TECHNICAL SUMMARY
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- DECTape
- UNIBUS
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INTRODUCTION

SYSTEM HIGHLIGHTS

One operating system, one user command language handles:

- Multiprogram Batch
- Remote Batch
- Timesharing
- Real-Time Tasks
- Dual Processors

Data communications: multi-speed lines, multi-character sets, synchronous, asynchronous.

Real-time task capabilities:

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

Disk optimization system

Public and private disk file structures

8 levels of file security in 3 classes

Timeshared maintenance diagnostics

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

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

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

Non-standard I/O devices can be added easily using standard interface routines

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, real-time applications.

Each of the six 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, no software changes are required to expand from the smallest system to the largest. The hardware which can be added in this expansion includes: disk/drum storage devices, memories, central processors, peripheral equipment and data communication systems.

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

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. DIGITAL believes that the user of the 70s 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, magnetic 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, BASIC 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 peripherals, remote stations, or interactive terminals. In addition, the user can specify many processing parameters, including start and completion dates and times, 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, inherent to a timesharing system.

The real-time DECsystem-10 user has a choice of response modes. One provides microsecond response to interrupt; while another provides millisecond scheduling of jobs in high priority run queues. On-line data acquisition, for example, might be performed by 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 administrator such as the ability to lock a job in core for fast response.

By granting special privileges, the administrator reserves system resources to assure required response for each real-time 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/E 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 simultaneously services a line printer and card reader, but it can also serve as a concentrator for up to 16 terminals. In another station arrangement, the remote processor might 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, multi-program 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.

### PERFORMANCE RANGE

<table>
<thead>
<tr>
<th>RELATIVE THROUGHPUT POWER</th>
<th>1040</th>
<th>1050</th>
<th>1055</th>
<th>1060</th>
<th>1070</th>
<th>1077</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5</td>
<td>3</td>
<td>2.5</td>
<td>3.5</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AVERAGE NUMBER OF SIMULTANEOUS TASKS UNDER MULTIPLE LANGUAGES</th>
<th>5–15</th>
<th>10–50</th>
<th>20–70</th>
<th>20–60</th>
<th>30–80</th>
<th>60–100</th>
</tr>
</thead>
</table>

### OPERATING CAPACITIES

<table>
<thead>
<tr>
<th>Number of simultaneous running jobs</th>
<th>127</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of concurrent batch streams</td>
<td>14</td>
</tr>
<tr>
<td>Maximum User File Size</td>
<td>No operating limit within the total file space available</td>
</tr>
<tr>
<td>Minimum File Size</td>
<td>128 words (768 characters)</td>
</tr>
<tr>
<td>Maximum core-resident job size (less monitor size)</td>
<td>256K words (1,280K bytes)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INPUT/OUTPUT</th>
<th>1040, 1050, 1055</th>
<th>1060, 1070, 1077</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low speed I/O rate (multiplexer)</td>
<td>200 words/second</td>
<td>370K words/second</td>
</tr>
<tr>
<td></td>
<td>1,000K bytes/second</td>
<td>1,850K bytes/second</td>
</tr>
</tbody>
</table>

| High speed I/O rate | 4,000K words/second | 4,000K words/second |
|                     | 20,000K bytes/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 64K words (320K bytes) to a maximum memory size of 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.

Multiple simultaneous jobs may be processed under timesharing, real-time and batch operations. All DECSYSTEM-10 language processors run on the 1040, provided there is sufficient memory to accommodate them. The system uses disk drives for both job swapping and file storage.
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 if there is one larger system with all resources shared among all users. Additional memory is required above the minimum 1050 system.
The 1060 is a K110 processor based system for the smaller installation whose performance requirements are not met by the DECsystem-1040. The 1060 provides more than double the central processor speed of the 1040 in addition to such features as instruction look-ahead, increased memory size, higher speed I/O capabilities and double-precision floating point arithmetic. Memory for the 1060 begins at 64K (320K bytes) and may be expanded to a maximum of 4 million words (20 million bytes). Disk storage requirements of the 1060 typically range from 60 million characters upwards. The system uses disk drives for both job swapping and file storage.
DECsystem-1070

