large variety of computational demands.

DECsystem-10 PERFORMANCE RANGE

	1040	1050	1055	1070	1077
RELATIVE THROUGHPUT POWER	1	2	4	5	10
AVERAGE NUMBER OF SIMULTANEOUS TASKS UNDER MULTIPLE LANGUAGES	4-12	10-50	20-60	30-80	N/A

DECsystem-10 OPERATING CAPACITIES

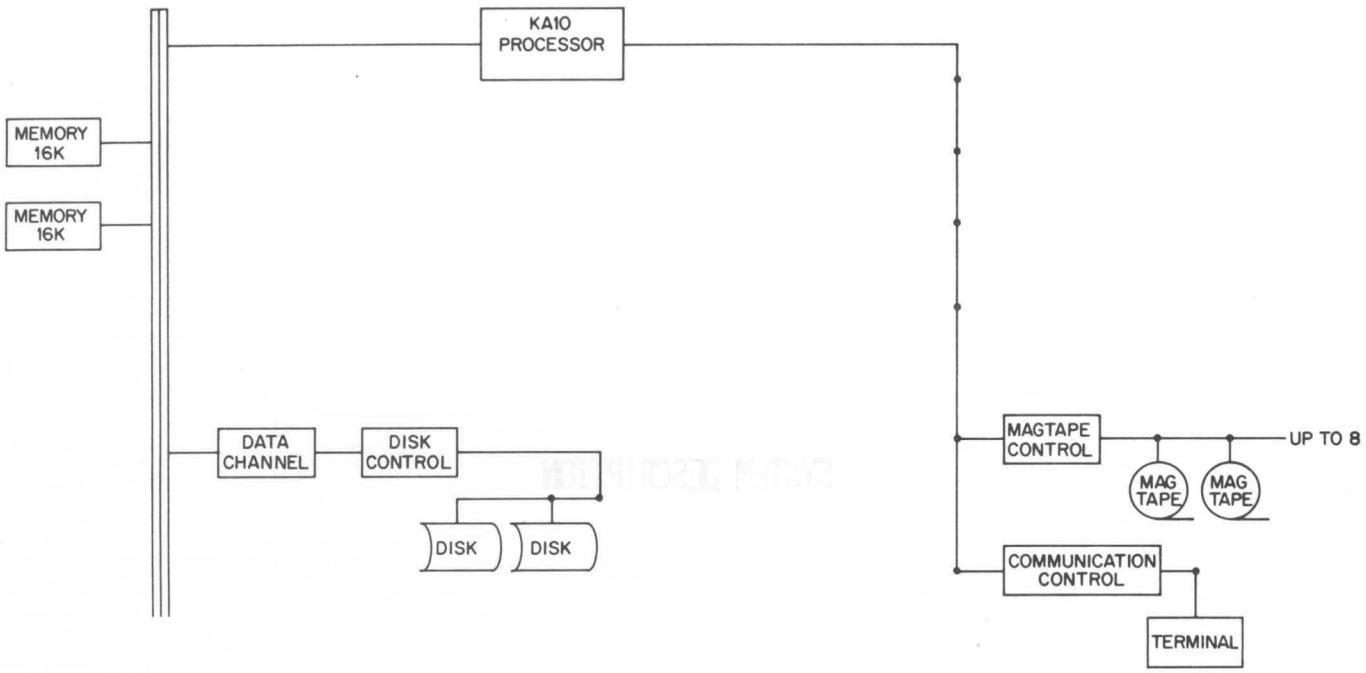
Number of simultaneous jobs	127
Number of concurrent batch streams	14
Maximum User File Size	No operating limit within the total file space available
Minimum File Size	128 words (768 characters)
Maximum core-resident job size (less monitor size on 1040, 1050, 1055)	256K words (1,280K bytes)

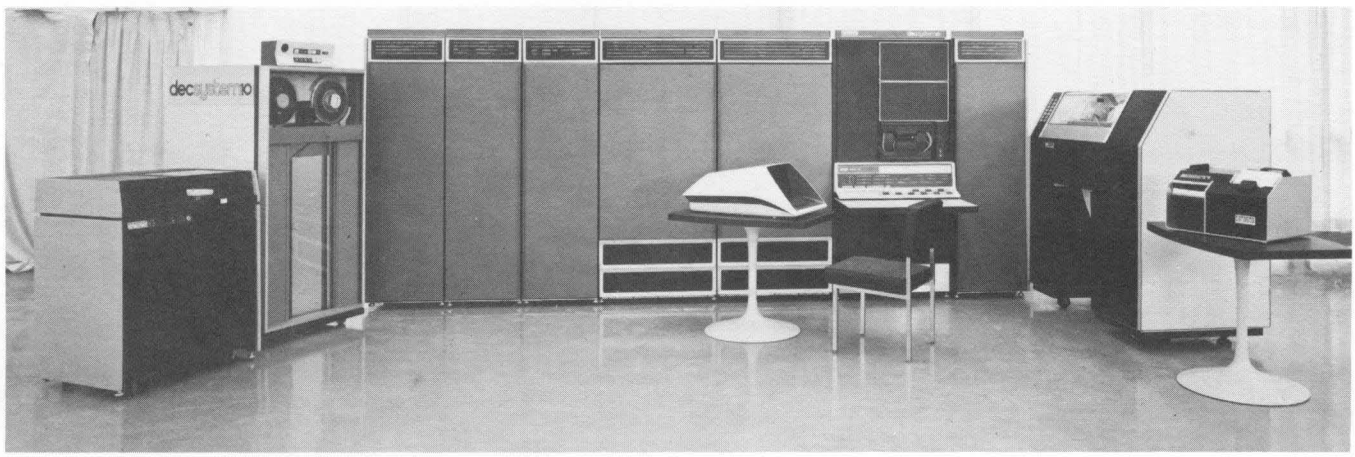
INPUT/OUTPUT	1040, 1050, 1055	1070, 1077
Low speed I/O rate (multiplexor)	222K words/second 1,110K bytes/second	370K words/second 1,850K bytes/second
High speed I/O rate (4 selector channels, 8 levels each)	4,000K words/second 20,000K bytes/second	4,000K words/second 20,000K bytes/second

SYSTEM DESCRIPTION

DECsystem-1040

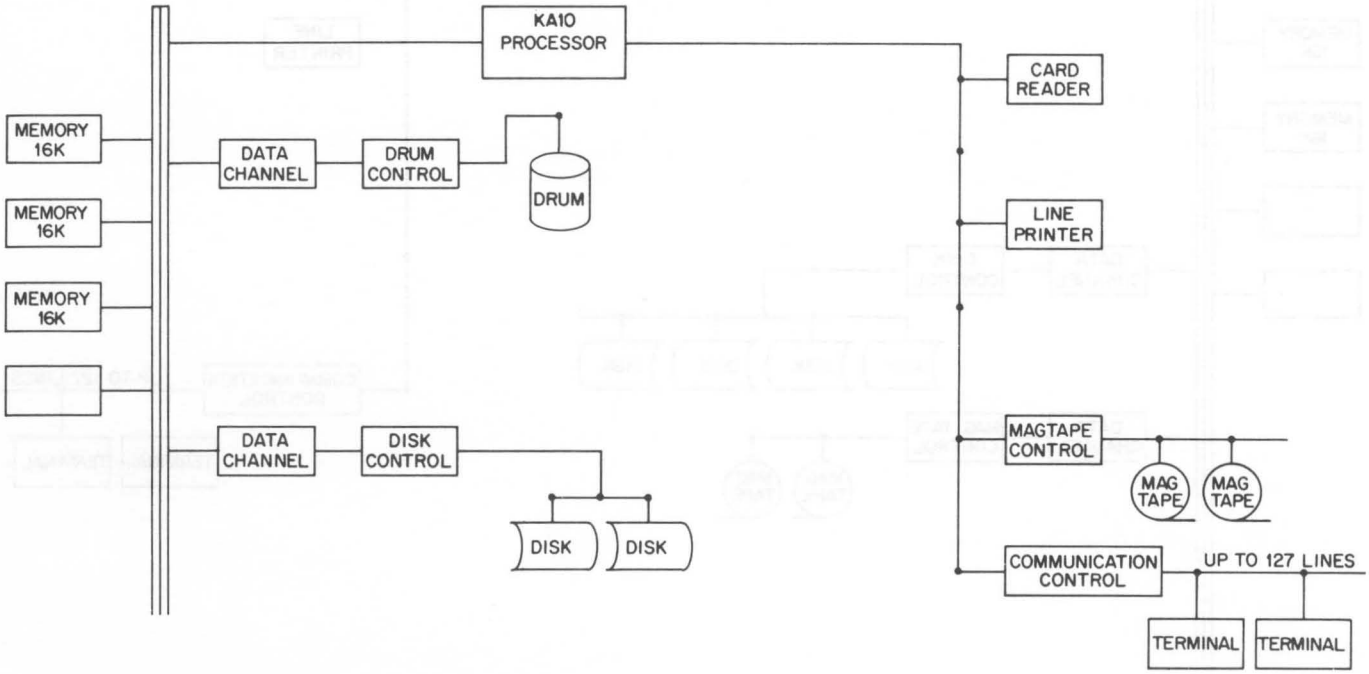
The 1040 is the smallest configuration in the DECsystem-10 family. It uses both the high-speed and low-speed memories, typically ranging in size from 32K words (160K bytes) to 64K words (320K bytes). Maximum memory size is 256K words (1,280K bytes). Disk storage capacity starts with 30 to 60 million characters and is easily expanded. Economical peripheral equipment for the smaller installation includes the CR10F low-speed card reader and the TU10 magnetic tape drive.

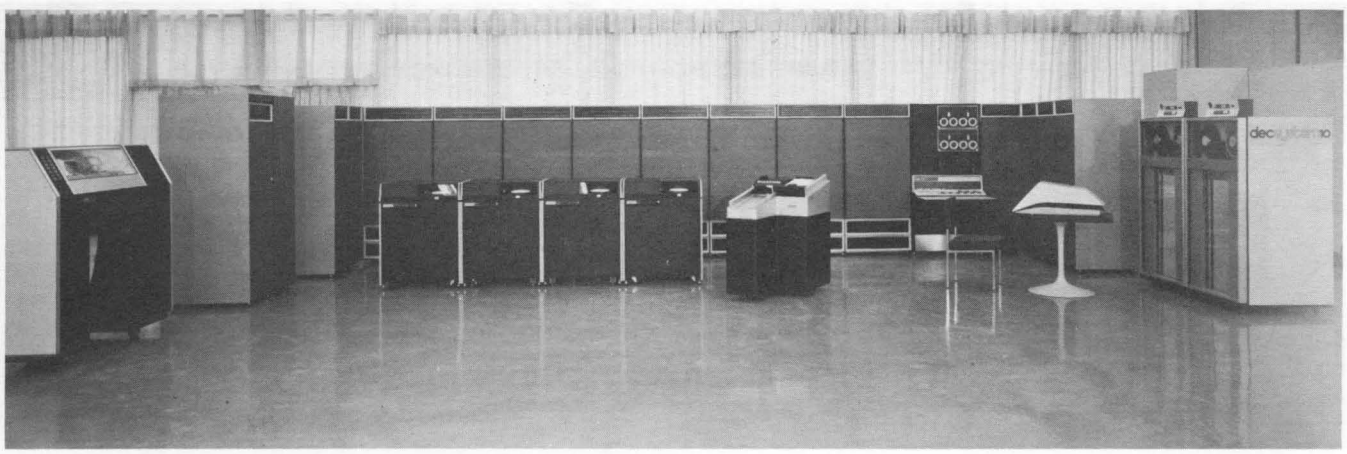




DECsystem-1050

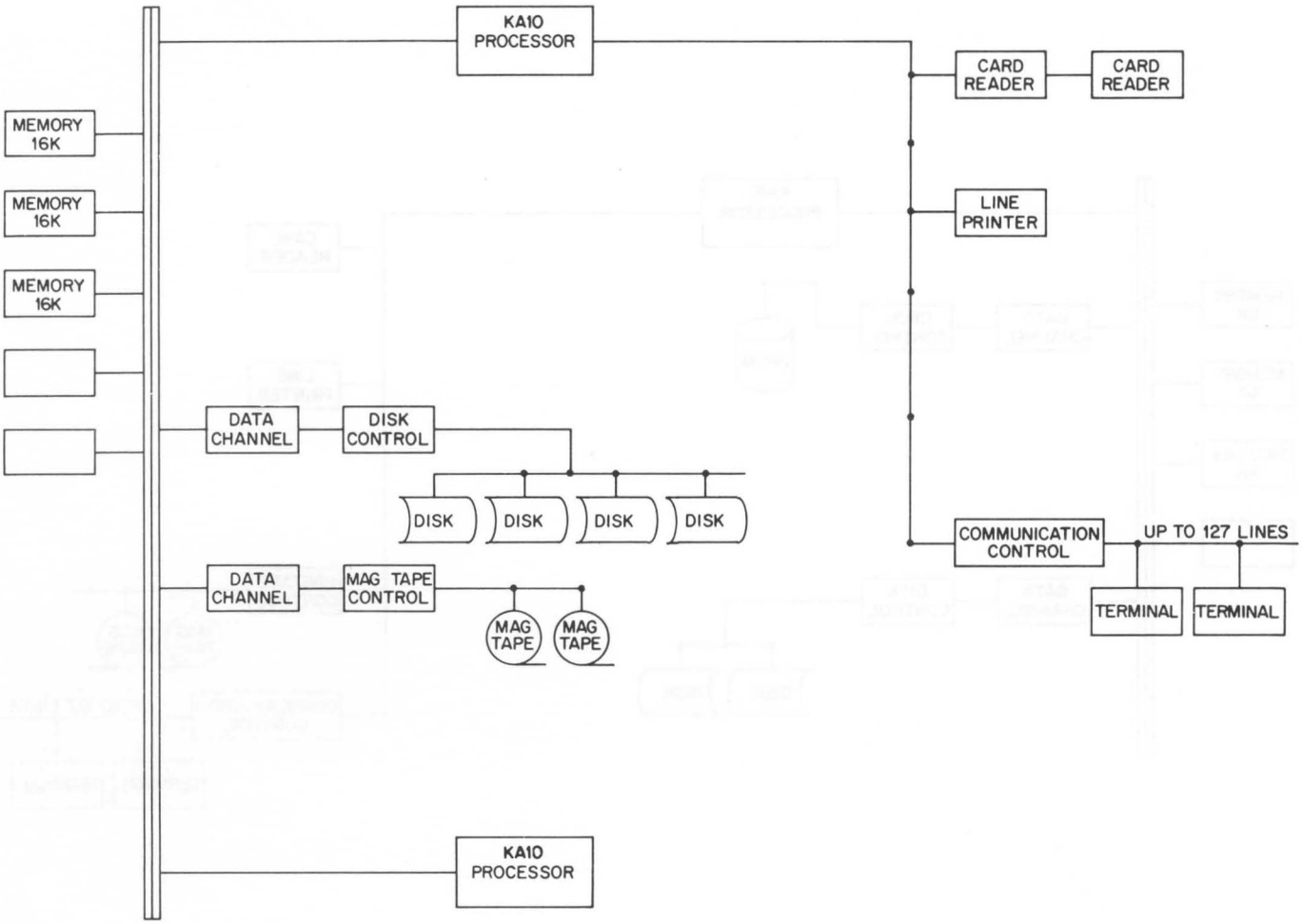
The 1050 is a medium power system with a typical memory range of 64K words (320K bytes) to 96K words (480K bytes). Maximum memory size is 256K words (1,280K bytes). A distinctive feature of the 1050 is the addition of the high-speed swapping drum which permits a substantial increase in the number of users making simultaneous access to the system. Disk storage typically ranges between 100 and 200 million characters and is easily expanded.





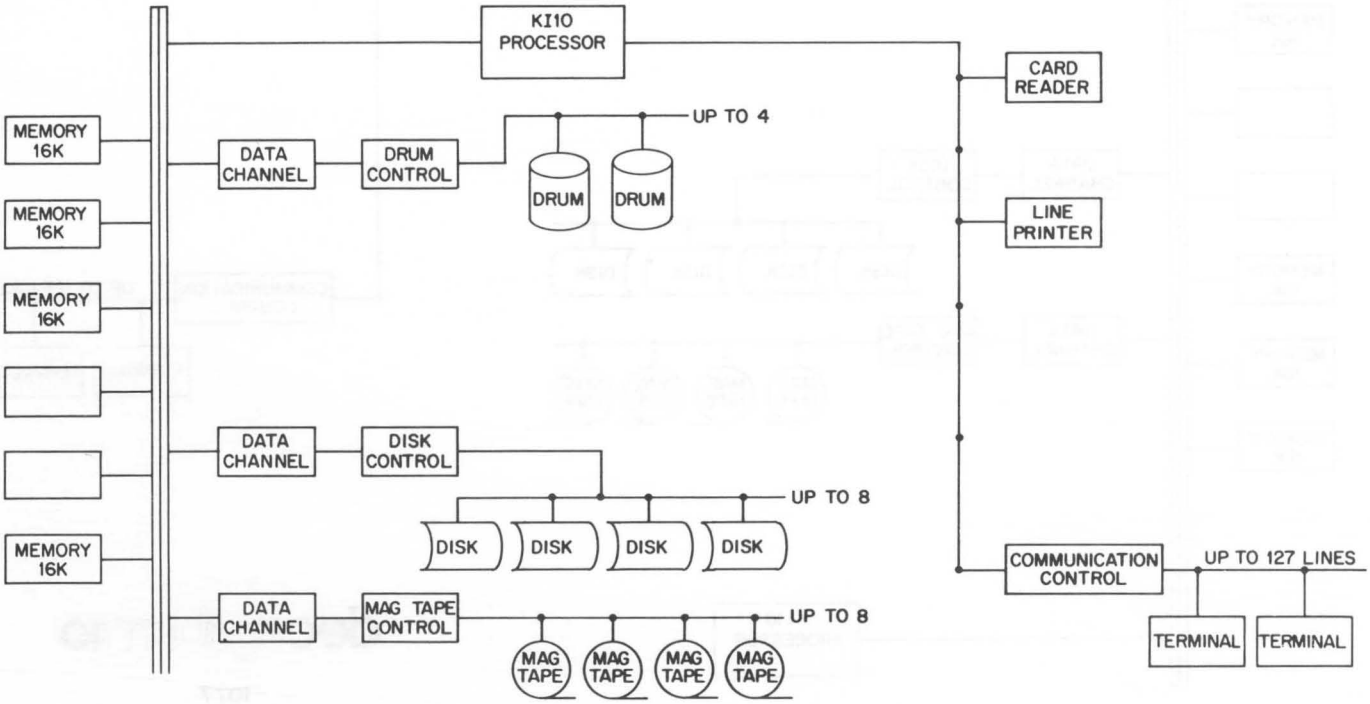
DECsystem-1055

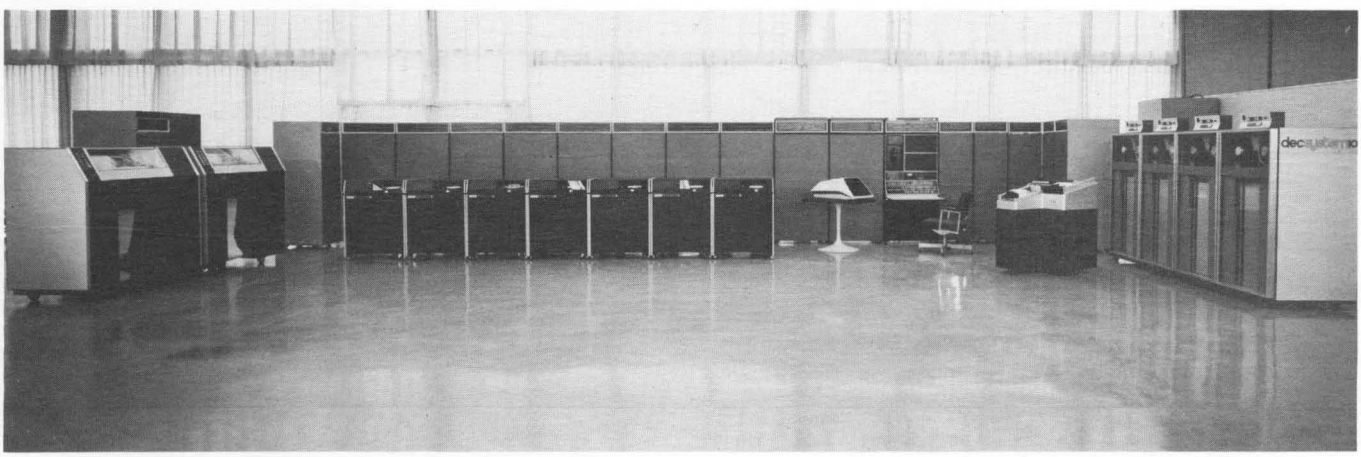
The 1055 is a dual processor 1050 system which provides increased computing capacity where processing power is in heavy demand under multi-task loads. To the user from any terminal, it looks as though there is one larger system with all resources shared among all users. Additional memory is required above the minimum 1050 system.