DECsystem-1070 is a large-scale computing system with more than double the central processor speed of the 1050. Features include instruction look-ahead, 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 (480 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 stations are multiplexed through the DC75 synchronous communications multiplexer, or the DS10 single-line synchronous interface.
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 if there is one larger system with all resources shared among all users. Additional memory is required above the minimum 1070 system.
MAXIMUM EQUIPMENT EXPANSION

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

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Maximum Number Units</th>
<th>Equivalent Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENTRAL PROCESSOR</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>CORE MEMORY (or equivalent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1040, 1050, 1055</td>
<td>256K words</td>
<td>1,280K bytes</td>
</tr>
<tr>
<td>1060, 1070, 1077</td>
<td>4,096K words</td>
<td>20,480K bytes</td>
</tr>
<tr>
<td>DISK FILE STORAGE</td>
<td>4 controls,</td>
<td>1.92 billion characters</td>
</tr>
<tr>
<td></td>
<td>8 drives each</td>
<td></td>
</tr>
<tr>
<td>SWAPPING DRUMS</td>
<td>2 controls,</td>
<td>13,800K bytes</td>
</tr>
<tr>
<td></td>
<td>4 drums each</td>
<td></td>
</tr>
<tr>
<td>MAGNETIC TAPE DRIVES</td>
<td>2 controls,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 drives each</td>
<td></td>
</tr>
<tr>
<td>DECTAPE DRIVES</td>
<td>2 controls,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 drives each</td>
<td></td>
</tr>
<tr>
<td>LINE PRINTER (Local)*</td>
<td>2</td>
<td>2,500 lines/min.</td>
</tr>
<tr>
<td>CARD READER (Local)*</td>
<td>2</td>
<td>2,400 cards/min.</td>
</tr>
<tr>
<td>CARD PUNCH (Local)</td>
<td>1</td>
<td>300 cards/min.</td>
</tr>
<tr>
<td>INTERACTIVE TERMINAL PORTS**</td>
<td></td>
<td>127</td>
</tr>
<tr>
<td>1040, 1050, 1055</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1060, 1070, 1077</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REMOTE BATCH STATIONS</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>(Includes Card Reader, Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Printer, and up to 16 terminals.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only 2 supported on 1040.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REAL-TIME APPLICATION DEVICE</td>
<td>64 device codes</td>
<td></td>
</tr>
</tbody>
</table>

* 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

<table>
<thead>
<tr>
<th></th>
<th>1040</th>
<th>1050</th>
<th>1055</th>
<th>1060</th>
<th>1070</th>
<th>1077</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of CPUs</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Number of Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double Precision Floating</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Point Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core Memory Size (36-bit word, min.-max. K words)</td>
<td>64–256</td>
<td>64–256</td>
<td>80–256</td>
<td>64–4096</td>
<td>96–4096</td>
<td>128–4096</td>
</tr>
<tr>
<td>Memory Speed—microseconds/word (microseconds/5 bytes)</td>
<td>Access: 0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Cycle: 1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Operand Length</td>
<td>Immediate, 36 bits half word, full word Immediate: 18 bits Half Word: 18 bits Full Word: 36 bits Byte: 0–36 bits</td>
<td>Same plus double word (Double Word: 72 bits)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instruction Lookahead</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Memory Interleaving</td>
<td>2 or 4 way</td>
<td>2 or 4 way</td>
<td>2 or 4 way</td>
<td>2 or 4 way</td>
<td>2 or 4 way</td>
<td>2 or 4 way</td>
</tr>
<tr>
<td>Memory Overlap Control</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Paging, Virtual Memory Capability</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Memory Protection</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Index Registers</td>
<td>15</td>
<td>15</td>
<td>15 each CPU</td>
<td>4x15</td>
<td>4x15</td>
<td>4x15 each CPU</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>16</td>
<td>16 each CPU</td>
<td>4x16</td>
<td>4x16</td>
<td>4x16 each CPU</td>
</tr>
<tr>
<td>Accumulators</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>2.5μs</td>
<td>2.5μs</td>
<td>2.5μs</td>
</tr>
<tr>
<td></td>
<td>6μs</td>
<td>6μs</td>
<td>6μs</td>
<td>3μs</td>
<td>3μs</td>
<td>3μs</td>
</tr>
</tbody>
</table>

13
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, when 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 unit operates independently, the processor can be executing a program in one unit 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 memory space through reentrant software. That is, only one copy of a language processor (or most systems programs larger than 1K) need be memory-resident to serve multiple users simultaneously.