DECsystem-1070

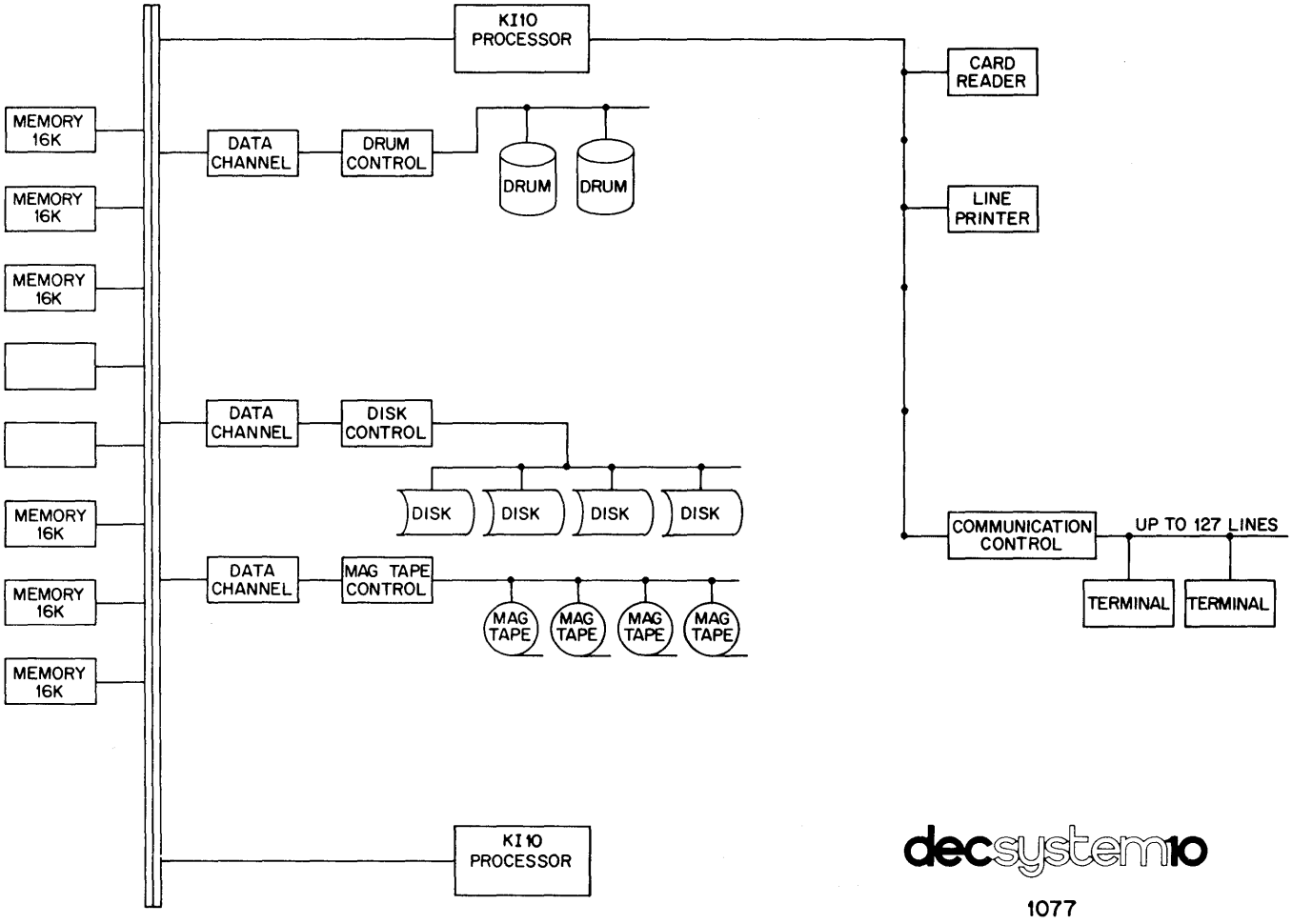
DECsystem-1070 is a large-scale computing system with more than double the central processor speed of the 1050. Features include instruction lookahead, increased memory size, hardware memory paging, higher speed I/O capabilities, double precision floating point arithmetic, and virtual memory capability. Memory for the 1070 begins at 96K words (490K bytes) and may be expanded to a maximum of 4 million words (20 million bytes). Disk storage requirements of the 1070 typically range from 240 million characters upwards. Up to 127 concurrent jobs may be run, and up to 127 interactive terminals may be connected to the 1070 from both local and remote sites. Multiple remote batch stations are multiplexed through the DC75 synchronous communications multiplexer.





DECsystem-1077

The 1077 is a dual processor 1070 system which provides increased computing capacity where processing power is in heavy demand under multi-task loads. To the user from any terminal, it looks as though there is one larger system with all resources shared among all users. Additional memory is required above the minimum 1070 system.



DECsystem-10 MAXIMUM EQUIPMENT EXPANSION

Except as noted, the expansion capacities apply to all five DECsystem-10 configurations and are supported by system software which is either now operational or will be operational by the 6.02 release. All devices are on-line and supported in normal multi-user operation.

Equipment	Maximum Number Units	Equivalent Capacity
CENTRAL PROCESSOR	2	-
CORE MEMORY (or equivalent) 1040, 1050, 1055 1070, 1077	 256K words 4,096K words	 1,280K bytes 20,480K bytes
DISK FILE STORAGE	4 controls, 8 drives each	1,920 million characters
SWAPPING DRUMS	2 controls, 4 drums each	13,800K bytes
MAGNETIC TAPE DRIVES	2 controls, 8 drives each	
DECTAPE DRIVES	2 controls, 8 drives each	
LINE PRINTER (Local)*	3	3,000 lpm
CARD READER (Local)*	2	2,400 cpm
CARD PUNCH (Local)	1	300 cpm
INTERACTIVE TERMINAL PORTS** 1040, 1050, 1055 1070, 1077	 63 127	
REMOTE BATCH STATIONS (Includes Card Reader, Line Printer, and up to 16 terminals. Only 2 supported on 1040.)	8	
REAL-TIME APPLICATION DEVICE	64 device codes	

* Additional remote units permitted.

** System software supports a total of 127 active jobs (timesharing, batch, real-time). A job may support multiple terminals, up to a total of 512 terminals on a system.

DECsystem-10 AT A GLANCE

	1040	1050	1055	1070	1077
Number of CPU's	1	1	2	1	2
Number of Hardware Instructions	366	366	366	377	377
Double Precision Floating Point Hardware	No	No	No	Yes	Yes
Core Memory Size (36-bit words) (min.-max. K words)	32-256	64-256	80-256	96-4096	128-4096
Memory Speed - microseconds/word (microseconds/5 bytes)	1.0	1.0	1.0	1.0	1.0
Operand Length	Immediate, 36 bits half word, full word			same plus double word	
Instruction Lookahead	No	No	No	Yes	Yes
Interleave	2 or 4 way	2 or 4 way	2 or 4 way	2 or 4 way	2 or 4 way
Memory Overlap Control	No	No	No	Yes	Yes
Paging, Virtual Memory	No	No	No	Yes	Yes
Base Registers	Yes	Yes	Yes	No	No
Memory Protection	Yes	Yes	Yes	Yes	Yes
Register Stacks: Index Registers	15	15	15 each	4x15	4x15 each
Register Stacks: Accumulators	16	16	16 each	4x16	4x16 each
Register Stack Switching	No	No	No	2.5μs	2.5μs
Interrupt Service Time	6μs	6μs	6μs	3μs	3μs
Maximum Interrupt Delay	40μs	40μs	40μs	10μs	10μs

MONITOR

INTRODUCTION

To keep multiple user programs running concurrently, DECsystem-10 uses multi-programming and swapping. The monitor maintains as many jobs as possible in core memory. However, if memory demand exceeds the supply the DECsystem-10 monitor can bring higher priority programs from disk or drum into memory, swapping them with lower priority jobs.

Because each memory block operates independently, the processor can be executing a program in one memory block while programs are being swapped in another. In addition, a program that has been swapped out does not have to be swapped into the same location to continue execution. Thus operation is much simpler than with systems that employ fixed or other cumbersome partitioning schemes.

The DECsystem-10 monitor saves core through reentrant software. That is, only one copy of a language processor (or any systems program larger than 1K) need be core-resident to serve multiple users simultaneously.

The monitor maximizes throughput by using an adaptive scheduling algorithm to schedule system resources. By assigning resources based on the recent history of each program, response time is kept to a minimum for highly interactive jobs, and jobs which require heavy processor use are operated efficiently without excessive swapping.

The monitor performs all I/O for the timesharing and batch user; buffering data, queueing I/O requests, and performing throughput optimization. In addition, all data seeks are overlapped; that is, requests for data transfer that are received simultaneously are queued in least-time-to-go order, taking into account the head's current track position and the rotational position of the disk or drum.

Although the monitor supplies the user with a broad range of services, it accomplishes its task with exceptionally low overhead. Studies indicate that a single compute-bound program experiences only five per cent more overhead than it would if operated singly, without the monitor. If swapping occurs, this overhead increases slightly.

TIMESHARING

The DECsystem-10 interactive user can perform a wide variety of tasks from solving a simple mathematical formula to implementing a complete information gathering and processing network. Depending on the system configuration and total computing load, the system can handle up to 127 active terminals simultaneously. These terminals can include CRT's and other terminals which operate at speeds from 110 to 2400 baud.

DECsystem-10 timesharing is general-purpose; i.e., the system is designed so that the command language, file structure, I/O processing, and job scheduling are independent of the programming language being used. In addition, standard software interfaces makes it easy for a user to develop his own special languages or systems. The large number of languages implemented on DECsystem-10s testifies to the value of this general purpose approach.

User Command Language

Through an easy-to-use command language, the timesharing user can control the running of his job to any desired extent. Specifically, he can:

- Compile, execute, and debug programs
- Create and edit files; list and delete files
- Communicate with the system operator and request such services as the mounting and dismounting of disk packs and magnetic tapes
- Assign himself specific resources such as magtapes, private disk packs, etc.
- Start, suspend, or terminate the job
- Spool program output to line printer, card punch, etc.
- Determine status of system and resources available
- Request a time and resource accounting of his own use of the system
- Send a message to any terminal in the system

In addition, since multiprogram batch uses the same command language as timesharing, any user may enter his program into the multiprogram batch run queue. Thus, any timesharing terminal can act as a remote job entry terminal.

Timesharing Peripherals

The timesharing user has access to any peripheral on the system. Access is achieved in three ways: through use of the ASSIGN command, I/O spooling, and common user files.

In direct assignment, the user employs an ASSIGN command to gain exclusive use of peripherals assigned to the public pool. When the request is received, the monitor checks to see that the device is not assigned to another user. If the device is available, the user is granted its dedicated use and he operates just as if he had access to a dedicated system. In this manner, individual users can have complete control of card readers, line printers, magtapes, card punches, private disk packs, paper tape readers and punches.

To improve input and output efficiency, the user can employ spooling for slow peripherals such as the card reader, card punch, paper tape punch, line printer, and plotter. By using a QUE command, I/O for these peripherals is first sent to high speed storage - either drum or disk pack - so that the user program does not take up valuable core space while I/O is being completed. Later the data is automatically transferred (unspooled) from fast storage to the CPU or shared slower device. This I/O buffering technique allows the peripherals to be used more efficiently by leveling the demand fluctuations experienced by slow peripherals.

Users may also share fast storage devices, such as public disk packs and drums, through the use of files. DECsystem-10 file service allows each user to be assigned storage quotas on either or both of these types of devices. Each file has a name

assigned by the user and protection codes which can specify different access privileges for project and non-project members. These codes, which include READ AND MODIFY; READ ONLY: EXECUTE ONLY: and NO ACCESS, preclude file access to unauthorized persons to maintain the security of proprietary projects and/or software.

DECsystem-10 never requires the user to preallocate file storage but dynamically provides storage space on demand. This feature is convenient for the user and it also prevents large blocks of storage from being tied up unnecessarily.

MULTIPROGRAM BATCH

The multiprogram batch system provides features which make the system easy to use, yet provides wide flexibility for both the user and the computer system operator. Users can enter programs through equipment at the central computer site, remote batch stations, or by using interactive terminals. The system provides throughput by optimized scheduling of system I/O and processor resources.

Using Multiprogram Batch

The multiprogram batch command language is easy to learn and compatible with the commands for interactive timesharing. Programs often require only a few control cards to operate. For example, to run a simple FORTRAN program, the user only requires the following control cards

```
$JOB
$FORTRAN
Program
$DATA
Program Data
END OF FILE
```

(These cards may be supplied by the installation operator.)

The batch command language also provides wide flexibility for the experienced user. For example, the user has a choice of submitting his job via card reader, magnetic tape, DECtape, or disk packs, in a variety of input modes: ASCII, binary, image, or 026 or 029 keypunch codes. He can also set "start" and/or "complete" time limits for program execution, giving a DO NOT START BEFORE date and time, or the date and time that a program must be completed. If execution order is important, the user can state, for example, that programs A and B cannot be started until program C has been executed. He can also request that a particular program be executed at specified intervals.

The user can control system response to error conditions. He can specify the emergency action to be taken if his program should contain a fatal error - such as, skip to the next program or transfer to a special error handling routine. To stop looping, he may set an execution time limit. He can also set limits on program output, such as the number of pages printed, number of cards punched, etc.

A user can also delete any of his jobs or change their parameters through his remote batch station or interactive terminal.

Although the system allows a large number of batch operating parameters to be specified, it will operate with very few user-specified values. If a particular parameter is missing, the system supplies a reasonable default parameter. These parameters can be adjusted by the installation.

Optimizing Batch Throughput

To optimize batch throughput, the DECsystem-10 monitor dynamically schedules system resources among user programs. The system can be entirely dedicated to batch operations or the computer system manager can dynamically specify the percentage of processing time and core memory that can be dedicated to batch processing. Jobs are scheduled on the basis of core requirements, the ratio of processing to input/output, processing time limit, and any specified user deadlines or priorities.

To provide fast throughput for high priority batch jobs, the monitor uses the same swapping technique that provides fast response for interactive users.

When a high priority job enters the run queue, the monitor checks to see if enough memory is available. If memory is not available, the monitor swaps a program (or programs) of lower priority to disk or drum storage.

Swapping provides greater efficiency than the traditional roll-in, roll-out techniques, since it occurs in milliseconds and takes place at the same time that the processor is operating other programs. This speed allows the monitor to fill the gaps in processor operation, by allowing other programs to operate while a high priority program waits for I/O or other services. For example, valuable core memory is not tied up while a tape is rewinding.

Throughput is increased by the spooling of input on the disk prior to program operation. Also, all requests to the operator for the mounting of tapes or disk packs may be staged. That is, the operator is alerted to perform these operations and must acknowledge his action before a program can enter a run queue for operation. Thus programs requiring these services never usurp core space while waiting for the operator.

Another core-saving feature is the spooling of output to slow devices such as line printers, card punches, plotters, and paper tape punches. In this operation, output is queued on secondary storage and fed from storage to the device so that a user's program will not take up valuable core space during the slow printing or punching procedure. Interactive users can also submit files to the output queue.

Batch jobs can share reentrant code with other batch jobs as well as with interactive timesharing programs. For example, only one copy of the FORTRAN compiler is needed to service any number of batch and timesharing jobs simultaneously. On other systems, each job needs its own compiler, so much more core would be required.

Operator Functions

Under normal operating conditions, multiprogram batch requires a minimum of operator attention. However, if desired, the operator can exercise any degree of control. He can specify the amount of system resources to be dedicated to batch processing by limiting the number of programs, and the core and processor time for individual and/or all batch programs.

The operator can stop a job at any point, requeue it, and/or change its priority. On spooled output, he can suspend a job and requeue it to be resumed later. The job can be resumed from the point where it was suspended, at the beginning, or at any point, as the operator sees fit. He can also request the sequential printing

of jobs which require the same forms. Alignment of these forms on the printer is aided by a special software feature which lets the operator repeat a filed alignment pattern until the printer is adjusted satisfactorily.

All these operations are performed through the use of one or more teletype or keyboard CRT consoles. In addition, these consoles allow the operator to determine the status of batch jobs by examining all the queues in the system. Operators at remote sites have similar access to status information.

REAL-TIME TASK HANDLING

Among the features of the real-time software are: fast response, high throughput, and no fixed memory partitions. Both single and dual processor systems are supported.

Every demand for system resources, ranging from the most time-critical real-time task to batch processing and timesharing, is handled efficiently. Real-time programs may be written in FORTRAN or MACRO-10 (assembly language).

In order to obtain fastest response, a job may be driven directly in response to the priority interrupt system and be run in Executive mode, providing response times limited only by the ability of the hardware to respond to interrupts (typically under 10 microseconds).

Response times of 100 microseconds may be obtained by programs running in User mode by means of the Real-Time Trap monitor call providing fast response while simultaneously offering protection to the rest of the system.

Response times of a few milliseconds or less may be assured by placing the program in any one of 15 high priority queues maintained by the system scheduler.

Using this mechanism, system response may be biased to favor real-time tasks, batch processing or any other program or group of programs - a very useful tool for the system administrator or batch operator.

Through a series of monitor calls, jobs may be run on a periodic basis under control of the system clock. Also, one job may request that another be run - a feature useful when a block of data has been input and an analysis job on the disk system is selectable. High priority queue assignments allow the system to be tailored to optimize performance.

Real-Time Software Features

Real-time programmers are able to call upon unique DECsystem-10 monitor features for various privileges and services.

Fast Response to Interrupts - Real-time programmers may dynamically connect and disconnect their time-critical real-time equipment and tasks to the DECsystem-10 priority interrupt system.

Response to interrupts is immediate. Real-time programs run at interrupt level in either Privileged User or Executive hardware modes. A spectrum of real-time privileges is provided to be administered by the system manager.

The interrupt service time for each data word in fast block mode is 6.4 microseconds and in normal block mode, 14.6 microseconds. User programs can get control in 3.1 microseconds, "super" Executive mode; in less than 10 microseconds, Executive mode; and in 100 microseconds with maximum security Privileged User mode. In all cases the real-time code is completely protected from the coding errors or program bugs of timesharing and batch processing users.

Core Management Control - The real-time programmer, by means of a monitor call, can cause his program to be "locked" into core and, thereby, to become protected against being "swapped" or rolled out onto the disk (drum). Prior to performing the "lock", the monitor positions the real-time code so as to ensure the efficient use of core by maximizing contiguous space in the remaining core area.

Job Priority Assignments - DECsystem-10 programmers, with privileges granted by the system administrator, can assign any of fifteen priorities to their job(s). The system may be biased to favor real-time, timesharing, and/or batch jobs of special interest. An analogous console command allows a terminal user to make these assignments. The job scheduler always scans high priority queues first and in descending priority order.

Jobs May Share A Common Data Area - Programs (more than one job) may share a common area in core. Thereby, a data collection or filtering program can pass data to a more extensive analysis program for processing. This technique, provided by the DECsystem-10 protection and relocation hardware, allows one to lock the smaller program in core, with the large analysis program remaining disk resident until needed.

Jobs May Go To Sleep Until Awakened - When a program is not needed until another task has been completed or until a specified length of time has passed, it may declare that it wishes to "hibernate." If a time is specified, it will awaken when that period has elapsed. If no time is given, the job will wait indefinitely until called by another job. "Waking" a suspended job is accomplished by executing the monitor call WAKE with the job number specified. Waking is immediate if the hibernating job has previously been given highest priority.

Real-Time Jobs Are Completely Protected From Background - Exec, Privileged User, and User hardware modes, plus memory protection and relocation hardware, provide protection from coding errors and program "bugs."

Protection Against Loss of Data Files - Redundant recording of file retrieval information ensures against loss of data files.

Protection Against Loss of Power - Power Failsafe hardware provides system security against loss of power.

No Fixed Memory Partitions - DECsystem-10 dual memory protection and relocation hardware provides absolute address protection and relocation of jobs throughout core memory - dynamically.

Reentrant Systems Software - Conserves core space in the multiprogram environment. Jobs may share core space.

Dual Processor System - Master-slave dual processor systems supported by system software.

Unified Job Control Language - One job control language for real-time, batch and timesharing users.

Higher Level Language Control of Real-Time Tasks - FORTRAN routines provided for real-time system usage.

Dynamic Scheduler - Does not use fixed time slot or round robin algorithm.

FILE HANDLING

File service for disk packs, drums and disks is designed for maximum convenience and system efficiency. Each user may have as many files as he desires on any of the file storage devices in the system. The only limit on file size is a quota, which the installation can set for each user, or the physical capacity of the installation-defined file structure, which can include storage on several like devices. Each file is referred to by name so that the user is not required to know where his file is physically located.

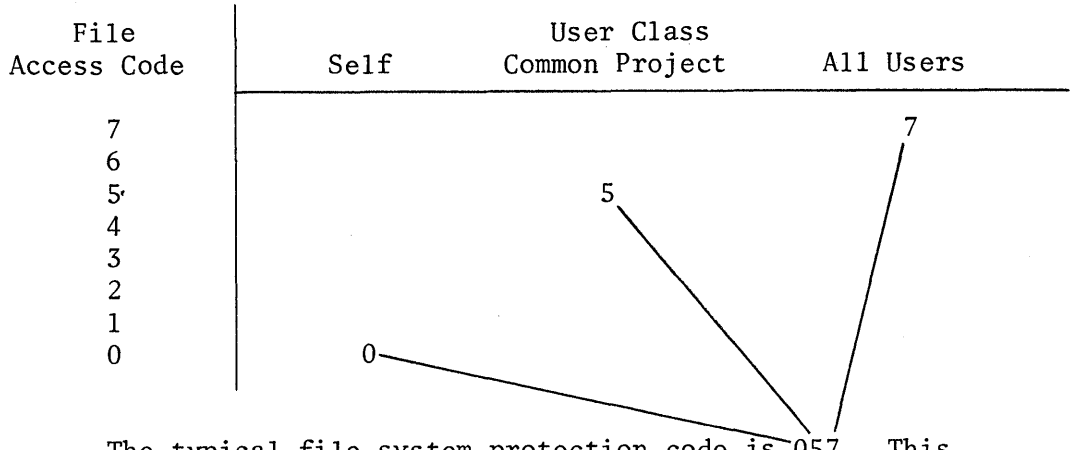
For user convenience, file organization is independent of access method. Therefore, it is not necessary to reorganize a file completely to change from sequential-access to random-access methods. The user may even change his access methods during file processing. For example, he could use random-access methods to find a pointer block, and then use sequential-access for the remainder of his processing.

File storage is dynamically allocated during program operations, so there is no need to preallocate a certain number of blocks before a file is established. This feature is especially useful during program development and debugging, when the final size of the file is still unknown. However, a user is not limited to automatic allocation. If he wants to, he can reserve a contiguous area on a drum or disk pack to make sequential and random processing even more efficient. When processing is completed, he can keep his preallocated file space for future use... or return some or all of it to the public pool.

For convenience and flexibility in system design, files can be shared concurrently (even with different access methods) among specified users through the use of protection codes. These codes, which are assigned when the file is created, describe the access privileges of the person who created the file, members of the same project, and all other system users. These persons or groups may be assigned any number of privileges such as EXECUTE ONLY: READ AND EXECUTE: READ, EXECUTE, AND MODIFY: or any of the groups may be completely excluded from file access.

Protection Level	Access Code	Access Privileges
Greatest Protection	7	No access privileges
	6	EXECUTE ONLY
	5	READ, EXECUTE
	4	APPEND, READ, EXECUTE
	3	UPDATE, APPEND, READ, EXECUTE
	2	WRITE, UPDATE, APPEND, READ, EXECUTE
	1	RENAME, WRITE, UPDATE, APPEND, READ, EXECUTE
Least Protection	0	CHANGE PROTECTION, RENAME, WRITE, UPDATE, APPEND, READ, EXECUTE

Files are assigned protection levels for each of three classes of users: self; users with a common project number; and all users. Each user class may be assigned a different access privilege, so that there are 21 possible combinations:



The typical file system protection code is 057. This protection excludes all general users, but permits users on the same project to READ and EXECUTE on the file. The file owner has all privileges.

Updating a file is performed by either of two methods - superseding or updating in place. When a person makes a change by superseding a shared file, concurrent users are not affected until they finish using the file and later reaccess it. In situations where users need immediate access to the most current data, such as in management information systems, data bases are updated in place. In this method, concurrent users receive changes as soon as they are made.

In some applications it is necessary for a person or group of users to have complete control of a file structure, such as when file processing depends on the mounting or dismounting of disk packs. A disk drive can be designated as private and assigned to one user, so that packs can be mounted or dismounted without disturbing other users.

On the DECsystem-10, file processing is highly efficient. In sequential processing, the monitor checks to see if the next block of data requested by the user physically follows the current block; if it does, the monitor uses command chaining, a hardware feature of the data channel, and loads additional buffers scattered throughout the user's core area. The system optimizes accesses, I/O requests are queued and processed on the basis of minimum access time. To assure retrieval of data positioned farthest from the moving head, both seek and latency algorithms employ a fairness clause, which means that after a given number of retrievals, the data that has waited the longest is accessed next. The number of retrievals is an installation parameter and can be adjusted to meet specific operating conditions. When multiple moving-head disks are employed, the monitor also overlaps seeks on all devices and allows simultaneous transfers to and from core memory via separate data channels.

The DECsystem-10 monitor avoids unnecessary file accesses by maintaining retrieval information for recently active files in an in-core data base. For reliability, the retrieval information is recorded in two separate locations on the file device, reducing the probability of destroying both directory locations simultaneously.

Swapping space (random-access storage which receives core memory overflow) may be allocated on any file storage device. The monitor employs the fastest device first. When its allocated space is full, the next fastest device is employed for swapping. No special device is required for operation; the system can use disk packs as the sole storage media just as easily as it can employ a full complement of disks, drums, and disk packs.

LANGUAGES

COBOL

The DECsystem-10 COBOL compiler is the complete implementation of the ANSI Standard COBOL X3.23 1968 and is designed to work in a batch or interactive environment.

Under batch, series of compilations, program loading and execution directions, and data decks can be stacked in a card reader (or any other device), leaving the user free to do other work while his batch job is running.

Timesharing terminal control of COBOL is especially helpful during the debugging stage of a program. The user is able to follow the progress of his program by causing the program to pause at any desired step during execution; he may then examine and modify his data at will before continuing execution. Having discovered the cause of an error in his program, the user can modify his source program on the disk, recompile and begin execution again, easily and in a short amount of time.

The COBOL compiler is very fast; compilation speeds vary from 2000 to 6000 statements per minute. Compilation times are 4 to 20 times faster than the IBM 360/50 COBOL compiler.

Listings produced by the compiler contain many documentation and debugging aids. English-language diagnostic messages are imbedded in the source listing at the point of error. The programmer need no longer thumb through a list of error codes and their meanings to find out what went wrong, he need not flip back and forth between his source listing and an error listing page to mark up his program.

In addition to the better diagnostics, the listing may also include, at the user's discretion, a complete map of his object program, a complete cross-reference list of his source program, and an easy-to-read listing of the compiled code. The latter is presented in the form used by MACRO, the DECsystem-10 assembly-language compiler. All object code is expanded to list the machine mnemonics and user-defined names in addition to the binary machine code.

The complete implementation of the COBOL SORT and REPORTWRITER statements reduces the workload of the business programmer. A major portion of a programmer's time is spent writing and debugging programs that sort and report data. The COBOL compiler allows this process to be done with a minimum of writing, reducing both coding and debugging time.

A complete ISAM package is included in the COBOL object-time system. This package allows the user to reference a large file of data without caring how it is actually stored on a peripheral device. The throughput for DECsystem-10 ISAM files is much improved over existing competitive systems. The time required to access a file is independent of the number of additions made to the file, reducing the need for major overhauls of the file. The technique of 'chaining' additions is not used; instead the index to the file is constantly updated to minimize the number of accesses necessary to retrieve records.

The conversion time necessary to take COBOL programs from another computer and put them on the DECsystem-10 is reduced. The COBOL compiler is ANSI-standard; features designed to work on a specific computer have been kept to a minimum, allowing the programs to be compiled on any computer having an ANSI compiler. For those programs written for older versions of COBOL, conversion programs (themselves written in COBOL) are provided, which modify the source program and flag any non-standard statements.

ISAM Indexed Sequential Access Mode

ISAM has been added to the DEC COBOL system to provide additional compatibility with other industry COBOL systems and with a small amount of programming. The programmer need only to know what he is looking for and not where it is physically located. All of the searching and movement of data is automatically handled by the COBOL Object Time System.

Each record in the file has a field called RECORD KEY. The contents of this field is unique in every record. When the programmer wants to read a specific record, he specifies the contents of that RECORD KEY, and the COBOL object-time system searches the file until that record is found, or tells the programmer that the record does not exist.

The search for the record involves looking through an index or dictionary associated with the data file in such a way as to reduce the number of times the file must be accessed. The maximum number of accesses for the largest data file is 11; the average is closer to 2 or 3; it could be none.

Whenever records are added to the file, the index is automatically updated; additions to the file will not degenerate the file as with other computers. The common technique of 'chaining' added records has been avoided. Whenever records have been deleted from the file, the empty space is used again for later additions. The net effect of the additions and deletion techniques drastically increases the time between major "overhauls" of the data file.

On-Line Debugging

The on-line debugging package permits user interaction during the execution of a program. No changes to a source program are necessary to use the facilities of the package; it is loaded with the object program when execution is to start.

The user can specify points within the program at which to pause during execution. During these pauses, the user may examine the contents of any data fields in order to check on the progress of his program, and if he so desires, alter those contents before proceeding.

All references to data and procedure items is made by using the name in the source program; the user talks to the debugging package using names with which he is familiar, rather than truncated or substituted names.

CREF Cross-Reference Listing

CREF is a documentation and debugging aid incorporated into the COBOL compiler. It produces a listing of every occurrence of a reference to each user-defined item, sorted on item name.

At the request of the user, the COBOL compiler will produce a map of the user's file, data and procedure items, listing the key parameters of each item.

These parameters include the source line number at which the item is defined and the address of the item in the object program. In addition, the access mode, recording mode and labeling conventions are listed for each file, and the size and usage is listed for each data item.

Report Writer

A major portion of the programming man-hours of a business-oriented system is devoted to the writing of report-producing programs. Not only are report programs the greatest percentage of programs written, but they are usually written by junior and, therefore, less experienced programmers who take longer than more experienced programmers to write and debug the programs.

The ANSI Report Writer feature in the COBOL compiler is one solution to the man-power problem. The programmer describes how a report is to look, instead of writing the tedious logic necessary to produce the report. That logic is created by the compiler from the description of the report. Not only is there a reduction in the time required to write the program; most of the errors in logic are removed.

SORT

When producing almost all reports, and when sequentially updating a file, data must be sorted into some order.

The SORT package is both small and fast. Sorting progresses at a rate of 1000 to 5000 records per minute using disk packs as scratch devices. Any other retrieval device may be used, including magnetic tape, DECtape or drums.

The COBOL compiler allows the user to specify, in a compact way, how a file is to be sorted. The sorting process may include editing of data, reading from more than one file or writing more than one file, including the production of a report, all in one program instead of a separate program for each function. Since only one program is written, documentation is improved, debugging is facilitated, and the intervention of an operator is reduced; in total, errors are reduced to a minimum.

RERUN

Many business-oriented systems include jobs which run for hours. If something should happen to disrupt that job, an entire day's work could be lost.

The RERUN feature provides the facility to periodically save the status of a job. In the event of a later disruption, the job may be restarted from the point of the last SAVE instead of starting again from scratch; a half-hour may be lost instead of a half-day.

CALL - Using FORTRAN and Assembly Language Routines

Occasionally, a process must be done which either cannot be done with a COBOL program or which may be written more quickly and efficiently in another language.

COBOL allows the user to write separate subroutines to be compiled either by FORTRAN or by MACRO (the assembly language), and to be called or entered from a COBOL main program.

An example of this approach is to use the more powerful COBOL device-handling routines and report-producing features, and to use a FORTRAN subroutine to compute complex scientific expressions. In this way, the more clumsy FORTRAN input-output is avoided, but the ability to use the scientific library is retained.

EBCDIC

The standard recording mode for COBOL programs is ASCII, in either 7-bit or 6-bit bytes. The user may, however, read or write magtape in EBCDIC in a format compatible with IBM/360.

FORTRAN IV

The DECsystem-10 FORTRAN IV language is a superset of the ANSI Standard FORTRAN IV. Both the compiler and object-time system are reentrant (shareable). The one-pass compiler produces optimized and efficient object code. The following is a summary of key features and/or extensions of DECsystem-10 FORTRAN IV:

- Sub-expression optimization
- Literals, Text and Constants may be specified by single quotes
- N-dimensional arrays
- ENCODE/DECODE statements
- Boolean operations equivalent (EQV) and exclusive (XOR), in addition to OR, AND, NOT
- The namelist feature provides format free-output operations
- The T-FORMAT specification allows for input/output data to be transferred direct to core memory beginning at any specified location
- Random-access features
- Compatibility with IBM-type statements, such as "REAL *8", etc.
- General Integer expressions in DO statements
- Implied DO loops in I/O statements in data statements
- Debug lines denoted by a "D" in column 1, compilation controlled by compiler switch
- Implicit statement
- Multiple returns from subroutines
- Full mixed mode arithmetic in expressions
- Octal Constants
- Logical Operations - full-word, masking operations for all logic functions (not just true or false), mixed mode expressions

. END= and ERR= in I/O statements

. Real-time support routines

. Device independence

The FORTRAN IV object-time system controls the input/output, format interpretation, and numerical conversion for programs compiled by the DECsystem-10 FORTRAN compiler. The FORTRAN user may reference any I/O device (line printer, card reader, magnetic tape, DECtape, paper tape reader and punch, disk, teletype and plotter). All special editing, conversion, and file structuring tasks are handled by the object-time system. Devices are normally specified by logical assignment so that physical device selection need not be made until runtime. The devices corresponding to the special I/O statements READ, PRINT, PUNCH, ACCEPT, and TYPE are also assignable at runtime. The object-time system is modular so that only those routines specifically required by an object program are loaded into core at runtime.

ALGOL

ALGOL is an implementation of the language ALGOL-60 on the DECsystem-10. The implementation is extremely efficient, employing sophisticated and up-to-date compiler and object-time system techniques. In addition to providing an ALGOL-60 with the minimum of restrictions, it has advanced features which enable the user to program a wide range of problems in a compact and flexible fashion.

Size: 12K high segment (shareable), 2K+ low segment (depends on size of program to be compiled)

Speed: Better than 5000 lines/minute (a 'line' defined as containing 24 significant symbols, unpacked; input from disk, output and listing to disk, measured C.P. time)

Features: The one-pass, single phase, highly efficient compiler has excellent diagnostics and generates efficient optimized object code

It features:

. Long real scalars, arrays and procedures, giving 54-bit mantissae (1050) or 62-bit (1070). 1070 version uses the new double precision hardware

. String scalars, arrays and procedures, and byte manipulation; allows the user to generate, manipulate and input/output strings of bytes or handle individual bytes of size between 1 and 36 bits. (Utilizes DECsystem-10 byte hardware.)

. WHILE statement and abbreviated form of FOR statement allow user greater flexibility in handling iterations.

. Procedures may be compiled independently of programs.

. Assignments are permitted within expressions.

. REMainder operator

. Unique implementation of dynamic own arrays.

. Octal boolean constants and integer/boolean and boolean/integer transfer functions.

. Alternative 'reserved delimiter word' or 'quoted delimiter word' hardware representations.

Restrictions:

. Numeric labels not allowed.

. All formal parameters must be specified.

. Identifiers are restricted to 63 symbols.

. Forward declarations must be given in certain *rare* circumstances for labels and procedures.

ALGOL Object-Time System

Size: 5K high segment (shareable), 2K+ low segment (depending on size of object program, library routines utilized, and heap and stack size).

The object-time system performs the following functions:

. Provides a flexible basic input/output system enabling the user to communicate with DEC directory and non-directory devices in ASCII and binary modes, handling single characters or numeric quantities in integer, fixed point and floating point modes. At all times the user has complete control of the input/output devices, and can handle up to sixteen devices simultaneously in a completely dynamic fashion. In addition, default teletype input/output and a further sixteen logical channels are provided.

. Storage management, including the heap (a storage area from which space may be borrowed -- used for input/output buffers, own arrays and dynamically created byte strings), and the stack (providing core expansion when necessary).

. Provides a reporting mechanism for runtime errors - allowing the user to selectively trap or monitor a wide range of error conditions. In addition, a checking mode is provided for the selective testing of array subscript bounds.

. A library of routines which may be incorporated in a user's program, including:

  . A set of mathematical functions, both single and double precision

  . Maxima/minima functions

  . String manipulation routines

  . Bit field manipulation routines

  . FORTRAN subprogram interface routines

BASIC

DECsystem-10 BASIC is similar to and encompasses features found on extended BASIC implementations offered by commercial timesharing service bureaus and by large university computer centers. A number of advanced features are included in DECsystem-10 BASIC to make it particularly easy to learn and easy to use. BASIC has been written as reentrant (shareable) code so that any number of simultaneous

users on a DECsystem-10 share a single copy of the BASIC system. Large numbers of users may simultaneously run BASIC jobs with very low system overhead and with crisp response times.

Extended features of the DECsystem-10 BASIC include:

- The PRINT USING statement: including the leading asterisk, floating dollar sign, and imbedded comma features
- Sequential-access file handling for both data and text
- Random-access file capability
- Up to 9 (15 with a future release) files open simultaneously
- Files may be opened and closed at runtime
- String handling ability - a full package including concatenation and a number of string functions
- Subroutine CHAIN feature to other BASIC programs
- I/O ability from/to any supported device (such as cards, paper tape, line printer, DECtape, magtape)
- Supports teleprinter and CRT terminals at multiple speeds
- Future BASIC releases will include string user-defined functions, the CALL subroutine statement capability with arguments, the COMPILE command to generate reusable object programs, and debugging features to permit the insertion of break points and changes using the PRINT and LET commands

MACRO-10 ASSEMBLER

The MACRO-10 is a powerful, two-pass assembler. It contains a number of useful and unique features to provide flexible, efficient, and concise machine language programming.

- MACRO-10 is completely device independent. It allows the user to specify at assembly time which device contains his source file and onto which devices to put the binary and listing files.
- MACRO-10 allows address arithmetic using FORTRAN-like expressions involving constants, absolute or relocateable symbols, together with arithmetic and logical operators. The expressions may be nested to any level.
- Constants may be expressed on the same line as the instructions which use them. These so-called literals may also be general expressions, and may themselves include literals.
- MACRO-10 contains many data generating pseudo-operations, and includes features for generating floating point constants, constants of any radix, text, and specification of bytes of any size (in terms of general expressions).
- MACRO-10 includes the pseudo-ops EXTERNAL, INTERNAL, and ENTRY for declaring symbols and entry points, for reference from other programs which are translated by MACRO-10, FORTRAN IV, or COBOL.

- The eleven conditional assembly pseudo-operations provide a highly useful feature for assembling portions of code on an optional basis, (such options being specified by a parameter assignment which may even be typed as input to the assembler at assembly time.)

- The object code produced by MACRO-10 may be either absolute or relocateable, and contains a symbol table that is compatible with the debugging program DDT.

- Segments of code may be relocated prior to their execution by the use of the PHASE/DEPHASE operators. This allows "tight loops" to be pushed into the fast registers for execution.

- Reentrant programs may be written by using the HISEG pseudo-ops.

The MACRO processor provides for concatenating completely general argument strings to the text in the body of a macro; for indefinite repeat operations on argument strings; for redefinition of symbolic parameters within a macro; and for unlimited nesting of macros (i.e., macro call within macro definitions). In addition, macros may contain any of the pseudo-operations or conditional assembly features described above.

TECO

TECO, a very powerful text editor, enables the advanced DECsystem-10 user to edit any ASCII text with a minimum of effort. All editing can be accomplished by using only a few simple commands; or the user may select any of a large set of sophisticated commands, such as character string searching, command repetition, conditional commands, programmed editing, and text block movement.

Because TECO is a character-oriented editor, one or more characters in a line can be modified without retyping the rest of the line. Any sort of document can be edited: programs written in FORTRAN, COBOL, MACRO-10, or any other language; memoranda; specifications; and other types of arbitrarily formatted text. TECO does not require that line numbers or any other extraneous information be associated with the text.