The monitor maximizes throughout 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 low speed (110-300 baud) terminals and several high-speed terminals (300-2400 baud) simultaneously. These terminals may include CRTs.

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 make it easy for a user to develop his own special languages or systems. The large number of languages implemented on DECsystem-10 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; find and search 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 magnetic tapes, private disk packs, etc.
- Start, suspend, or terminate jobs
- 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 I/O spooling, common user file and the ASSIGN command.

For input and output efficiency, the system usually employs spooling for slow peripherals such as the card reader, card punch, paper tape punch, line printer, and plotter. By using a QUEUE 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 service. 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 in order 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 unnecessarily tied up.

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 magnetic tapes, private disk packs, and drums.

The operator may also assign a device to the "restricted" pool (which prevents the device from being directly assigned by the user) in order to reserve it for batch jobs.

MULTIPROGRAMMING 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 generally 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
$FCRTRAN
Program
$DATA
Program Data
END OF FILE

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 (ANSI) 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 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. Or 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 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 field alignment pattern until the printer is adjusted satisfactorily.

All these operations are performed through the use of one or more teleprinter 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 which provides 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—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, become protected against being "swapped" or rolled out onto the disk or drum. Prior to performing the "lock," the monitor positions the real-time code 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 privileged 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—Executive, 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.

No Memory Partitions—DECSystem-10 dual memory protection and relocation hardware provide 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 standard 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 fixed-head 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.
<table>
<thead>
<tr>
<th>Protection Level</th>
<th>Access Code</th>
<th>Access Privileges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greatest Protection</td>
<td>7</td>
<td>No access privileges</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>EXECUTE ONLY</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>READ, EXECUTE</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>APPEND, READ, EXECUTE</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>UPDATE, APPEND, READ, EXECUTE</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>WRITE, UPDATE, APPEND, READ, EXECUTE</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>RENAME, WRITE, UPDATE, APPEND, READ, EXECUTE</td>
</tr>
<tr>
<td>Least Protection</td>
<td>0</td>
<td>CHANGE PROTECTION, RENAME, WRITE, UPDATE, APPEND, READ, EXECUTE</td>
</tr>
</tbody>
</table>