DECsystem-10 SOFTWARE BY FUNCTION

Languages

ALGOL
AID
***APL
*BLISS
BASIC
COBOL
*FAIL
FORTRAN
*LISP
MACRO
PAL10
*PAL12
*PALXII
*SAIL
*SNOBOL

Monitor Utilities

BOOTS
DAEMON
DTBOOT
FILDDT
LOGIN
LOGOUT
L680
MAGRIM
MONEY
MONGEN
REACT
TENDMP
X680

Editors

LINED
*SOS
TECO

Batch Subsystems

BATCON
CDRSTK
OPSER
QUEUE
SPOOL

System Communication

GRIPE
OMOUNT
PLEASE
UMOUNT

General Utilities

BINCOM
CHAIN
CODE
COPY
CREF
DDT
DUMP
FILEX
FUDGE2
GLOB
LOADER
PIP
RUNOFF
SRCCOM
SORT
SOUP
SYSTAT

Disk Utilities

ALCFIL
DELFIL
DIRECT
DMPFIL
DSKLST
DSKRAT
LOOKFIL
QUOLST
REDALL
SETSRC

Simulation Systems

***CSSL-10
*GASP-II
**POOMAS
*SIM8
*SIM11
**SIMULA-67

Algebraic Systems

***IAM
**MATHLAB
*REDUCE2

Special Applications

COBRG
*SCHOLAR/TEACH
*SREG
*TUGP
*SQUAW
*VB1Ø
*SPSS

In DECUS* Under development** For sale by the developer***

Note: For a complete catalog of Application Packages, Math Libraries, etc. available on the DECsystem-10, refer to the "DECsystem-10 Application Software Bulletin."

SOFTWARE REFERENCE DOCUMENTS

Additional information on the Monitor, Languages, Utilities and Application Software is provided in the following DECsystem-10 handbooks:

INTRODUCTION TO DECsystem-10 SOFTWARE (DEC-10-MZDA-D)

An overview of the DECsystem-10 Monitor, System Software, Languages, Utilities, and Hardware. Includes a detailed Glossary of terms for the beginner.

DECsystem-10 USER'S HANDBOOK (DEC-10-NGZA-D)

Contents

- Introduction to Timesharing
- Getting Started With Timesharing
- Getting Started With MPB
- Introduction to TECO
- TOPS-10 Operating System Commands
- PIP
- TECO

MATHEMATICS LANGUAGE HANDBOOK (DEC-10-KRZA-D)

Contents

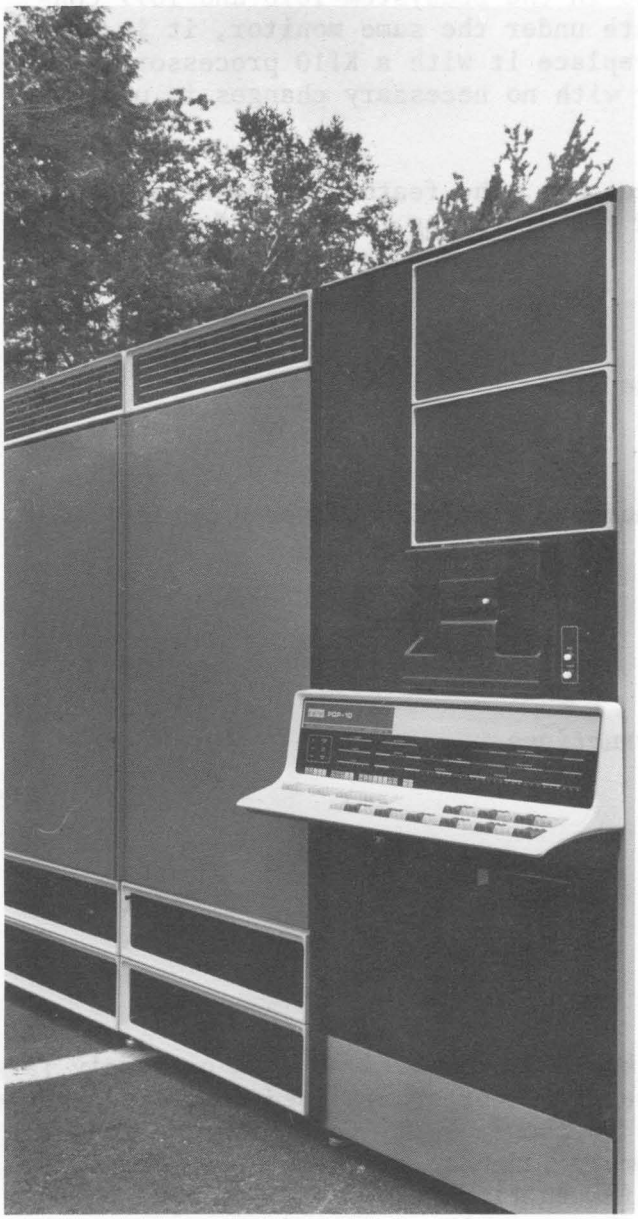
- FORTRAN
- BASIC
- AID
- ALGOL

COBOL LANGUAGE HANDBOOK (DEC-10-KC1C-D)

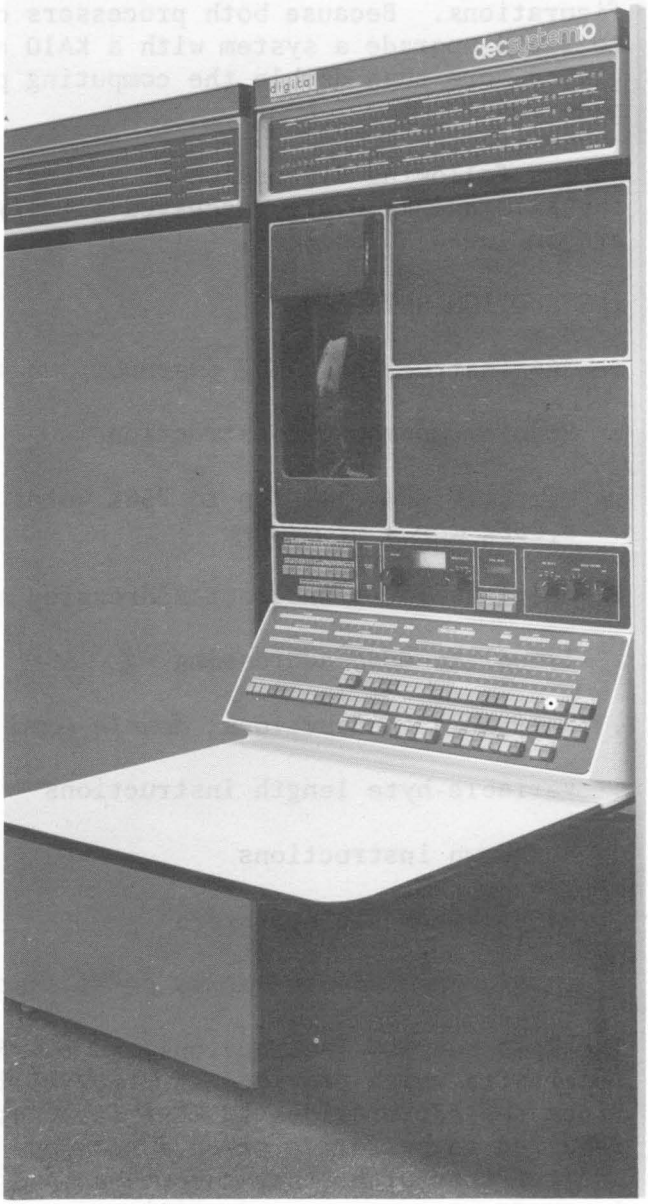
DECsystem-10 ASSEMBLY LANGUAGE HANDBOOK (DEC-10-NRZA-D)

Contents

- System Reference Manual
- MACRO-10
- TOPS-10 Monitor Calls
- LOADER
- DDT
- BINCOM
- SIRCOM
- CREF
- FUDGE2
- GLOB



The KA10



The KI10

Within the family of five DECsystem-10 configurations, there are two central processor units. Both operate under the same DECsystem-10 monitor, execute the same software, and both share most models of DECsystem-10 peripheral equipment. The two processors differ in their speed, method of addressing, memory capacity, program size, auto-diagnostic and restart features, and priority interrupt system.

The KA10 central processor is used in the DECsystem-1040, 1050 and 1055. The more powerful KI10 central processor is used in the DECsystem-1070 and 1077 configurations. Because both processors operate under the same monitor, it is easy to field upgrade a system with a KA10 and replace it with a KI10 processor, giving more than double the computing power with no necessary changes in user programs.

In the following discussion of central processors, the features common to both the KA10 and KI10 are discussed jointly and the differing features of the KI10 are included in *italics*.

INSTRUCTION SET

- 366 instructions, 378 *instructions on the KI10*
- Modular mnemonic construction
- Directly addresses up to 256K words of memory, *directly addresses up to 4,096K words of memory*
- Multiple-level indirect addressing
- Immediate-mode addressing
- Half-word instructions, *double-word instructions*
- Variable-byte length instructions
- Pushdown instructions
- 64 programmable operators
- *Double precision floating point instructions*

The KA10 has 366 instructions *and the KI10 has* 378 *instructions* - an extremely large repertoire which provides the flexibility required for specialized computing problems. Since the set provides so many instructions to choose from, fewer instructions are required to perform a given function. Assembly language programs are, therefore, shorter than with other computers, and the instruction set simplifies the monitor, language processors, and utility programs. For example, compiled programs are often 30 to 50 per cent shorter, require less memory, and execute faster than those of comparable computers.

In addition to these instructions, the DECsystem-10 provides 64 programmable operators, 33 of which "trap" to the monitor (monitor calls) and 31 of which trap to the user's core area. The remaining instructions, out of a possible 512 that the 9-bit operation field makes possible, are unimplemented and reserved for future expansion.

The instruction set, despite its size, is easy to learn. It is logically grouped into families of instructions, and the mnemonic code is modularly constructed. All instructions are capable of directly addressing a full 256K or 4,096K words of memory without resorting to base registers, displacement addressing, or indirect addressing. Instructions can also use indirect addressing with indexing to any level. Most instruction classes, including floating point, allow immediate mode addressing, where the result of the effective address calculation is used directly as an operand.

- Half-Word Data Transmission
- Full-Word Data Transmission
- Byte Manipulation
- Logic
- Fixed Point Arithmetic
- *Floating Point Arithmetic*
- *Fixed/Floating Conversions*
- Arithmetic Testing
- Logical Testing and Modification
- Program Control
- Input/Output Operation
- Unimplemented User Operations
- *Trap Handling*

Half-Word Data Transmission

The half-word data transmission instructions move a half word and may modify the contents of the other half of the destination location. There are 16 instructions which differ in the way that they move the half-word and in the way they modify the other half of the destination location.

Full-Word Data Transmission

The full-word data transmission instructions move one or more full words of data from one place to another. The instructions may perform minor arithmetic operations such as forming the negative or the magnitude of the word being processed.

Byte Manipulation

The five byte manipulation instructions pack or unpack bytes of any length anywhere within a word.

Logic

The logic instructions provide the capabilities of shifting and rotating, as well as performing the complete set of 16 Boolean functions of two variables.

Fixed Point Arithmetic

The fixed point arithmetic instructions provide the capabilities of shifting, adding, subtracting, multiplying, and dividing numbers in fixed point format.

Floating Point Arithmetic

The KI10 has instructions to perform scaling, negating, addition, subtraction, multiplication, and division upon numbers in floating point format - both single and double precision accuracy. In single precision floating point formats one bit is reserved for the sign, 8 bits are used for the exponent and 27 bits are used for the fraction. In double precision floating point formats one bit is used for the sign, 8 bits are used for the exponent and 62 bits are used for the fraction.

Fixed/Floating Conversions

Instructions in the KI10 instruction complement provide the capability of converting fixed point formats to or from floating point formats.

Arithmetic Testing

The KI10's arithmetic testing instructions may jump or skip, depending on the result of an arithmetic test and may first perform an arithmetic operation on the test word.

Logical Testing, Modification, and Skip

These instructions use a mask to modify and/or test and/or skip on selected bits in AC.

Program Control

Program control instructions include several types of JUMP instructions and the subroutine control PUSHJ and POPJ instructions.

Input/Output Operations

Input/output instructions govern all transfers of data to and from the peripheral equipment and also perform many operations within the processor. Block transfer instructions handle bulk data transfers to/from I/O devices.

Unimplemented User Operations

Many of the codes not assigned as specific instructions are executed as unimplemented user operations wherein the word given as an instruction is trapped and must be interpreted by a routine include for this purpose by the programmer. Those UUO's reserved for use by the monitor are labeled monitor UUO's (MUUO's), while user UUO's are labeled local UUO's (LUUO's). Instructions that are illegal in user mode also trap in this manner.

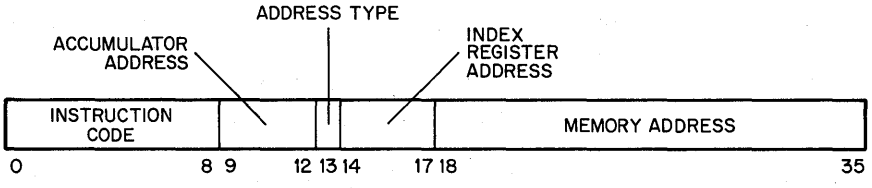
Trap Handling

The KI10 provides facilities for handling arithmetic overflow and underflow conditions, pushdown list overflow conditions, and page failures directly by the execution of programmed trap instructions. This trap capability prevents requiring recourse to the program interrupt system. A trap instruction is executed in the same address space as the instruction which caused the trap. Thus, user programs can handle their own traps if desired by requesting the monitor to place a jump (for example) to a user routine in the trap location.

INSTRUCTION FORMAT

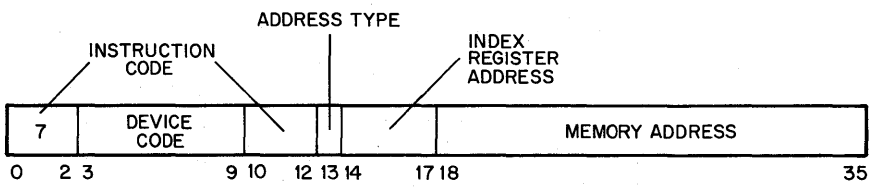
In all but the input/output instructions, the nine high order bits (0-8) specify the operation, and bits 9-12 usually address an accumulator but are sometimes used for special control purposes, such as addressing flags. The rest of the instruction word usually supplies information for calculating the effective address, which is the actual address used to fetch the operand or alter program flow. Bit 13 specifies the type of addressing, bits 14-17 specify an index register for use in address modification, and the remaining eighteen bits (18-35) address a memory location.

The instruction codes that are not assigned as specific instructions are performed by the processor as so-called "unimplemented operations", as are the codes for floating point and byte manipulation in any KA10 that does not have the optional hardware for these instructions.



BASIC INSTRUCTION FORMAT

An input/output instruction is designated by three 1s in bits 0-2. Bits 3-9 address the in-out device to be used in executing the instruction, and bits 10-12 specify the operation. The rest of the word is the same as in other instructions.



IN-OUT INSTRUCTION FORMAT

TYPICAL DECsystem-10 INSTRUCTION TIMES (usec)	1040	1050	1055*	1070	1077*
Fixed Point Add	2.8	2.8	2.8	1.5	1.5
Fixed Point Multiply	9.8	9.8	9.8	4.1	4.1
Jump	1.5	1.5	1.5	1.1	1.1
Single Precision Floating Point Add	9.8	9.8	9.8	3.6	3.6
Double Precision Floating Point Multiply	59.4	59.4	59.4	7.6	7.6

* Dual processor systems execute two instructions simultaneously

NUMBER SYSTEM

The standard arithmetic instructions in the DECsystem-10 use twos complement, fixed point conventions to do binary arithmetic. In a word used as a number, bit 0 (the leftmost bit) represents the sign, 0 for positive, 1 for negative. In a positive number, the remaining 35 bits are the magnitude in ordinary binary notation. The negative of a number is obtained by taking its twos complement. Zero is represented by a word containing all 0s.

Fixed Point Arithmetic

Two common conventions are to regard a number as an integer (binary point at the right) or as a proper fraction (binary point at the left); in these two cases, the range of numbers represented by a single word is -2^{35} to 2^{35} -1 or -1 to 1 - 2^{-35}. Since multiplication and division make use of double length numbers, there are special instructions for performing these operations with integral operands.

The format for double length fixed point numbers is just an extension of the single length format. The magnitude (or its twos complement) is the 70-bit string in bits 1-35 of the high and low order words. Bit 0 of the high order word is the sign, and bit 0 of the low order word is equal to it. The range for double length integers and proper fractions is thus -2^{70} to 2^{70} -1 and -1 to 1 -2^{-70}.

Floating Point Arithmetic

The KI10 has hardware for processing single and double precision floating point numbers, whereas the KA10 can generally process only single precision numbers and the hardware for this is optional (although this hardware does include features that facilitate double precision arithmetic by software routines).

The KI10 includes eight double precision instructions and three fixed floating conversion instructions. A double precision word consists of the sign, an 8-bit exponent and a 62-bit fraction. This gives us a precision in the fraction of 1 part in 4.6×10^{18} and an exponent of a power of 256.

The same format is used for a single precision number and the high order word of a double precision number. A single precision floating point instruction interprets bit 0 as the sign, but interprets the rest of the word as an 8-bit exponent and a 27-bit fraction. Single precision floating point numbers have a fractional range in magnitude of ½ to 1 -2^{-27}. Increasing the length of a number to two words does not significantly change the range but rather increases the precision; in any format the magnitude range of the fraction is ½ to 1 decreased by the value of the least significant bit. In all formats the exponent range is -128 to +127.

PROCESSOR MODES

Instructions on the KA10 are executed in one of two modes. According to whether a mode bit has been set, programs operate in either User mode or Executive mode. In Executive mode operations, all instructions are legal, addresses are not relocated, and all core locations are accessible. The monitor operates in Executive mode and is able to control all system resources and the state of the processor. In User mode operations, addresses are relocated, certain instructions are illegal, causing monitor traps when executed, and address references are confined within two program segments.

The KI10 further divides Executive and User mode operation into four submodes. User mode is subdivided into public and concealed submodes and Executive mode into supervisor and kernel submodes. For each 512-word page in the system, information is stored in a table maintained by the operating system which specifies whether or not a page can be accessed, altered and if it is defined to be public or concealed. The Executive and User modes subdivide on the KI10 according to whether the active program is running in a public or concealed area.

If a program is running in public mode, pages within the user's addressing space are accessible only if the pages are listed in the user's page map and are defined to be accessible from public mode. Pages designated public are, by definition, accessible. Pages designated concealed may, in special cases, be accessed if they contain defined entry points, i.e. portals which permit entry from public mode programs. In concealed mode operations, programs can access all of the virtual addressing space. However, if a program running in concealed mode executes an instruction from an area designated to be public, the state of the processor transfers over into public mode. Ordinary users operate in public mode. Concealed areas can be used for proprietary coding that can be executed but not altered or examined by users operating in public mode.

The supervisor and kernel submodes are similar but not identical to the public and concealed submodes. Supervisor mode programs can access but cannot alter areas designated as concealed. Also, any instruction executed out of a public area from either supervisor or kernel mode returns the processor to supervisor mode. In kernel mode operations, all of memory is accessible and can be altered. Programs operating in kernel mode can address portions of memory directly, without paging, and it is through a kernel mode program that page restrictions are established. Functions delegated to supervisor mode generally include those affecting individual users as opposed to overall system management of input/output, priority interrupts, page map accounting, etc., which are handled by kernel mode programs. The ability of kernel mode programs to supply information which supervisor mode programs can read but not alter allows well-debugged portions of the operating system to be hardware protected from other portions undergoing modifications or design changes.

USER MODE	
Public Mode	*Concealed Mode*
. *User Programs* . *256K Word Address Space Per User* . *All Instructions Permitted Unless They Compromise Integrity of System or Other Users* . *Can Transfer to Concealed Mode Only at Entry Points*	. *Proprietary Programs* . *Can READ, WRITE, EXECUTE or TRANSFER to Any Location Labeled Public*

EXECUTIVE MODE (Monitor)	
Supervisor Mode	*Kernel Mode*
. *Performs General Management of System* . *Performs Those Functions That Affect Only One User At A Time* . *Executes In Virtual Address Space Labeled Public*	. *Performs I/O For System* . *Performs Those Functions That Affect All Users* . *Physical Address Space Only, No Paging*

KA10 PROCESSOR PROTECTION AND RELOCATION REGISTERS

Features

. Protection and Relocation Registers

. Multiprogram protection

. Dynamic core allocation

. Reentrant programs

Dual memory protection and relocation registers protect other users and the monitor from errors in the active user program. If a user attempts to reference core outside his area, his program is stopped from operating and another program is run. The feature also permits dynamic core allocation, allowing each user program to be assigned either one or two segments of memory. One of these segments can be write-protected so as to protect critical programs or data from errors committed by the user himself. Segments - which are multiples of 1024 words - may be located anywhere in core and may contract and expand as needs dictate. Core management techniques, employed by the monitor, insure efficient core usage.

This feature also makes possible the reentrant or recursive use of language processor and systems programs. With the DECsystem-10, all language processors and most utility programs are reentrant. That is, each program is written in two parts. One part contains pure or reentrant code that is not modified during execution and it can be used to simultaneously service any number of users. A separate second part of the program belongs strictly to each user and consists of the code and data that is developed during the compiling process. This section is stored in a separate area of core. Such a system allows more users to occupy a given amount of core simultaneously or, conversely, less core is required to service a given number of users. The result is better response for all users.

KI10 PROCESSOR ASSOCIATIVE MEMORY PAGE ADDRESSING

KI10 Features

- *High capacity multiprogram throughput*
- *4,194,304 words of addressable memory*
- *No memory shuffling*
- *Efficient memory packing in 512-word pages*
- *Large programs do not require a continuous overlay*
- *Individual pages may be locked in core*
- *Reentrant programs*

Address Mapping

The KI10 provides memory address mapping from the program's memory address space (referred to as the effective address) to the physical memory address space by substitution of the most significant bits of the memory address. This mapping provides access to the entire physical memory space which is 16 times larger than the maximum user address space. The user's effective address space is 256K words addressed with 18-bit addresses; the physical address space is 4,096K words addressed with 22-bit addresses where 4,096K is equivalent 4,194,304 decimal.

Effectively, the memory mapping process utilizes the most significant 9 bits of the virtual address as an index into the appropriate page map (User or Executive). The data located by the index provides 13 bits which are appended to the least significant 9 bits of the effective address in order to form the 22-bit physical address. Also provided are 3 bits which indicate what type of memory requests are allowed to the page in question (none, read-only, proprietary, etc.)

Associative Memory

If this scheme were implemented exactly as outlined above, every user memory reference would require two actual memory references, one to obtain the memory mapping data and one to obtain the user's mapped memory reference. In order to reduce the number of actual memory references to nearly the same number as required by the program, an associative memory mapping unit is used as shown in the figure.

If the address is in the range 0 through 17 inclusive, the hardware register blocks are referenced instead of the memory system. Otherwise, the User mode bit and the high order 9-bits of the virtual address are compared against the contents of the associative memory registers which are part of the memory mapping hardware. These 10-bits will either match exactly one of the associative registers or none.

If a match exists, the contents of the related register supplies the 13-bit most significant portion of the physical memory address and also supplies three-bits which indicate what types of memory references are allowed to this page. If the memory request is not consistent with the request type allowed bits, a page failure occurs. When a page failure occurs, the current page failure word is stored in the user's location 426 if the failure was from Executive address space; or stored in the User's location 427 if the failure was from User address space. The instruction located at the Executive or User's location 420 is executed.

Physical Address

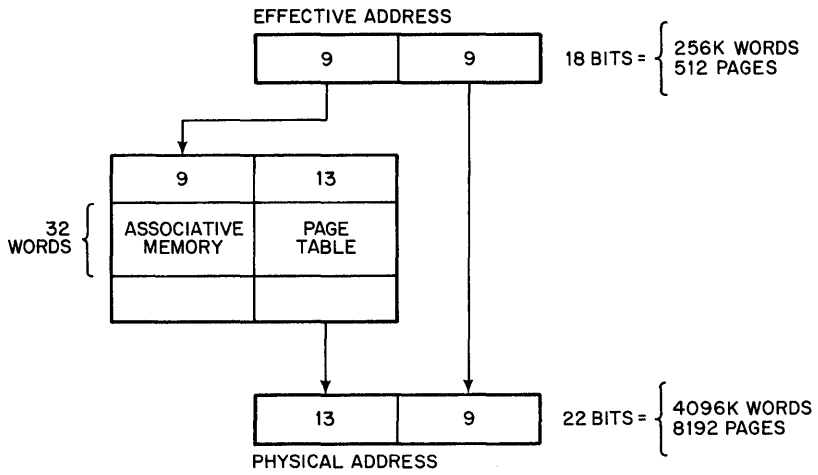
If the memory request is consistent with the request type allowed bits, the physical address used consists of the 13 bits from the related register as the most significant bits of the physical address and the 9 least significant bits of the effective address as the least significant bits of the physical address.

When the relocation data for a referenced page does not exist in the associative memory, the hardware reads the relocation data from the page table in core and stores it into the word of the associative memory which is indicated by the contents of the page table reload counter. After reloading, this counter is incremented to point at the next word in the associative memory.

Any time a word of the associative memory is referenced and the reload counter is pointing at it, the reload counter is incremented to point at the next word in the associative memory. Thus, at worst, a page which was just referenced would not have its word in the associative memory replaced by the next memory reference. If a particular word in the associative memory has not been referenced in some time, the reload counter would be left pointing at this word, having been pushed away from all words in associative memory which have been used. Thus, a one-bit approximation to "least-recently-used" page table operation is obtained.

Monitor Programming For Paging

The monitor assigns the core area for each user by loading the various page tables, setting up the trap locations in the user page map, and responding appropriately when a trap occurs. The monitor provides memory protection for itself and each user by filling the page tables only with those entries which are allowed to be accessed. A zero access bit in the page table will cause a reference to the associated page to initiate a page failure trap to the monitor.



Addressing's Associative Memory

PRIORITY INTERRUPT SYSTEM

Features

- Multiple levels
- Device priorities assigned through software
- Block move instructions
- *10μsec response to interrupts*
- *Interrupt directly to memory*
- *Immediate instruction execution*

The DECsystem-10 priority interrupt system is one of the most flexible systems available today. Devices are assigned under program control to any one of seven priority levels through the dynamic loading of a 3-bit register within the device. Each interrupt level has any number of high-speed programmable sub-levels. Thus, a program can change the priority level of any device or disconnect the device from the system and later reinstate it at any other level. In the same manner, a program can set, enable, or disable, any combination or all levels with a single instruction. In addition, the program can assign some or all devices to the same level, allowing them to operate on a first-come, first-served basis.

A set of instructions (block in and block out) allow blocks of information to be transferred between a device and memory. These instructions identify the source of the interrupt, update the word count and data address, transmit or receive the block of information, and dismiss the interrupt.

The system can also generate interrupts through software. Real-time hardware can thus operate on a high priority level while related computations, particularly if they are lengthy, can be performed on a lower level.

The DECsystem-10 program-assignable priority interrupt system provides much greater flexibility than permanently hard-wired systems. Hard-wired systems require a large number of levels, often operate at extremely high overhead, and cannot change device priorities without system shutdown and rewiring.

An interrupt on the KI10 causes the processor and the interrupting device to immediately initiate one of several possible actions. In response to the "interrupt grant" signal from the processor, the device may supply a 36-bit word which is decoded as 18 bits address, 12 bits data, 3 bits interrupt level, 3 bits function. The processor then does one of the following:

- *Execute the instruction found at the supplied 18-bit address*
- *Transfer a word into or out of the addressed location*
- *Add a signed 12-bit value to the addressed location*

Peripheral devices which are not equipped with the decoding logic perform an interrupt and transfer of control as on the KA10, to one of the standard interrupt trap locations.

DK10 REAL-TIME CLOCK

Features

- High resolution (10usec)
- External clock input to 400 kHz
- Assignable to any interrupt channel
- Time of day and interval timing
- Clock can be read without loss of counts

The DK10 real-time clock is supplied with each DECsystem-10 and provides high resolution time keeping for time accounting, time base maintenance, periodic high frequency interrupts, and interval timing. Meeting the most demand real-time requirements, the clock provides 10μsec resolution and a choice of up to 2^{18} possible timing intervals, so that interrupts can be programmed at intervals from 10μsec up to 2.6 seconds.

In addition to an interval register, the DK10 has a frequency counter which counts the pulses of an internal 100 kHz±0.01% clock, or an external clock having a maximum frequency of 400 kHz. The clock also includes a comparator network which provides a running comparison between the frequency counter and the interval register. When the frequency counter reading equals the total on the interval register, a program interrupt is generated and the frequency counter is automatically reset so that it can time the next interval.

The clock, which is assignable to any interrupt channel, can be used to pace real-time, monitor, or other functions performed in either Executive or User modes. In fact, a system can have two clocks - one for each mode - since two device codes are available for clock use. The clocks are synchronized to the DATAI instructions so that they can be read - at any time - by the DECsystem-10 without losing a clock pulse.

To use the DK10 as a time of day clock, the desired interval (which will determine clock accuracy) is set into the interval counter. Software establishes the desired clock format and updates the stored information each time the clock provides an interrupt.

FAST REGISTER BLOCKS

. Serve as memory, accumulators, index registers

. Implemented by fast integrated circuitry

. Executes floating point

. 4 blocks of 16 registers

General-purpose registers are another DECsystem-10 feature that helps improve program execution. These fast integrated circuit registers can be used as accumulators, index registers, or as the first locations in core memory. Since the registers can be addressed as memory locations, they do not require special handling instructions.

One set of fast registers is included in the KA10 and four sets of fast register blocks are included in the KI10. Context switching on the KA10 is performed by storing the register information into core locations. Program switching time between register stacks is 2.5usec. On the KI10, different register blocks can be used for the operating system and individual users. This eliminates the need for storing register contents when switching from User mode to Executive mode. Also, a critical real-time program is able to maintain its own register block for handling data and interrupt sequences at maximum speed.

SAFETY FEATURES

. Power failsafe

. *Automatic restart*

. Temperature protection

If system power fails, a power failure detection circuit detects the condition and causes an interrupt. The interrupt can trigger the operation of a program which saves all valuable registers so that the system can be restarted in a minimum amount of time.

On the KI10, an automatic restart capability has been added to resume normal operations in the event of a power surge or outage. All three phases of AC power are monitored. Out-of-tolerance conditions on any phase will initiate a sequence of power-down operations. A program selectable automatic restart capability is provided to allow resumption of operations when power returns. The system will begin operations at the point of termination. Alternatively, a manual restart may be used.

Temperature sensors strategically placed within equipment units detect high temperature conditions and cause power shutdown. This, in turn, initiates the power failure interrupt.

PROGRAMMABLE VOLTAGE MARGINS

On the KI10, the DC voltage level supplied to the system logic can be set under program control to any one of 64 discrete levels. This allows for on-line diagnostics to be run through a range of voltage levels without requiring manual settings for individual values.

MULTIPLEXED I/O BUS

- Full word path (36-bit)
- Block input/output instructions
- 200kHz word rate (KA10)
- *350kHz word rate (KI10)*

The DECsystem-10 multiplexed I/O bus provides a 36-bit full word parallel path between memory and an I/O device for purposes of control or low-speed data transfer. To initiate a high-speed data transmission between memory and a device connected to the memory bus, a control word is first transferred over the I/O bus to the buffer of the high-speed device controller. Then on command of the block input or output instructions, entire data blocks are moved directly to or from memory with a single instruction. For a description of the memory bus, see the discussion of Central Memory.

The I/O bus may also be used as a control and data path to/from a large number of low-speed I/O devices. Transfer is performed in 36-bit words in parallel at speeds of 200kHz on the KA10 and *350kHz on the KI10*. Thus each data transmission instruction moves one word of data between memory and the buffer of the device controller. When block input or output instructions are used, entire blocks of data are moved to or from the device with a single instruction.

CENTRAL MEMORY

Features

- Expandable to 256K words (DECsystem-1040, 1050, 1055)
- Expandable to 4,096K words (DECsystem-1070, 1077)
- Asynchronous operation
- Full-word data transfers
- Direct data channels

To meet the requirements of large systems, DECsystem-10 core memory can be modularly expanded to 4 million (4,194,304) words, all directly addressable. Memory can be comprised of combinations of modules in 16K blocks or larger.

The structure of the memory bus gives the central processor and high-speed data channels simultaneous access to separate memory modules and allows each to operate at its own top speed. Since the data channels are direct, only when the processor and a data channel access the same module can the processor lose a memory cycle.

Each memory module contains up to four ports and each port can be further expanded through the use of the MX10 memory multiplexor. The multiplexor handles up to eight data channels, interleaving data from the channel on a word-by-word priority basis. Such parallel operation yields many-fold improvements over systems which provide only a single path to memory.

Memory Bandwidth

The memory bus system allows each data channel to transmit full 36-bit words in parallel at speeds of one million words (five million 7-bit characters) per second. In total, the memory structure operates at rates of up to 20 million characters a second when four I/O devices and processors are simultaneously transferring data.

Each memory module provides switches which allow it to represent any 16K module in the addressable memory space. Thus, one module can replace another without rewiring. Switches are also provided for memory interleaving.

ME10 CORE MEMORY

ME10 Features

- Overlapped memory control operation
- 4-way interleaving
- 22-bit address logic
- Instruction lookahead logic
- 550 nanosecond read access time

Each ME10 core memory bank contains 16,384 words (36 bits plus parity) of storage. Read access time is 550 nanoseconds nominally with a maximum access time of 610 nanoseconds and a complete cycle time of 1 microsecond. Up to sixteen memory modules may be connected to provide 262K words of high-speed core storage. Each module may contain up to four memory ports for connection to processors, data channels, and the data channel multiplexer. Two or four-way interleaving is provided by switches on each memory module.

The KI10 permits overlapped memory control functions when configured with the ME10. The overlapped memory control permits the KI10 to start another data fetch before the last data fetch has been completed. Address logic decodes a 22-bit address for large memory DECsystem-1070 or 1077 systems using the KI10 processor.

ME10 Specifications

Word Size	36 bits plus parity
Minimum Memory Size	16K (K+1024 words)
Expansion Module Size	16K
Maximum Number of Words	256K
Read Access Time	550 nanoseconds
Memory Cycle Time	1.0 microsecond

MD10 MASS CORE MEMORY

MD10 Features

- Requires only 4.5 square feet of floor space to store 128K
- 800 nsec access time
- Modularly expandable to 128K per unit
- 256K words of directly addressable memory (maximum)
- Switchable memory block address
- Two and four-way interleaving

The MD10 mass core memory system lets DECsystem-10 users expand system memory at minimum cost.

The basic MD10 unit is a single cabinet containing 64K of 36-bit, 1.8μsec memory. To expand the MD10, the user can add up to two MD10E 32K expander units to the same cabinet, providing a maximum capacity per MD10 of 128K. Thus a user has the option of implementing his system with 64, 96, or 128K blocks up to the maximum directly addressable memory capacity of 256K words. Each MD10E unit is easily plugged into the MD10 to simplify field expansion.

The MD10 contains four memory ports and is supplied with the cabling necessary to connect DEC-supplied peripherals.

Because of the asynchronous operation of the processor, the MD10 memory can be intermixed with DEC memories of various speeds; for example, it can be used in the same system with the MA10 or ME10 1μsec memories.

MD10/MD10E Specifications

Word Size	36 bits plus parity
Minimum Memory Size (MD10)	64K (K=1024 words)
Expansion Module Size (MD10E)	32K
Maximum Memory Block Size	128K (one MD10 plus two MD10E's)
Read Access Time	800 nsec
Memory Cycle Time	1.8μsec
Electrical Requirements	120 or 220VAC±10% 60Hz±2% or 50Hz±2% for any of the following voltages: 110, 115, 200, 216,230 all voltages ±10%

DATA COMMUNICATION SYSTEMS

The DECsystem-10 data communication systems have been designed for flexibility and ease of use. The system is designed for ease of expansion to distribute computer power to a continually growing user community. In concept, the DECsystem-10 communication systems provide a transparent link between remote users and the central site. Because of this transparency, users at remote sites use the same set of commands as users at the central site. DECsystem-10 data communication systems also link a network of computers together from both local and remote sites. Data collection stations, remote control stations, remote concentrators are easily tied into a single data network.

A complete range of data communications equipment is available on the DECsystem-10.

- Asynchronous systems - both hard-wired and computer-controlled interface systems for multiple terminals at several speeds.
- Synchronous communication systems - both low capacity and high capacity systems which provide communications interfaces to remote batch stations, concentrators, and remote computer sites.
- Terminal equipment - teleprinters, CRT terminals.
- Remote batch stations - remote card and line printer equipment, including remote terminal concentration through the batch station.

ASYNCHRONOUS COMMUNICATIONS

Asynchronous communications equipment and terminals cover a broad range of application within the DECsystem-10. Asynchronous equipment is used for interactive program development, operator control of the system, production program control and running, data entry, program entry, interactive problem solving, student instruction terminals and information storage retrieval equipment. Asynchronous communications are generally used to link terminal equipment of two types - hard copy (such as the teletype models LT33 and LT35) and CRT terminals (such as the VT05 and VT06). Local terminals, within 1500 feet of the computer site, are connected over dedicated direct electrical connections. Remote terminals, located beyond this distance, are connected over dedicated or dial-up telephone lines.

Speeds of asynchronous hard-copy terminal equipment generally range over 10, 15, 30 characters per second, although new terminal equipment includes printers which print in excess of 100 characters per second. CRT terminals range in speed over 30, 120, 240 characters per second, depending on their communications interfaces.

Interactive terminals on the DECsystem-10 use the 7-level ASCII code as a standard format. Computer-based communications interfaces may be programmed to handle non-standard communications codes.

Asynchronous line speed is described in baud units, a measure of the speed of data transmission. As a general approximation, the baud rate is ten times the terminal character rate; that is, a 10-character per second printer runs on a 110-baud line and a 240-character per second display runs on a 2400-baud line.

Three modes of operation are supported with DECsystem-10 terminals.

Full Duplex - The communications paths to and from the computer are completely separate. The user's typing is normally echoed by the computer, verifying correct transmission of input data and allowing the user to "type ahead."

Full Duplex With Local Copy - There are independent communications paths, but input typed by the user is echoed directly by the terminal. User type-ahead goes correctly to the computer but may interface with the printed output. Commonly used in the TWX network or when using terminals incapable of full duplex operation.

Half Duplex - There is a common path for input and output. Users must not input while output is in progress. Available only when using the DC10C telegraph interface.

The goal of an interactive terminal system is to match all users to the system in such a way that they feel the terminal is identified closely with the computer. In this way, the machine becomes an easy and natural extension of each application. To do this, the computer must be a willing partner in the interchange so that the user feels he is in control of the terminal and not the reverse. Typically, a user types his input in bursts, occasionally makes mistakes, and reads fast on output. Communications systems for the DECsystem-10 have been human-engineered to deal with these user characteristics. The system accepts characters at uneven rates, allows for single character or line correction of mistakes, and allows the user to continue typing at his own speed - even typing ahead of the computer's response to his characters. When users are entering large volumes of data and need no prompting, the system accumulates data and anticipates on-going entries so that theuser can continue to type despite fluctuations in the system response.

Features of DECsystem-10 interactive communications include the ability to delete one or more characters or lines, retype characters and lines, interact on a character or line basis depending on the application, suppress unwanted output, and make use of prompt messages to call for input. Through the SEND command, terminals may converse with the Systems Administrator at the central site.

DC10 DATA LINE SCANNER

- System supports up to 63 interactive terminals.
- Terminals may include paper tape reader or punch. On paper tape reader, the reader must be equipped to respond to the X-ON, X-OFF reader control characters.
- Speeds may be 110, 150, 300, 600, 1200 or 2400 baud.
- Up to 16 of the 2400-baud teletype-compatible CRT terminals or 32 of the 1200-baud teletype-compatible CRT terminals.

The data line scanner provides a two-way interface between the -10 and a maximum of 64 teletype-like stations. The data lines are controlled by the central processor on a priority interrupt basis. Each data line serviced can be connected for any of three signaling speeds.

Baud rates available and software supported include 110, 150, 300, 600, 1200 and 2400. The three clock frequencies used in establishing the signaling speeds of the data lines are generated in the DC10A and routed to the DC10B's where they are assigned on a line-by-line basis. The crystal frequency of the three clocks can be selected during manufacture to meet the customer specifications. Standard software for DC10 service limits input rate to 300 baud. Modifications to scanner service routine can be made to increase the input rate on a line-by-line basis. Output speed may be considerably higher, up to 4800 baud.

Data sets such as those used in the Dataphone, TWX and Telex systems can be used directly with the DC10B with manual data set control. The DC10E provides the computer with control over these data sets. This option allows positive automatic control over the data sets which is useful in multi-user timesharing systems with switched network access.