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 8 levels in each of the three user classes:

```
<table>
<thead>
<tr>
<th>File Access Code</th>
<th>Self</th>
<th>Common Project</th>
<th>All Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>4</td>
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<tr>
<td>3</td>
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<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

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 one 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 re-access 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 criteria," 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

- Sequential and Random Access
- Library
- Sort
- Segmentation
- Report Write
- Batch and timesharing modes
- On-line editing and debugging
- Wide choice of peripherals

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.

The COBOL operating system is a shareable program. Only one copy of it is needed on the system, regardless of how many users are running COBOL programs. User programs may also be made shareable, so that if many users need to run the same program at the same time, only one copy of the executable code is required.

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. By use of a simple COBOL-oriented debugging 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.

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 listings and an error listing page to mark up his program. These diagnostics are also displayed on the user's terminal during compilation.

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 easy-to-read listings 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 REPORT-WRITER features 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 randomly or sequentially 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 DIGITAL COBOL system to provide additional compatibility with other industry COBOL systems and with a small amount of programming. The programmer need only 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 are 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 field in order to check on the progress of his program, and if he so desires, to 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 manpower problem. The programmer describes how a report is to look, instead of writing the tedious logic necessary to produce the report. The 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 but most of the errors in logic are also 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. In the event 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 and thus 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 use 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.

FORTRAN-10
The DECSYSTEM-10 FORTRAN-10 language is a superset of the ANSI standard FORTRAN-IV. FORTRAN on the DECSYSTEM-10 features a high-speed compiler which generates reentrant object programs and includes an optional global optimization phase. With global optimization, the compiler produces highly optimized object code. The FORTRAN-10 compiler operates at about 3000 lines per minute.

Features:
- Multiple statements per line
- Labelled constants
- Array subscripts and DO loop parameters may be any arithmetic expression, including subscripted expressions
- Array subscripts may have negative or zero values
- PARAMETER statement—a general string replacement MACRO
- EXTERNAL identifiers
- GLOBAL variables
- Multiple ENTRY and RETURN points to/from subroutines
- Completely general file OPEN statement
- Ability to diagnose non-standard FORTRAN language usage
- Explicit byte manipulation capabilities, including a byte data type
- Object time system which can read or generate data files compatible with other language processors
- Automatically selects double-precision floating point hardware when available
- Sub-expression optimization
- N-dimensional arrays
- ENCODE/DECODE statements
Boolean operations equivalence (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 directly to, or from, core memory, beginning at a location specified by T-format description

Random-access features

Compatibility with IBM-type statements, such as "REAL *8", etc.

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

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

Graphics Support package

Device independence

**FORTRAN-10 Object-Time System**

The FORTRAN-10 object-time system controls the input/output, format interpretations, and numerical conversion for programs compiled by the DECSYSTEM-10 FORTRAN-10 compiler. The FORTRAN-10 user may reference any I/O device (line printer, card reader, magnetic tape, DEC-tape, 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 assign-able at runtime.

**ALGOL**

ALGOL is an implementation of the ALGOL-60 language 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.

Speed: Better than 5000 lines/minute (a 'line' defined as containing 24 significant symbols, unpacked; input from disk, output and listing to disk, measured central processor 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 (KA10) or 64-bit mantissae (KI10). KI10 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.)
- Abbreviated form of FOR and WHILE statements allows user greater flexibility in handling iterations.
- Procedures may be compiled independently of programs.
- Assignments are permitted within expressions.
- RFMainder operator.
- Unique implementation of dynamic OWN arrays.
- Octal and boolean constants and integer/boolean and boolean/integer transfer functions.
- Alternative "reserved delimiter word" or "quoted delimiter word" representations.

**ALGOL Object-Time System**

The object-time system performs the following functions:

- Provides a flexible basic input/output system enabling the user to communicate with DIGITAL 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 terminal input/output and sixteen more 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 run-time 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 subscripts within 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 time-sharing 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, trailing minus sign, and
  imbedded comma features and the ability to left or
  right justify or center string output.
- Sequential-access file handling for both data and text
- Random-access file capability
- Up to 9 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
  (including substring and search).
- 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 the CALL