Characteristics of the DC10 Options

Option	Function	Contains
DC10A Control Unit	Provides the necessary interface between the central processor and up to 8 line groups.	1 Control unit 1 cabinet with power supplies 1 set of I/O bus cables 4 line group connecting blocks 4 external cable blocks 21" of panel mounting space
DC10B 8-Line Group Unit	Provides the necessary interface between the control unit and 8 teletype-like devices.	1 8-line group 1 set of cables to control unit
DC10C 8-Line Telegraph Relay Assembly	Provides relay buffering for full or half duplex circuits.	1 telegraph relay assembly 1 relay bias panel
DC10D Telegraph Power Supply	Provides the necessary power to operate the telegraph lines associated with approximately 4 telegraph relay assemblies.	1 125 Vdc, 2A power supply
DC10E Expanded Data Set Control	Provides status and operational controls for 8 standard data sets, 2 with automatic calling provisions.	8 expanded data set controls 2 automatic calling unit controls* 1 set of cables to control unit
DC10F Expander Cabinet	Provides additonal panel mounting space for large data line scanner systems.	1 cabinet with power supplies 4 line group connecting blocks 4 external cable blocks 42" of panel mounting space

* Requires custom software

DC68A COMMUNICATION SYSTEM

The DC68A programmable communications system is built around the 680/I communications version of the PDP-8/I. Characters are assembled via program control, which results in a very low incremental cost per line. The DC68A is optimized for a large number of 110 baud lines, but will operate at speeds up to 300 baud. The PDP-8/I is under monitor control and transfer across the interface occurs on the character-by-character basis. The DC68A provides on-line servicing of up to 63 communication lines. Terminals can be local or remote through data sets. The standard configuration includes one DA10 interface, one PDP-8/I-D computer (4K of memory with MP8/I parity option, and a Model 33ASR teleprinter), one DL8/I serial line adapter, one DC08A serial line multiplexor, and three clocks for line frequency operations at 110, 150, or 300 baud rates.

The M750 dual serial line adapter implements two full duplex channels in the basic communication system. One unit is required for every two local or data set lines. The DC08B local line panel accommodates up to 48 local terminals suitable for direct 680/I connection. The DC08F modem interface and control multiplexor accommodates up to 32 dual modem control units to handle up to 64 asynchronous lines. The DC08G dual modem control unit implements two modem control units in the DC08F. It includes 25-foot cables with modem connector DB-25D.

Baud Rate*	Suggested Maximum Number of Lines		
	Case 1	Case 2	Case 3
110	63	30	35
150	-	20	-
300	-	-	5

* Other clock speeds, less than 300 baud, are available on request.

SYNCHRONOUS COMMUNICATIONS

The DECsystem-10 synchronous communications systems provide error-free, high-speed paths between the central computer and remotely located batch stations, or other computer systems. The DECsystem-10 synchronous equipment controls the transmission over a network which includes the computers, line interfaces, transmission line, and receiving equipment. Transmission over high-speed synchronous lines is on a message basis in contrast with the character-by-character basis of lower speed asynchronous transmission.

Message-oriented software supplied with the DECsystem-10 makes efficient use of high-speed transmission in both directions simultaneously on a full duplex line. The synchronous multiplexer handles error control, message formatting and message acknowledgments. On long messages, the data transmission is pipelined, a technique which increases line efficiency by fully overlapping the acknowledge-continue signals. Transmission errors are detected using character parity and longitudinal data checks, and data errors are corrected through re-transmission of the erroneous block.

DECsystem-10 synchronous communication equipment includes: the DS10 single synchronous line interface; the DC75 synchronous communications multiplexer; the DC71 remote station, including card reader, line printer, and up to 16 terminals.

DS10 SINGLE LINE SYNCHRONOUS INTERFACE

DS10 Features

- 9600 bits per second (software supported)
- 20,000 bits per second (maximum)
- Full DECsystem-10 software for communication to remote stations
- Compatible with synchronous modems that meet EIA RS-232B or C Standards
- Modem control and data operate on separate interrupt channels
- Interchangeable circuit cards for synchronization and EOT codes
- Programmable character width, 6 or 8 bits
- Continuous character repetition without processor attention

The DS10 single line synchronous interface is a 9600-bit per second (maximum rate that is software supported. Unit can transmit up to 20,000 bits per second) interface, which allows the DECsystem-10 to communicate with remote devices such as other computers, high-speed displays, remote job entry, and remote batch terminals. System software supports two DS10 units with the total throughput of 9600 baud for the two units.

The DS10 communicates with the remote stations in full duplex mode. Compatible modems include the Bell System 201, Bell System 203, ICC Modem 2200, or any synchronous modem which conforms to the Electronics Industries Association RS-232B or C Computer Interface Standards.

The DS10 minimizes interrupt overhead by using a full word buffer and assembling serial data into words for transmission to the DECsystem-10 and disassembling 36-bit words into characters for serial transmission to remote stations. Character length is programmable in either 6 or 8 (software supported) bits.

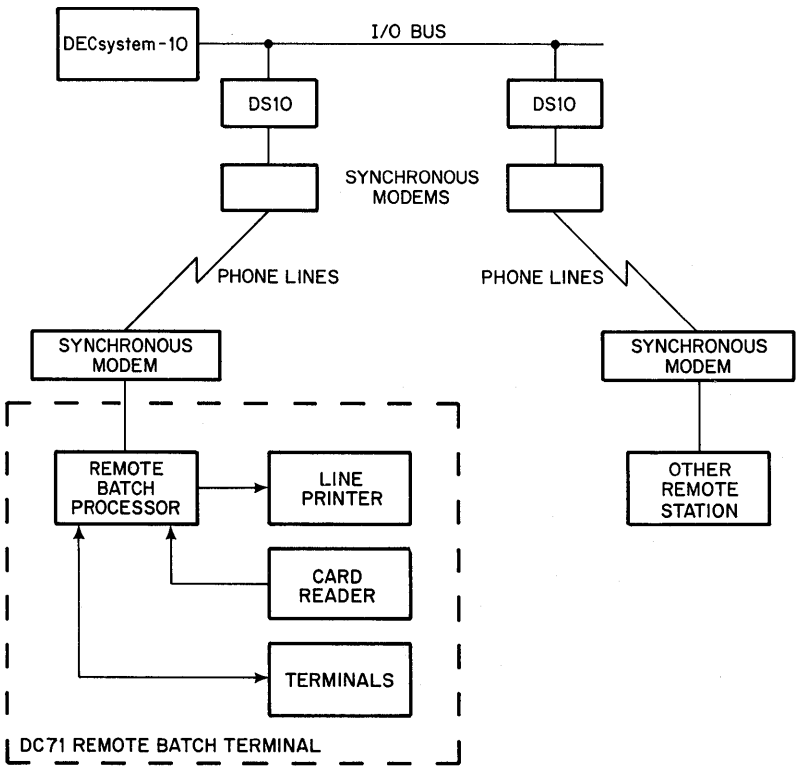
The device assembles 6-bit data into a 6-character word and 8-bit data into a 4-character word. On remote transmission, the DS10 receives a 36-bit word from the DECsystem-10, disassembles it into 6- or 8-bit characters and transmits them serially through the modem.

Interchangeable circuit cards for the device make it possible to use various synchronization and end of transmission (EOT) codes. The DS10 can also continuously repeat a character supplied by the central processor without processor attention. Character repetition is useful, for example, to keep a transmission line open.

Message formatting, error detection, and code conversion are handled by the DECsystem-10 service program, allowing the DS10 to interface a variety of terminals. DECsystem-10 software uses Digital Equipment Corporation standard communication format.

Specifications

Type	Single line synchronous modem interface to EIA RS-232B or C modems
Speed	9,600 bits per second (software supported) 20,000 bits per second (maximum)
Number Per System	Two (Note: Speed limits are total rates for 1 or 2 DS10 units)
Method of Attachment	I/O bus
Power Consumption	450 Watts
Heat Dissipation	1600 BTU per hour
Operating Temperature	60^{o} F. to 95^{o} F. (15^{o} C. to 35^{o} C.)
Dimensions	69" x 22" x 29" (1.75m x .56 m x .72 m)
Weight	300 lbs. (140 Kg)
Relative Humidity	20% to 80%



DC75 SYNCHRONOUS COMMUNICATIONS MULTIPLEXER

Recommended for applications involving multiple synchronous lines, special remote devices or high data rates, the DC75 system handles a traffic load of approximately 10,000 characters per second, including error checking, formatting and line control. The DC75 consists of a high-speed channel interface to the DECsystem-10 memory bus, mini-computer (PDP-11) multiplexer controller, and a synchronous line scanner. The multiplexer controller packs and unpacks characters directly into the DECsystem-10 memory and can execute instructions from the -10 memory for bootstrap purposes. The synchronous line scanner handles up to 8 full duplex lines and can be expanded to 16 lines. The multiplexer hardware may be programmed to handle character sizes of 6, 7, 8 and 12 bits, and may be programmed to recognize a variety of sync codes in full or half duplex operation. Standard system software supplied with the DC75 operates full duplex using 8-bit characters.

Data transmission takes place in both directions simultaneously without interfering with the DECsystem-10 processor. Idle characters are automatically transmitted.

DC75 Features

- 8 full duplex synchronous lines
- Speeds of 2400, 4800, 9600 bits per second
- Total capacity of eight 4800-bit per second lines or equivalent, corresponding to a total full duplex transmission of 10,000 characters per second

Provisions exist to add up to four PDP-11-based controllers, each driving expanded scanners, for a total of up to 64 synchronous transmission lines.

DC71 REMOTE BATCH STATION

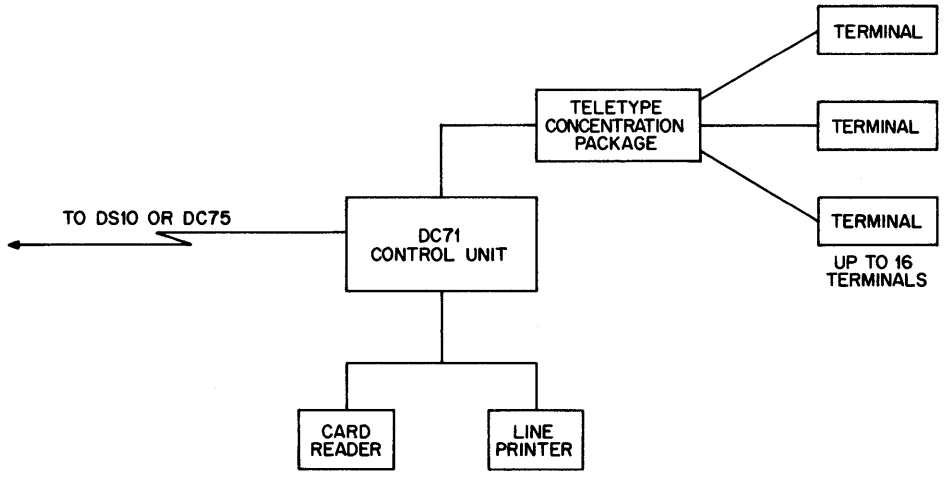
- Full duplex, bi-directional, simultaneous transmission
- Card reader, 300 cards per minute
- Line printer, 132 columns, 245 lines per minute (64 character Model DC71A) or 173 lines per minute (96 character Model DC71B)
- Up to 16 local terminals at speeds of 110, 150, 300 or 2400 baud
- Split terminal speed possible with 2400/150 for ease of use with high-speed CRT terminals
- Computer-based remote station offers flexibility for special remote transmission needs
- Automatic error checking and line control
- Dedicated line or dial-up option
- Interface to EIA-RS232-C standard modems, Bell 201 or 203, or equivalents

In the DECsystem-10 remote station concept, a small computer is used as a device controller for a variety of peripherals that are normally directly connected to the central processor. Through a communications link to the small computer, peripherals such as card readers, line printers, terminals and A/D converters can be operated almost anywhere within phone communication distances of the central processor. To the users at these locations, the remote peripherals appear like peripherals at the main site.

This concept not only brings the processing power of the DECsystem-10 to remote locations, but it also makes possible a variety of remote station configurations. For example, a batch processing station is no longer restricted to a card reader, line printer, and console teletype. In addition to inputting batch programs, the station can serve as a terminal concentrator for up to 16 terminals, either hard-copy or CRT, at speeds up to 240 characters per second.

A remote station can also serve real-time functions using the small computer to collect data from an A/D converter. This data, recorded on magtape, can later be read by the DECsystem-10. With all its flexibility, the remote station is easy to use. Programs that operate on the DECsystem-10 need no modifications to operate through the remote station. Also, I/O requests for remote peripherals are like those used for local peripherals.

The remote station concept makes it easy to develop integrated networks of small computers and remote facilities. For example, remote batch processing stations at branch offices and plants can perform on-site processing and supply data for management reports. Engineering, sales, or research personnel at these locations can use remote station terminals to access large data bases in the DECsystem-10, to input data, or to write programs. Process engineers can use the DECsystem-10 to evaluate their remote station control system or perform other related investigations.



Remote Batch Stations

The DC71 remote batch station consists of a mini-computer processor, a card reader, a line printer, and a teleprinter console. The operator at the remote site can initiate a stream of batch jobs in the same way that they are initiated at the DECsystem-10 computer center; he merely loads the cards into the card reader. Jobs enetered from the remote station are multiprogrammed and may operate concurrently with each other on jobs from other remote stations. To improve operating efficiency, output for the remote line printer is spooled.

With permission from other stations, operators can direct output to (or receive input from) other stations or the computer center. The operator merely indicates the desired station number. If the number is not specified, the monitor assumes that the output is for the same station that started the program.

Remote Terminal Concentrator

In addition to performing batch operations, a remote station can serve as a terminal concentrator. The remote station can concentrate up to 16 devices, including teletypes and various keyboard CRT devices that are teletype-compatible but operate at higher speeds. Terminals on the concentrator, like other DECsystem-10 terminals, can be used for remote job entry or for timesharing operations, such as interactive computation and/or program development.

Terminal concentrators eliminate the need for individual long distance lines between each terminal and central computer. Through synchronous modems, one phone line services the concentrator which, in turn, services the terminals and the batch station peripherals. Unlike hard-wired multiplexing systems, the computer-based concentrator insures that line errors introduced during transmission do not result in data errors. Another benefit of using the computer-based remote station is that the low-speed terminals can be operating simultaneously with the card reader and the line printer. Band width on the high-speed line is allocated on a demand basis, allowing high-speed operation of the terminals most of the time under normal user loads. The remote concentrator will also handle high-speed CRT terminals, providing interleaved character transmission in a manner which gives the effect of broadening the speed of the line when multiple terminals are used simultaneously.

Local terminals connected to the DC71 must be hard-wired (up to 1500 feet) and meet the EIA or 20 milliamp specification. Terminals may operate at 110, 150, 300 or 150/2400 (split speed) baud. Input baud rate should be less than or equal to 300 baud.

Remote Real-Time Stations

The remote station concept can also be applied to real-time applications, combining the advantages of a dedicated control computer with the power and flexibility of a large general-purpose computer. Real-time functions of the remote station can be as simple or as complex as the user desires. In the simplest case, the small computer buffers the communication line and handles error checking to ensure reliable transmission. For more complex data acquisition operation, the remote station can operate independent of the DECsystem-10.

In more complex operations, the DECsystem-10 can request samples of process variables, make needed calculations and, with the results, adjust the parameters being maintained by the remote station control system.

For real-time station application, the user can incorporate his program with the communication software provided.

DC71D, E

Local terminals connected to the DC71 must be hard-wired (up to 1500 feet) and meet the EIA or 20 milliamp specification. Terminals may operate at 110, 150, 300 or 150/2400 (split speed) baud. Input baud rate should be less than or equal to 300 baud.

EIA terminal operation requires a BC01J-25 cable to terminals such as the VT05 or VT06 or a BC01A-25 cable to 103 modems or the equivalent. Manual data set control must be used.

Modems

A 4800-baud modem is recommended for the DC71 system, particularly if multiple terminals are to be concentrated using the DC71D and E. Modems (not supplied by DEC) should be compatible with the EIA-RS232-C standard and equivalent to the Bell 201 or 203 modems.

PERIPHERAL EQUIPMENT

A full line of peripheral equipment is included as an integral part of the DECsystem-10. All peripheral equipment is software supported by the one expandable DECsystem-10 monitor for all configurations. As equipment is added to expand a DECsystem-10, the monitor generation routine automatically includes the handling routines for the new peripheral. No program changes are required.

The complete listing of all DECsystem-10 peripheral equipment is given in the publication "DECsystem-10 Configurator" (DEC-105X10X). The following peripheral equipment is described in this section:

. RM10B	HIGH-SPEED SWAPPING DRUM
. RP02, RP03	DISK DRIVE SYSTEMS
. CR10D, CR10E, CR10F	CARD READERS
. CP10	CARD PUNCH
. TU40	MAGNETIC TAPE TRANSPORT
. TU10	MAGNETIC TAPE TRANSPORT
. TU56	DECTAPE TRANSPORT
. LP10	LINE PRINTERS
. VT05, VT06	ALPHANUMERIC TERMINALS

RM10B HIGH SPEED FIXED HEAD DRUM

Features

- Increased multiprogram performance
- High transfer rate (1.2 million char/sec)
- High reliability
- Four swapping drums per controller
- Over 1.3 million words of total storage
- Latency minimization capability

The RM10B high speed fixed head drum provides DECsystem-10 with a fast access, high transfer rate swapping device which greatly enhances system performance and load handling capacity.

The RM10B provides 345,600 36-bit words of fast access storage available for swapping and for storage of program libraries. With zero positioning time, an average latency time of 8.3 ms, and a transfer rate of 4.1μsec per 36-bit word, the swapping drum can swap a typical 4K user job in or out of core memory in as little as 27 msec.

To provide reliable operation and prevent costly head crashes, the RM10B uses a "flying head" construction and tapered drum design. Operating on the principle of a flyball governor, the drum automatically retracts from the read/write heads whenever rotation drops below 65% of the device's operation speed. This design provides better reliability by eliminating the hydraulic, pneumatic, or electrical drive units required by other systems.

Control for the swapping drum is provided by an RC10 controller which is interfaced to both the input/output bus and to a DF10 data channel which is, in turn, interfaced directly to one port in each of the DECsystem-10 system's memory modules. The same RC10 controller can operate up to four swapping drums, making possible a total swapping capacity of 1,382,400 words.

The DF10 data channel allows data transfers between the drum and core memory to take place simultaneously with central processor computation, as long as the channel and the processor are not accessing the same memory module. The DF10 also provides gather/read and scatter/write operations so that data buffers in core need not be contiguous.

For further efficiency, the RC10 controller contains sector counters which allow the system programmer to minimize the effective rotational latency in a multi-drum system. To reduce latency, the programmer queues multi-drum requests in a "minimum time to go" order.

RM10B Specifications*

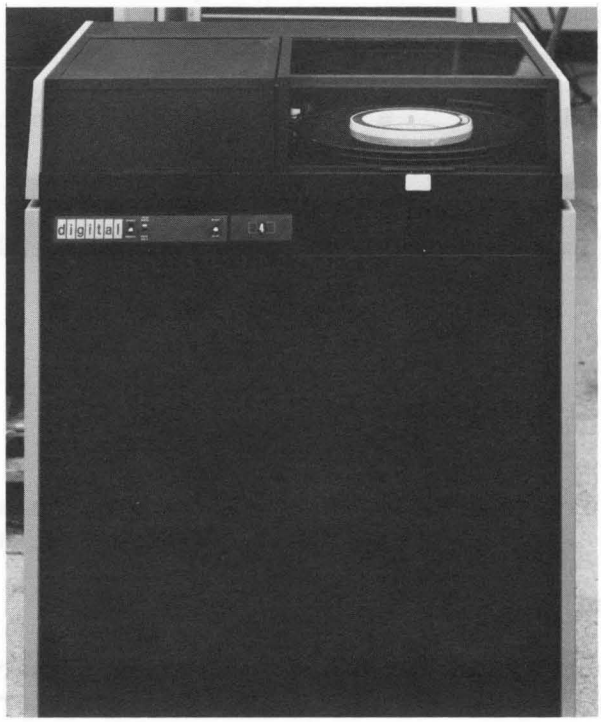
Type of Memory	Rotating fixed head drum
Drum Capacity	345,600 36-bit words

* Performance figures for 60Hz are based on a rotational speed of 3600 RPM; figures to 50Hz are based on 3000 RPM.

RM10B Specifications (Continued)

Number of Drums Per Controller	4
Capacity With 4 Drums	1,382,400 36-bit words
Method of Transfer	6-bit parallel
Positioning Time	None (fixed head)
Latency	8.3ms at 60Hz 10ms at 50Hz
Minimum Word Transfer Time	4.1µs at 60Hz 5.0µs at 50Hz
Maximum Word Transfer Time	240K words/sec at 60Hz 200K words/sec at 50Hz
Character Type	7 bit USASCII
Maximum Character Transfer Rate	1.2 million char/sec at 60Hz 1.0 million char/sec at 50Hz
Rotational Speed	3600 RPM at 60Hz 3000 RPM at 50Hz
Electrical	60Hz±1%, 208Vac±10% line-to-line, 3 phase neutral return or 50Hz±1%, 416Vac ±10% line-to-line
Surge Current	15 AMPS/phase
Power Consumption	1100 Watts
Heat Dissipation	4000 Btu/hr.
Humidity	20% to 80%
Temperature	60°F to 95°F (15°C to 35°C)
Organization:	
Number of heads	540
Number of tracks	90
Number of sectors per track	60
Sector size	64 words

DISK SYSTEMS



System Features

- Fast access
- 1.966×10^9 characters on-line storage
- Up to 4 controllers per system
- Up to 8 drives per controller
- Intermixing of drives
- Interchangeable disk packs
- Overlapped positioning with multiple drives
- High transfer rate
- Latency minimization sector counters
- Swapping capability

DECsystem-10 disk systems offer rapid access on-line storage in large capacities at low cost. Modularly expandable, a system allows up to 4 controllers each with 8 drives, giving a total capacity of 327,680,000 words, or in excess of 1,966 million characters.