  subroutine statement capability with arguments, the
  COMPile command to generate reusable object
  programs, and debugging features including the
  insertion of break points and directly executable changes
  using the PRINT and LET statements.

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 relocatable 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-10, 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 relocatable, 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 transferred
  into the fast registers for execution.
- Reentrant programs may be written by using the
  TWOSEG or 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.

SOFTWARE REFERENCE DOCUMENTS

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

DECsystem 10 USER's Handbook (DEC 10 NGZB-D)
- Introduction to DECsystem-10 Software
- Getting Started with Timesharing
- Beginners Guide to Multiprogram Batch
- Introduction to TECO
- TECO, Text Editor and Corrector Program
- LINED, Line Editor for Disk Files
- PIP, Peripheral Interchange Program
- DECsystem-10 Operating System Commands

DECsystem-10 Mathematical Language Handbook
(DEC-10-KRZB-D)
- FORTRAN
- BASIC
- ALGOL

DECsystem-10 Assembly Language Handbook
(DEC-10-NRZB-D)
- System Reference Manual
- MACRO
- Monitor Calls
- Loader
- DDT, Dynamic Debugging Technique
- Utilities

DECsystem-10 COBOL Language Handbook
(DEC-10-KCIC-D)
- COBOL

DECsystem-10 COBOL Language Supplement
(DEC-10-KCIC-D(S))
- Report Writer
- Indexed Sequential Access Mode
- Debugging
- Table Handling

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CENTRAL PROCESSORS

KA10 Processor

X110 Processor
Within the family of six 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 K110 central processor is used in the DECSYSTEM-1060, 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 K110 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 K110 are discussed jointly and the differing features of the K110 are included in italics.

INSTRUCTION SET

- 366 instructions on the KA10, **378 instructions on the K110**
- 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 instructions
- Half-word instructions, **double-word instructions**
- Variable-byte length instructions
- Pushdown instructions
- 64 programmable operators (monitor calls and user system calls)
- **Double precision floating point instructions**

The KA10 has 366 instructions and the K110 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 are unimplemented and reserved for future expansion. An attempt to execute one of these unimplemented instructions results in a trap to the monitor.

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 words of memory without resorting to base registers, displacement addressing, or indirect addressing. Instructions may, however, 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

Both processors have instructions to perform scaling, negating, addition, subtraction, multiplication and division upon numbers in single precision, floating point format. 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.

The K110 has instructions to perform all of the above functions in double precision floating point format as well as single precision floating point. 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 K110 instruction complement provide the capability of converting fixed point formats to or from floating point formats. Two sets of instructions are provided to perform this function: one set optimized for FORTRAN and a second set optimized for ALGOL.

**ARITHMETIC TESTING**

The 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 an 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 direct 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 (UUOs)**

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 included for this purpose by the programmer. Those UUOs reserved for use by the monitor are called monitor UUOs (MUUOs), while user UUOs are called local UUOs (LUUOs). Instructions that are illegal in user mode also trap in the same manner as MUUOs.

**TRAP HANDLING ON THE K110**

The K110 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 avoids 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 the non-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 always supplies information for calculating the effective address, which is used for immediate mode data or 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) contain a memory address.

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 KAI0 that does not have the hardware for these instructions.

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**IN-TABLE INSTRUCTION TIMES**

<table>
<thead>
<tr>
<th></th>
<th>1040</th>
<th>1050</th>
<th>1055*</th>
<th>1060</th>
<th>1070</th>
<th>1077*</th>
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<tr>
<td>Fixed Point Add</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
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<td>Fixed Point Multiply</td>
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<td>9.8</td>
<td>9.8</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
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<tr>
<td>Jump</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Single Precision Floating Point Add</td>
<td>9.8</td>
<td>9.8</td>
<td>9.8</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
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<tr>
<td>Double Precision Floating Point Multiply</td>
<td>59.4</td>
<td>59.4</td>
<td>59.4</td>
<td>7.6</td>
<td>7.6</td>
<td>7.6</td>
</tr>
</tbody>
</table>

* Dual processor systems execute two instructions simultaneously
NUMBER SYSTEM

The standard arithmetic instructions in the DECSYSTEM-10 use two's 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 represent the magnitude in ordinary binary notation. The negative of a number is obtained by taking its two's 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 \( -(2)^{-35} \). Since multiplication and division make use of double length numbers, there are special instructions for performing these operations with results that can be represented by a single word.

The format for double length fixed point numbers is just an extension of the single length format. The magnitude (or its two's 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 ignored. The range for double length integers and proper fractions is thus \( -(2^{19}) \) to \( 2^{19} - 1 \) or \(-1 \) to \( -(2^{-70}) \).

Floating Point Arithmetic

The KI10 has hardware for processing both single and double precision floating point numbers. The KAI10 has hardware for processing only single precision numbers 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 a precision in the fraction of 1 part in \( 4.6 \times 10^{34} \) and an exponent of 2 of a power of from \(-128 \) to \(+127 \).

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 from \( \frac{1}{2} \) 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 from \( \frac{1}{2} \) to 1 decreased by the value of the least significant bit. In all formats the exponent range is from \( 2^{-128} \) to \( 2^{127} \).

PROCESSOR MODES

Instructions on the KAI10 are executed in one of two modes depending upon whether a mode bit has been set.

Programs operate in either User mode or Executive mode. In Executive mode operations, all implemented 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 two submodes each. 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. Within User mode there are the public and concealed submodes; within Executive mode, the supervisor and kernel submodes.

If a program is running in public mode, pages within the user’s addressing space are accessible only if they 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 be accessed only at 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 portions of the operating system to be hardware protected from other portions undergoing modifications or design changes.
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.

**K10 PROCESSOR ASSOCIATIVE MEMORY PAGE ADDRESSING**

**K10 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 K10 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 to 4,194,304 decimal).

The memory mapping process utilizes the most significant 9 bits of the effective address as an index into the appropriate page map (User or Executive) in memory. 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 & Physical Address**

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 below.

If the address is in the range 0 through 17 (octal) inclusive, the hardware fast register blocks are referenced instead of the memory system. Otherwise, the User mode bit and the high order 5-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 a no-match occurs.

If a match exists, the contents of the related register supply the 13-bit most significant portion of the physical memory address and also supply 3-bits which indicate
what types of memory references are allowed to this page, i.e., if the memory request is not consistent with the request type allowed bits, a page failure occurs.

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, i.e., a no-match, the hardware reads the relocation data from the page table in memory and stores it into 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.

This scheme of associative addressing, like the protection and relocation registers on the KA10, allows programs to be assigned to either one or two segments thus allowing reentrant coding.

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.

PRIORITY INTERRUPT

Features
- Multiple levels
- Device priorities assigned through software
- Block move instructions
- 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 sublevels. 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 K110 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 33-bit word which is decoded as 18 bits address, 12 bits data, 3 bits function. The processor then does one of the following:
- Executes the instruction found at the supplied 18-bit address
- Transfers a word into or out of the addressed location
- Adds a signed 11-bit (12 bits = sign + 11 bits) 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 (10 μsec)
- External clock input to 400 kHz
- Assignable to any interrupt channel
- Total elapsed time and interval timing
- Clock can be read without loss of counts

The DK10 real-time clock is supplied with each DECSytem-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 10 μsec resolution and a choice of up to $2^{18}$ possible timing intervals, so that interrupts can be programmed at intervals from 10 μsec 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. Clock updating is interlocked with the DATAI instructions so that it can be read correctly—at any time—by the DECSytem-10 without losing a clock pulse.

FAST REGISTER BLOCKS
- Serve as memory, accumulators, index registers
- Implemented by fast integrated circuitry
- All usable for single and double precision floating point
- 4 blocks of 16 registers

General-purpose registers are another DECSytem-10 feature that help improve program execution. These fast integrated circuit registers can be used as accumulators, index registers, or as the first locations in 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 K110. Context switching on the KA10 is performed by storing the register information into core locations. Program switching time for the K110 between register stacks is 2.5 μsec. On the K110, 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 K110, an automatic restart capability has been added to resume normal operations in the event of a power outage. All three phases of AC power are monitored. Low voltage 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. Alternatively, a manual restart may be used.

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

PROGRAMMABLE VOLTAGE MARGINS

On the K110, the DC voltage level supplied to the system logic can be set under program control to any one of 64 discrete levels. This allows on-line diagnostics to be run through a range of voltage levels without requiring manual settings for individual values. This feature also allows field service personnel to run diagnostic tests without disturbing normal operations.

MULTIPLEXED I/O BUS
- Full word path (36-bit)
- Block input/output instructions
- 200 k word/sec rate (KA10)
- 370 k word/sec rate (K110)

The DECSytem-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 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 200 k words/sec on the KA10 and 370 k words/sec on the K110. 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 (DECSytem-1040, 1050, 1055)
- Expandable to 4,096K words (DECSytem-1060, 1070, 1077)
- Asynchronous operation
- Full-word data transfers
- Direct data channels

To meet the requirements of large systems, DECSytem-10 core memory can be modularly expanded to 256K or 4096K words, all directly addressable. Memory can be comprised of combinations of modules in 16K, 32K, 64K, etc. blocks.