The RP10C disk controller operates with any combination of two disk drives, the RP02 and RP03, with storage capacities of 5,120,000 and 10,240,000 36-bit words per pack, respectively. Thus a system using eight RP02 drives provides a total on-line capacity of 41,574,400 words, and eight RP03 drives, 83,148,800 words. In addition to storage, a disk system can be used to swap programs in and out of core memory.

RP10 Disk Drive Controller

The RP10C disk drive controller provides control for as many as eight disk drives: RP02, RP03, or a combination of RP02's and RP03's. Through the DF10 data channel, both drives transfer data directly to and from memory.

Since the controller provides overlapped positioner operation, the operating system (monitor) will simultaneously position two or more disk drives, shortening the effective access time and increasing throughput. In addition, the monitor uses the controller's sector counters to minimize the effect of rotational latency and further increase throughput.

Controller Specifications

AC Voltage	115V±10%, 60Hz±2Hz 230V±10%, 50Hz±2Hz
Current	8A @ 115V
Power Dissipation	900 Watts
Heat Dissipation	3100 Btu/Hr.
Operating Temperature	60°F. to 95°F. (16°C. to 35°C.)
Relative Humidity	20% to 80%
Height	69 inches (176 cm)
Width	21.25 inches (53.9 cm)
Depth	27 inches (68.6 cm)
Weight	390 lbs. (178 kg)

RP02, RP03 Disk Drives

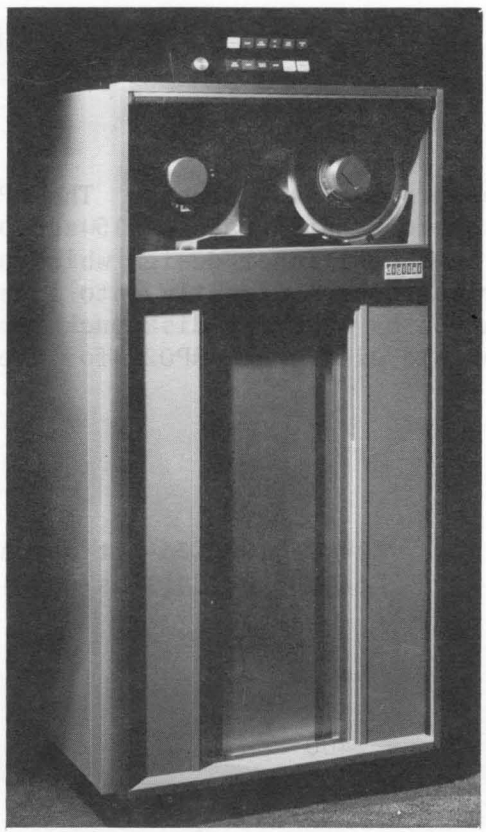
DECsystem-10 disk drives provide fast access. The RP02's and RP03's transfer up to 25,600 words in a single access at a rate of 15usec per 36-bit word. Access speed is due to a high-speed head positioner design which uses a servo-controlled linear motor to convert electrical energy directly into linear motion. A dynamic disk brake facilitates operation by reducing disk pack replacement time. Each disk drive includes one removable disk pack, RP02P for the RP02 and RP03P for the RP03.

Drive Specifications

	RP03	RP02
Disk Pack Capacity	10,240,000 36-bit words	5,120,000 36-bit words
Data Transfer Rate	66,666 words(15µs/word)	66,666 words(15µs/word
Access Time		
Track-to-Track:	7.5 ms	12 ms
Average	29 ms	35 ms
Maximum	55 ms	60 ms
Rotational Speed	2400 rpm	2400 rpm

Organization	128 words/sector 10 sectors/track 20 tracks/cylinder 400 cylinders/disk pack	128 words/sector 10 sectors/track 20 tracks/cylinder 200 cylinders/disk pack
Number of Heads	20	20
Number of Recording Surfaces	20	20
Number of Disks	11	11
Operating Environment		
Operating Temp. Range	60°F to 90°F(16°C to 32°C)	60°F to 90°F(16°C to 32°C)
Relative Humidity	8% to 80%	10% to 80%
Power Requirements	3-phase, 60Hz:6A/phase (running),30A/phase (starting surge) 3-phase 50Hz: 6A/phase (running),30A (starting surge) Drive uses one phase; system uses 3-phase	3-phase, 60Hz:7.8A/phase (running),25A/phase (starting surge) 3-phase 50Hz:7.8A/phase (running),30A (starting surge) Drive uses one phase system uses 3-phase
Dimensions		
Width	30 inches (76.2 cm)	30 inches (76.2 cm)
Depth	24 inches (61.0 cm)	24 inches (61.0 cm)
Height	39 inches (101.6 cm)	39 inches (99.0 cm)
Weight	390 lbs. (177.3 kg)	395 lbs. (179 kg)

TU40 MAGNETIC TAPE SYSTEM



System Features

- Transfer rates - 120kc at 800cpi, 83.4kc at 556cpi, and 30kc at 200cpi
- Automatic loading of 5", 8½", and 10½" reels and automatic loading of industry-standard tape cartridges
- Automatic power window
- Selectable recording densities on both 7 and 9-channel drives of 200, 556, or 800cpi NRZI
- Single capstan drive and air bearings at point of wear provide reliability and trouble-free operation
- TU40 may be mixed with other DEC drives on the same TM10B controller
- Standard file protection using ANSI-standard write rings
- ANSI-standard recording methods

The TU40 DEC magtape transport provides the latest design features for easy operation and high-performance reliability.

The power window and automatic threading features eliminate a great deal of effort in mounting tapes. To load the unit, the operator simply places the supply reel on the hub and pushes the load button. The TU40 then automatically loads itself and is ready for operation in seven seconds.

The TU40 accepts all standard tape reels - five-inch mini-reels, also 8½ and 10½-inch, 2400-foot reels. In addition, TU40's accept industry-standard cartridges.

The tape path of the TU40 is constructed to provide gentle tape handling characteristics. For example, the only surfaces the oxide touches are the tape cleaner and the read/write head. (During rewind, the tape is removed from these surfaces.) Air bearings are used at all tape turnaround points to eliminate lateral tape forces which cause damage to the edges of the tape.

Tape is also maintained in the vacuum column during rewind, providing constant tape tension to produce a uniform tape pack in the rewind reel.

Supplementary Specifications

Transfer rates	120kc at 800cpi, 83.4kc at 556cpi, and 30kc at 200cpi
Tape Speed	150 ips (3.9 mps)
IRG	0.6 inch, 9-track 0.75 inch, 7-track
Load Time	7 seconds
Start/Stop Time	2.5 milliseconds
Rewind Speed	500 ips average
Rewind Time (2400-foot reel)	66 seconds maximum

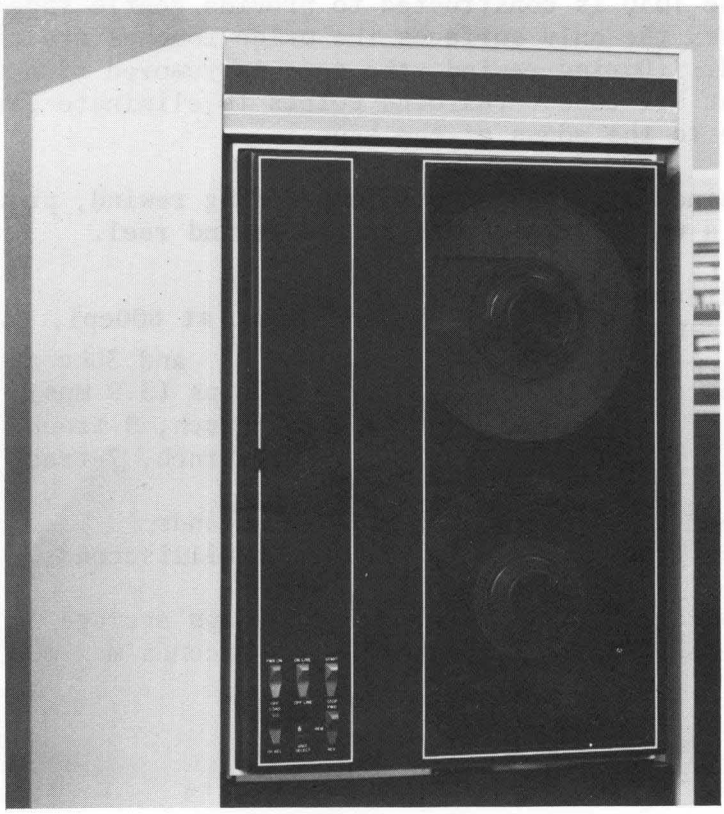
Supplementary Specifications (Continued)

Power	208/230 VAC, 50/60Hz
Power Consumption	2.3 KVA
Heat	5200 Btu/hr.
Operating Temperature	50°F to 110°F
Non-Operating Temperature	-30°F to 150°F
Humidity Operating	20% to 80%
Non-Operating	5% to 95% (no condensation)
Altitude Operating	10,000 feet
Non-Operating	20,000 feet
Height	67 inches
Width	30½ inches
Depth	30 inches
Weight	900 pounds

Designations:

TU40-A	9-channel, 60Hz
TU40-B	9-channel, 50Hz
TU41-A	7-channel, 60Hz
TU41-B	7-channel, 50Hz

TU10 MAGNETIC TAPE SYSTEM



TU10 Features

- Low cost
- Industry compatibility
- 36KC, 45 ips
- 200, 550, 800 bpi
- 7 or 9 channel

The TU10 is a low cost, industry-compatible magnetic tape transport. From one to eight TU10 transports may be interfaced by a TM10 control unit. Each transport is mounted in a standard 19-inch cabinet.

TU10 Specifications

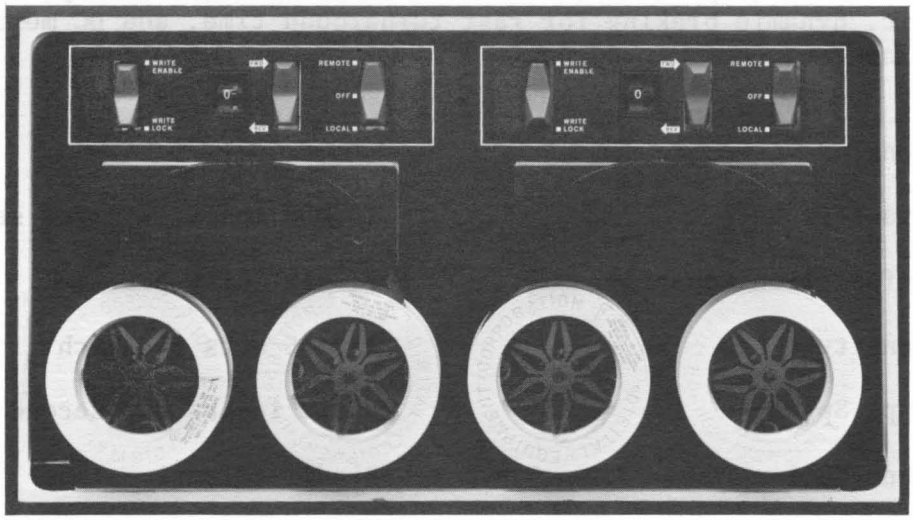
Tape	0.5-inch wide, industry standard
Tape Speed	45 inches per second, reading and writing
Packing Density	7-channel: 800, 556, and 200 BPI; selectable under program control, 9-channel: 800 BPI
Maximum Transfer Rate	36,000 characters per second
Rewind Speed	150 IPS
Inter-record Gap	Will read tape with gap of 0.48 inches or more; will write tape with gap of 0.52 inches or more (compatible with industry standard)
Recording Mode	NRZI, industry compatible
Magnetic Head	Dual gap, read after write
Data Transfer Method	Non-processor request (DMA "cycle stealing")
Tape Handling Method	Direct-drive reel motors, servo-contolled single capstan, vacuum tape buffer chambers with constant tape winding tension. There are no dancer arms to cause non-uniform tape tension and stretching.
BOT, EOT Detection	Photoelectric sensing of reflective strip, industry compatible
Skew Control	Deskewing electronics included in TU10 transport to eliminate static skew
Write Protection	Write protect ring sensing on TU10 transport

Data Checking Features	Read after write parity checking of characters; longitudinal redundancy check (7 and 9-channel); cyclic redundancy check (9-channel)
Programmable Commands Accepted by Transport	Rewind and Go Offline; Read; Write; Write End of File Character, Space Forward; Space Reverse; Write with Extended Inter-Record Gap; Rewind to BOT
Extended Features	Self-test of TM10 control with TU10 offline; core dump mode for 7-channel units
Environmental Requirements	40°F to 110°F, 20% to 95% relative humidity
Local Transport Controls	Online/Offline, Forward/Reverse/Rewind, Unit Select, Power on/Off, Start/Stop, Brake Release/Load
Reliability	Dual-gap, read-after-write head checks parity character-by-character. Longitudinal redundancy check automatically performed on both 7 and 9 channel units; cyclic redundancy check automatically performed on 9-channel units. Ruggedized construction; shock mounted. Power failure interlocks prevent tape damage or data loss.
Capacity	10½ inch reel capacity permits up to 2400 feet of tape per transport
Expandability	Up to 8 transports may be driven by one TM10 controller in any combination of 7 and 9-channel units. Thumbwheel indicator switch selects logical unit assignments

Model Designations

TU10E Magnetic Tape Unit	Reads and writes 9-channel USASI standard magnetic tape at 45 inches/second and a density of 200, 556 and 800 bits/inch (36K characters/sec.)
TU10F Magnetic Tape Unit	Reads and writes 7-channel industry-standard tape at 45 inches/second and a density of 200, 556, and 800 bits/inch (36KC).

TU56 DECTAPE TRANSPORT



Features

- Low price form of magnetic tape
- Pocket sized reels
- Highest reliability
- Not sensitive to line voltage or frequency variation
- Storage equivalent to 10,000 average punched cards
- File index storage and retrieval
- Bi-directional
- Word addressable
- Not sensitive to dirty environments

TU56 Dual DECtape Transport

Digital Equipment Corporation's popular computer peripheral, a DECtape, is available in a vastly improved dual reel version which is completely compatible with all DECtape controllers.

This fixed address, bi-directional magnetic tape storage system provides random access for high-speed reading or writing of files on 260 feet of 3/4-inch wide magnetic tape, contained on a reel less than 4 inches in diameter. Redundant recording (each bit of data is recorded on two separate tracks) assures high reliability and eliminates the need for parity checking.

The dual unit allows for the mounting of two tape transports in just 10½ inches of a standard 19-inch equipment rack. Other features of the DECtape unit include: all T^2L logic, dynamic braking for fast turnaround time, and DC motor drive to eliminate line frequency dependency.

Specifications

Transfer Rate	15,000 characters per second
Information Capacity	2.7×10^6 bits per reel
Density	350±55 bits per inch
Tape Speed	93±12 inches per second
Tape Motion	Bi-directional
Start Time	150 msec
Stop Time	100 msec
Turnaround Time	200 msec
Reel Capacity	250 ft. of 3/4 inch, 1 mil Mylar tape
Reel Size	3.9 inches in diameter
Mounting	Mounts in a standard 19-inch equipment rack
Size	10½ inches high 19 inches wide 9-3/4 inches deep
Cooling	Internally mounted fans provided
Power Requirements	a. +10V@0.53 amps or +5V@0.55 amps b. -15V@0.45 amps c. 115/220VAC±10%@2.85/1.43 amps 47-63Hz
Environmental	
Temperature	$40^{\circ}F$ to $90^{\circ}F$
Humidity	15% to 80% Relative Humidity
Internal Temp. Rise	10%F above ambient
Reliability	Recoverable error rate - greater than 1 part in 2.5×10^{10} transfers

CR10 CARD READERS

Features

- Reads 100,000 cards, 60% punched, 1 read error allowed
- Reads 200 passes of 500 cards
- 1200, 1000 and 300 cpm rates
- "Riffle air" feature separates cards - minimizes effects of card damage and humidity
- Advanced design vacuum picker prevents double picking
- Cards can be loaded or unloaded while reader is operating
- Automatic blower shutdown, optional
- Quiet operation
- Can permit reading of cards punched with verifying marks in column 81

Designed to meet varying throughput requirements and provide reliable, quiet, trouble-free operation, the CR10 card readers accept 80-column EAI standard cards.

For fast throughput, the user can choose the console model CR10E which processes 1200 cards per minute, or the table model CR10D which processes 1000 cards per minute. The CR10F card reader is a lower-cost table model which operates at a lower speed (300 cpm) but utilizes the same excellent features as the high throughput models.

Reader design helps prevent card jams and keeps card wear to a minimum. The readers also have a high tolerance to cards that have been subjected to high humidity or to rough handling, and are worn, nicked, warped, bent, folded or otherwise damaged.

To keep cards from sticking together, the readers use a special "riffle air" feature. The bottom half-inch of cards in the input hopper is subjected to a stream of air which separates the cards and air-cushions them from the deck and from each other. This action unsticks those cards attracted electrostatically, and loosens those cards attached through torn webs or hole locking. It also separates cards that are swollen and stuck from excess humidity.

Cards entering the reader are selected through an advanced-design vacuum picker. The picker and its associated throat block prevent the unit from double picking, so that cards which have been stapled or taped together (unless such taping is on the leading edge) will not enter the card track. To minimize the chances of jamming, the card track is short (less than four inches) so that only one card at a time is in motion.

The "riffle air" and vacuum picker design features greatly extend card life. Stoppages are also reduced since the reader automatically tries six times before it determines that a card cannot be picked.

The read station of the card readers uses infrared light-emitting diodes as its light source and phototransistors as its sensors to provide complete reliability. No adjustments are required during the ten-year life expectancy of the diodes.

Traditional incandescent sources, on the other hand, require continual adjustment with age. Since the readers require minimum mechanical adjustments and no electronic adjustments, reader availability is high and downtime for maintenance is minimized.

Operation is flexible. Cards can be loaded and unloaded while the reader is operating. For operator convenience, a switch can be set to provide system blower shutdown or continual running after the last card has been read. Automatic shutdown reduces computer room noise level, and also informs the operator that the card hopper is empty.

Cards must meet ANSI-X3.11-1969 Standard and the environment must conform to the recommended environment listed in the appendix to the Standard.

Card Reader Specifications

	CR10E Console	CR10D Table Top	CR10F Table Top
Reading Rate (cpm)	1200	1000	300
Input Hopper Capacity(cards)	2200 - 2300*	950 - 1000*	550 - 600*
Output Hopper Capacity(cards)	2200 - 2300*	950 - 1000*	550 - 600*
Size Envelope (HxWxD)			
Inches	42x25x40	17x24x19	13x20x15
Centimeters	107x64x102	43x61x48	33x20x38

* Depending on card stock

Weight (maximum)			
Pounds	300	100	70
Kilograms	660	220	154
Power Consumption (VA)			
Starting	3000	1500	1500
Running	500	460	460
Heat Dissipation (BTU/Hour)	1900	1600	1600

CP10 CARD PUNCH

Features

- 200 - 365 cards per minute
- 1000 card stacker capacities

The CP10A card punch punches cards at the rate of either 200 cards per minute when punching all 80 columns, or 365 cards per minute when punching only the first 16 columns. The card hopper and stacker capacities are 1000 cards.

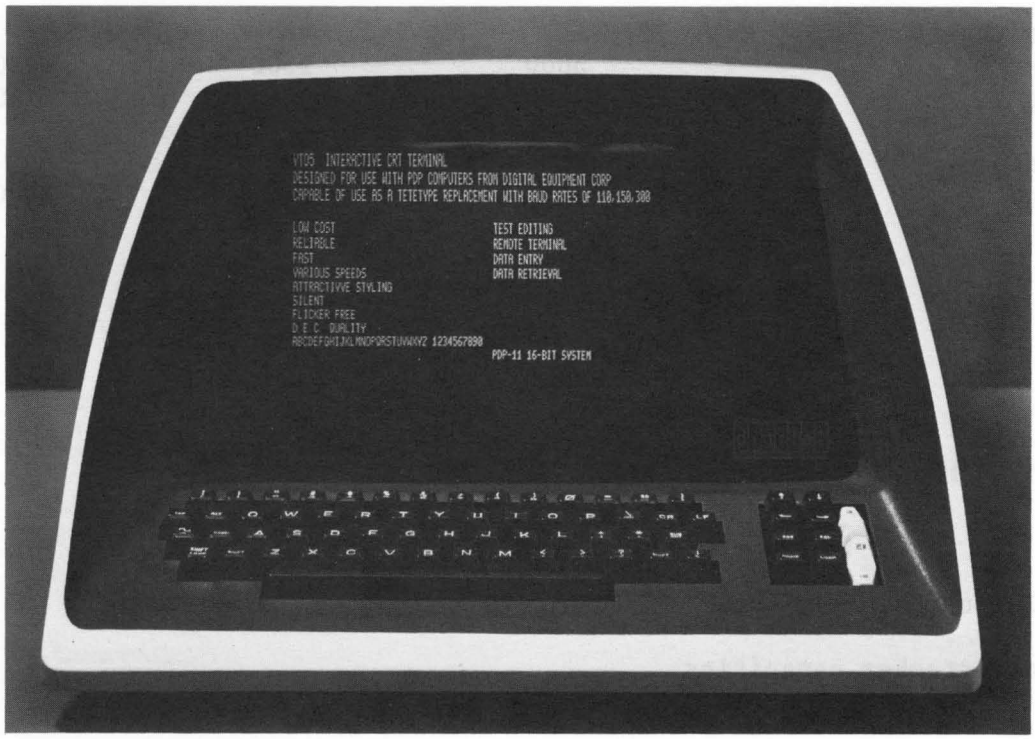
LP10 LINE PRINTER

Features

- 300 or 1000 lines per minute
- 132 columns per line
- 64 or 96-character set, upper/lower case
- Output spooling
- Up to 3 local line printers

Line Printers	Characters	Lines/Minute	Columns/Line
LP10A	64	300	132
LP10C	64	1,000	132
LP10D	96	600	132

VT05 ALPHANUMERIC TERMINAL



VT05 Features

. Speeds up to 300 baud

. Completely interchangeable with teletype (20 mil current loop)

. EIA RS-232C compatible communications interface

. 20 lines, 72 characters/line

. Direct cursor addressing

. Concurrent video-alphanumeric imaging

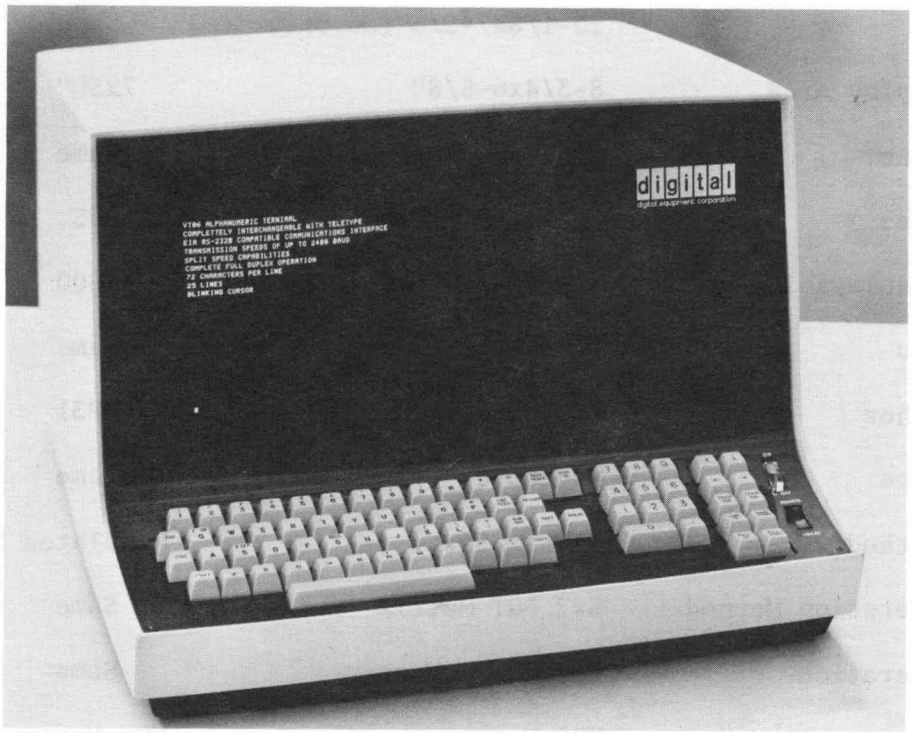
. Easy-to-read characters

. Raster Scan

. 64-character set keyboard

The VT05 is a flexible, high-performance alphanumeric display terminal with a video cathode ray tube display and communications equipment. It is capable of transmitting data over standard phone lines and data sets in half or full-duplex modes at rates up to 300 baud. For remote users, the VT05 serves as a non-mechanical terminal that handles data speeds many times faster than that of conventional teletypewriters. If desired, the aplhanumerics can be superimposed on a background video image derived from a closed circuit TV camera or video tape player.

VT06 ALPHANUMERIC TERMINAL



VT06 Features

. Speeds up to 2400 baud

. Completely interchangeable with teletype

. EIA RS-232C compatible communications interface

. 25 lines, 72 characters/line

. Split high and low-speed data transmission rates

. High-speed CRT display

. Easy-to-read characters

. Modulated scan

. 64-character set keyboard

The VT06 is a flexible, high-performance alphanumeric display terminal with a cathode ray tube display and communications equipment capable of transmitting data over standard phone lines and data sets at half or full-duplex at rates up to 2400 baud.

The VT06 offers the remote user a non-mechanical terminal that handles data speeds over 24 times faster than that of the typical slow, noisy, mechanical, and unattractive, standard electro-mechanical terminal devices.

Alphanumeric Terminal Specifications

	VT05	VT06
Screen Size	10-1/8x7-5/8"(26.6x19.5cm)	Same
Character Display Area	8-3/4x6-5/8"	7x5½"
Characters/Line	72	Same
Number of Lines	20	25
Characters Displayable	1440	1800
Contrast Ratio	12:1	Same
Type of Phosphor	P4 (white)	P31
Deflection Type	Magnetic	Same
Deflection Method	Raster Scan	Modulated Scan
Character Generation Method	5x7 DOT Matrix	Same
Character Generation	Read Only Memory	Same
Refresh Buffer	MOS Memory	MOS Memory
Memory Size:		
ROM	2240 Bits	2240 Bits
Refresh Buffer	9816 Bits	10800 Bits
Display Refresh Rate	60/50H_3(Power Line Freq.)	Same
Character Set	Upper Case ASCII	Same
Character Size	.23x.11"	.16x.11"
Cursor	Non-destructive, blinking	Same
Video	Standard EIA-compatible video signal	Same
Keyboard/Control		
Type	Electronic(wafer switch) Standard model TTY layout	(read relay)
Character Set	Selectable (upper case, standard ASCII; upper/ lower case, full ASCII)	Standard ASCII; Addl. key numerical entry
Controls:		
Cursor	Up, down, left, right, home up, direct address-ing, tab	Up, down, left, right, home up, home down
Erase	To end of line, to end of frame	Same

Alphanumeric Terminal Specifications (Continued)

	VT05	VT06
Erase Lock	Prevents inadvertent erasure	
Power	On, off	Same
Mode	Remote, local	Same
Transmission	Full, half-duplex	Same
Mechanical/Environmental		
Dimensions:		
Width	19"	19"
Height	22"	14"
Depth	34"	20"
Weight	55 lbs.	48 lbs.
Heat Dissipation	800 Btu/hr.(max.)	Same
Operating Temperature	40^{o}-100^{o}F(4.4^{o}-37.8^{o}C)	Same
Humidity	10-95%	Same
Power Consumption	130 watts	Same
Data Transmission	Crystal Controlled, Selectable send/receive 110,150,300 baud	Send/receive 110,150,300, 600,1200,2400 Split speed 110/1200, 110/2400, 150/1200, 150/2400 Single phase

CUSTOM EQUIPMENT & SOFTWARE

- Interprocessor Buffers
- Bus Switches
- Analog to Digital Subsystems
- Precision Graphic Display System
- Digital Plotter Interface
- Card Punch

DEC's Computer Special Systems organization is dedicated to serve customer needs for custom computer hardware and software systems. Whether the need is for a custom-built peripheral, an interface to a unique process or device, a multi-processor system, or a complete turnkey package, Computer Special Systems provides a total capability gained from over six years of experience with all of DIGITAL's products. Examples include:

- Integrated system software and system management
- Application packages used as part of a medium-scale PDP-10-based stock exchange
- A software system to enable DECsystem-10 to communicate with and control a network of PDP-15 graphic systems over high-speed parallel data paths
- Full-scale system diagnostic and exerciser packages for tandem PDP-10 systems

In addition to its one-time design and manufacture capability, Computer Special Systems produces a limited product line. Several custom products have been developed and are offered as custom options on the DECsystem-10. A small sample is outlined below. For additional technical specifications, pricing information, or availability, contact a DECsystem-10 representative or Computer Special Systems directly.

INTERPROCESSOR BUFFERS

PDP-15 To DECsystem-10 Memory Link Type DA15C

The DA15 memory interface forms a link between a PDP-15 central processing unit and the DECsystem-10 core memory system. In operation, the DA15C is transparent to the PDP-15 CPU. The DECsystem-10 maintains direct control over the relocation and protection functions for that area of -10 memory allocated to the PDP-15; memory protection violations initiate PDP-15 program interrupts.

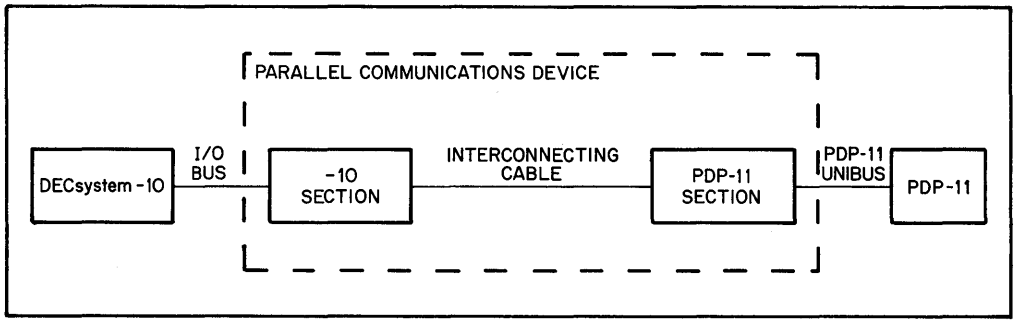
PDP-X to DECsystem-10 Interprocessor Buffer Type DA27

The DA27 family of interprocessor buffers will allow either direct memory block transfers, or individual CPU-controlled transfers between the DECsystem-10 and the PDP-8, PDP-11, or PDP-15 computer systems. Will allow interfacing of up to 16 PDP-X computers via one DA27 master control on the DECsystem-10.

DECsystem-10 TO PDP-11 LINK

This parallel communications device (PCD) serves as a medium speed transfer link between DECsystem-10 and PDP-11 processors. All data transfers are accomplished under program control. The maximum transfer rate is therefore specified by the hardware and software priorities which exist at the time of operation. The interface provides inter-processor interrupt capabilities for use during data transfer operations and is capable of operating in a full-duplex mode.

The PCD hardware consists of two major sections; one section connects to the DECsystem-10 I/O bus and the other to the PDP-11 Unibus. These major logic sections can be separated by up to 2,000 feet. This separation is made possible by the use of special driver circuits. Because the two sections interact on a demand-response basis, the introduction of lengthy cables between the two sections degrades the maximum transfer rate.



DUAL PROCESSOR BUS SWITCHES

I/O Bus Switch Type DT01C

This device is designed to allow a given device(s) (connected to the program controlled transfer - I/O - bus) to be switched between two DECsystem-10 processors. It is designed for use in redundant and resource-sharing systems. Multiple switches may be used in a given configuration. The switch can be controlled manually or under software control.

Memory Bus Switch Type DT04C

This device is functionally similar to the DT01C but allows switching of a device(s) between two memory bus structures of the DECsystem-10. Most direct memory type devices require both the DT04C and the DT01C to implement full switching capabilities.

ANALOG TO DIGITAL CONVERTERS

Simple ADC Subsystem Type AD01C

The AD01C is a low-cost, multi-channel analog subsystem which provides users with a basic controller for inputting hi-level analog data. Designed and manufactured by DIGITAL, the AD01C interfaces directly to the DECsystem-10 I/O bus and operates under program control. As many as 32 channels of single ended data can be handled by the AD01C. Throughput rates of the 10-bit converted signals are determined by user software, but can approach 20KHz.

ADC System AD10

The DEC AD10 converter system interfaces with the DECsystem-10 and features a wide range of differential input with flexible multiplexer expansion capabilities. It is designed for real-time applications of data acquisition and the reduction of time-dependent analog voltage signals from laboratory instruments such as the gas chromatograph.

The AD10 combines a reliable solid state multiplexer with high resolution analog-to-digital converter. Input range is ±10mv to ±10v with stepped or automatic range features. Can be expanded up to 192 channels with direct address or scan addressing controls.

GRAPHICS DISPLAY

Precision Incremental Display System Type VB10C

The VB10C display system, designed and manufactured by DIGITAL, provides the DECsystem-10 alphanumeric and graphic display capabilities. Connection to the computer system is through both the I/O and memory buses, thereby permitting information to be displayed with minimal software overhead.

Information may be displayed as straight lines, vectors, curved lines, characters or single random-position points. The following seven modes of operation are available in the basic VB10C:

Parameter	Zoom, intensity change, light pen, etc.
Point	Random X-Y coordinates
Vector	Magnitude and direction of straight lines
Vector Continue	Straight line to the raster edge
Increment	Contiguous point plotting
Character	ASCII 128-character set
Subroutine	Controller accesses other display subroutines in core by means of jump, jump-and-save, or jump-indirect instructions, thereby allowing nesting of subroutines

The following two optional modes are also available:

Slave	Control commands to four slave monitors
Raster	Intensity information for five successive horizontal points

PERIPHERAL DEVICES

Gould 4800 Printer/Plotter

This interface allows the Gould 4800 printer/plotter and alphanumeric character generator, manufactured by Gould, Inc., to be attached to the DECsystem-10 computer system. The printer and control provide users with a high-performance hard-copy graphics and alphanumeric capability. Operating at up to 4800 lines per minute, the combination provides multiple fonts, upper and and lower case alphanumerics, and line-drawing features for the generation of graphics, schematics or charts.

Information is transferred to the Gould 4800 in parallel via a DF10 channel controller. For alphanumerics, a 6 or 7-bit ASCII code is used to define the 64 or 128-character set. In the graphics mode ("bit mode") six bits are transferred, each bit representing a dot location on the page.

Low Cost Card Punch

A low cost, reliable punch (Data Products SP120) is available interfaced to the DECsystem-10 I/O bus. The punch speed is 100 to 275 cpm and handles industry-standard (EIA-RS292) cards.

NETWORK SYSTEMS

- Specialization of tasks to optimize individual processor capabilities
- Shared system resources to minimize hardware and software redundancies
- Increased reliability of operations by means of system component backup
- Establishment of a common data base

The DECsystem-10 As Network Executive

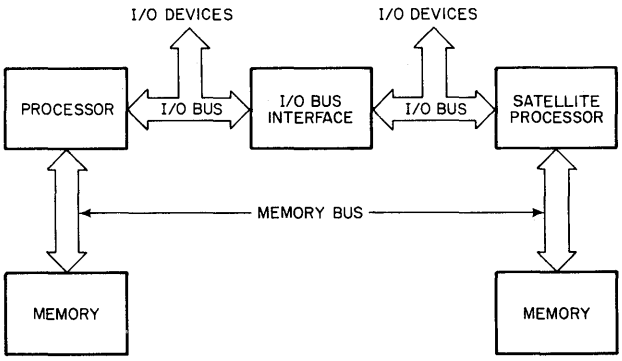
Successful network operations depend primarily on the computing and interactive capabilities of the network executive. The executive must be able to manipulate files and process data within the time frame of the other satellite processors, and allow multiple user interaction for operating on data files and program development. The logical choice of executive for any computer network is the DECsystem-10 with its speed, precision, and multiprogram capabilities. The hardware and software of the -10 are designed for easy and efficient access by other processors whether they are 60-bit super-computers or 12-bit mini-computers.

The -10 software allows for efficient multiprogram operations which take full advantage of the processor power for many concurrent tasks. Within the time frame required, the DECsystem-10 can service the simultaneous input/output requirements of many other processors and data communication lines. In a properly implemented network of this type, each element in the network can be doing those operations it does best, resulting in a savings of computing power, development effort and system maintenance.

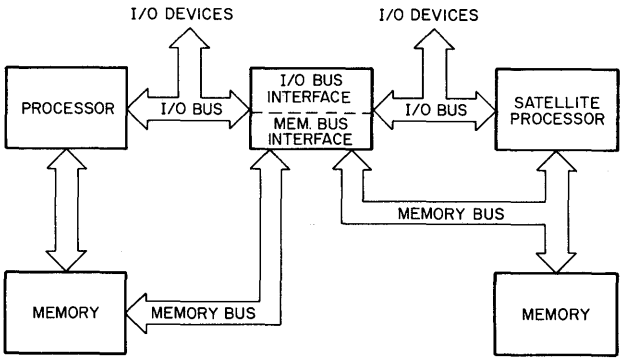
The -10's overall advantage as network executive is further augmented by its ability to simulate other PDP processors. Using the terminals on the -10, a programmer is able to write, edit, assemble, and execute machine language programs for PDP processors. Software for satellites can be written and checked out prior to adding the satellite to the network. If the satellite is already operative, the system can perform simultaneous dedicated operations and program development. The satellite processor can be functioning in the network or in a stand alone mode while programs are developed on the -10 for subsequent implementation. Once the programs are operational, they can be transferred through the network to the satellite for immediate operation. The result is minimal downtime on the satellite for program modifications or system change-overs.

In the case of multiple -10 systems or networks involving very large computers, the ability to interactively develop operating systems or to change the software on-line assumes an added significance. Necessary changes in the software operating systems of the larger computers require an extensive effort in programmer time and quite often an extended period of time for testing and implementing the changes. In most cases, single processor systems cannot give any throughput during this time. With a dual processor system, the necessary throughput can be maintained with one processor while the other is used for implementing and testing the software changes.

Used as the executive for one or more very large systems, the -10 can do most of the file manipulating and dispatching. This has a twofold advantage: (1) Software alterations can be localized to the -10 operating system where they can be easily effected through interaction with the logic via the -10 terminals and multiprogram software; and (2) unnecessary changes in the software systems of the very large computers can be avoided.



Input/Output Bus Links Between the DECsystem-10 and a Satellite Processor



Interprocessor Connections for Extended Memory Operation

SERVICES

EQUIPMENT MAINTENANCE CONTRACTS

A comprehensive selection of field service maintenance contracts is offered, all of which provide the necessary parts, labor and test equipment to insure reliable systems operation. Preventive maintenance is planned to fit the system configuration and workload.

In addition to resident engineer service and hourly on-call service, DEC offers service contracts for 8, 12, 16, 20 or 24 hours/day, five, six, or seven days a week. Combinations (16 hours/day weekdays, 8 hours/day on weekends, etc.) may be purchased.

SOFTWARE SUPPORT AND CONTRACT PROGRAMMING

Local DECsystem-10 software specialists assist with the installation of and additions to the computer system. On-going advisory and remedial support is supplied to assist the installation staff. In addition, DEC offers a range of contract programming services which range from on-site application assistance to project responsibility for complete application program systems.

CUSTOMER TRAINING

DEC offers a series of training courses which are designed to familiarize the new user with the DECsystem-10 hardware, software and operation. A set of training credits is included with the purchase of each system. Classes are generally given at the DEC Training School, Maynard, Massachusetts, although contract on-site training may be arranged.

DOCUMENTATION

DIGITAL supplies two types of documentation, Software Notebooks and handbooks. A DECsystem-10 customer receives two copies of an 8-volume looseleaf Software Notebook; a complete reference source that is amended quarterly with updates and improvements. The first copy is received shortly after the order is received; the second copy at the time the system is delivered.

Handbooks compile individual manuals into groups for convenient customer use. A new DECsystem-10 customer receives one carton of each handbook (approximately 20 handbooks per carton) when the order is placed.

For more information about DECsystem-10, simply complete, staple and mail this reply card.

☐ Please have a sales engineer call.

Please send me the following literature:

☐ Technical Summary, DECsystem-10 (96 pages)
☐ DECsystem-10 in the Sciences (20 pages)
☐ DECsystem-10 in Industry (20 pages)
☐ DECsystem-10 in Education (20 pages)
☐ DECsystem-10, Commercial Applications (20 pages)
☐ Real-Time Systems (16 pages)
☐ Application Notes (4-6 pages each)
☐ Applications in Science, Volume 2 (200 pages)
☐ Products and Services Catalog (180 pages)
☐ Annual Report

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Printed in U.S.A. 10IX 01271 1936/L 14 15