The structure of the memory buses 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 (one for each possible bus) and each port can be further expanded through the use of the MX10 memory multiplexer. The multiplexer handles up to eight data channels, interleaving data from the channels on a word-by-word priority basis. Such parallel operation yields many 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 per second when four I/O devices and processors are simultaneously transferring data.

In addition, each memory bus is capable of handling a maximum of sixteen memory modules. Each memory module provides switches which allow it to represent any module of its size in the addressable memory space. Thus, one model can replace another without rewiring. Switches are also provided for memory interleaving.

MF10 MEMORY SYSTEM

MF10 Features
- 550 nanosecond access time
- Overlapped memory operation
- Two- or four-way interleaving
- 22-bit address logic
- 1024K words (36 bits plus parity per word) directly addressable memory (maximum)
- Compatible with both KA10 and KI10 processors
- Easy to change lamps
- Lamp test
- Quick-latch cable connections

The MF10 Memory System permits DECSytem-10 users to expand the KA10 and KI10 system memories for maximum performance. The KI10 in particular benefits from the advanced control logic features of the MF10 Memory System. Included is overlapped memory control logic which permits the KI10 to transmit an address to a second memory bank for the next data fetch while waiting for the preceding data request to be satisfied by another memory bank. This feature gives KI10/MF10 configurations a high throughput rate under heavy processing loads.

The MF10 Memory System is a ferrite-core memory having a nominal read access time of 550 nanoseconds, a maximum read access time of 610 nanoseconds, and a cycle time of 950 nanoseconds. Up to 16 MF10 modules may be combined to provide 1024K words of high-speed memory. Each module may contain one to four memory ports for connection to processors, data channels and data channel multiplexers. Two or four-way interleaving is provided by switches on each memory module. Address logic decodes a 22-bit address, providing 4096K words of addressing capability.

Because of the asynchronous operation of the DECSytem-10 processor, the MF10 memory can be intermixed with other DECSytem-10 memory units of various speeds to provide the exact performance required.

Specifications

<table>
<thead>
<tr>
<th>Word Size</th>
<th>36 bits plus parity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Memory Unit Size</td>
<td>32K (K = 1024 words)</td>
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<tr>
<td>Expanded Memory Unit Size</td>
<td>64K words</td>
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<td>Maximum Memory System Size</td>
<td>1024K words</td>
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<tr>
<td>Read Access Time</td>
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<td>Typical</td>
<td>550 nanoseconds</td>
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<td>Maximum</td>
<td>610 nanoseconds</td>
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<tr>
<td>Memory Cycle Time</td>
<td>950 nanoseconds</td>
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</tbody>
</table>

ME40 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 unit contains 16,384 words (36 bits plus parity) of storage. Read access time is 550 nanoseconds nominal 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 256K words of high-speed core storage. Each module may contain up to four memory ports for connection to processors, data channels, and data channel multiplexers. 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-1060, 1070, or 1077 systems using the K110 processor.

**ME10 Specifications**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>Word Size</td>
<td>36 bits plus parity</td>
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<tr>
<td>Memory Unit Size</td>
<td>16K (K = 1024 words)</td>
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<td>Maximum Memory System</td>
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<tr>
<td>Size</td>
<td>256K</td>
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<td>Read Access Time</td>
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<tr>
<td>Memory Cycle Time</td>
<td>1.0 microsecond</td>
</tr>
</tbody>
</table>

**MD10 MASS CORE MEMORY**

**MD10 Features**

- Requires only 4.5 square feet of floor space for 128K of storage
- 800 nsec access time
- Modularly expandable to 128K per unit
- 256K words of directly addressable memory (maximum)
- Switchable memory block address
- Two or 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, 1.8 μsec 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 a 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 DIGITAL supplied peripherals.

Because of the asynchronous operation of the processor, the MD10 memory can be intermixed with DIGITAL memories of various speeds; for example, it can be used in the same system with the MF10 or ME10 1.0 μsec memories.

**MD10/MD10E Specifications**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Size</td>
<td>36 bits plus parity</td>
</tr>
<tr>
<td>Minimum Memory Unit Size</td>
<td>64K (K = 1024 words)</td>
</tr>
<tr>
<td>(MD10)</td>
<td></td>
</tr>
<tr>
<td>Expanded Memory Unit Size</td>
<td>96K or 128K</td>
</tr>
<tr>
<td>(MD10E)</td>
<td></td>
</tr>
<tr>
<td>Maximum Memory System</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>256K</td>
</tr>
<tr>
<td>Read Access Time</td>
<td>800 nanoseconds</td>
</tr>
<tr>
<td>Memory Cycle Time</td>
<td>1.8 microseconds</td>
</tr>
</tbody>
</table>
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 service 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.” The following peripheral equipment is described in this section:

- **RM10B** IIIIGH-SPEED SWAPPING DRUM
- **RP02, RP03** DISK SYSTEMS
- **CR10D, CR10E, CR10F** CARD READERS
- **CP10A** CARD PUNCH
- **TU40** MAGNETIC TAPE SYSTEM
- **TU10A** MAGNETIC TAPE SYSTEM
- **TU56** DECTAPE TRANSPORT
- **LP10F, LP10H** LINE PRINTERS
- **VT05** ALPHANUMERIC TERMINAL
- **LA30** DECRIVER TELEPRINTER
- **GT40** GRAPHICS SYSTEM

### 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 msec, and a transfer rate of 4.1 msec 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*

<table>
<thead>
<tr>
<th>Type of Memory</th>
<th>Rotating fixed head drum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drum Capacity</td>
<td>345,600 36-bit words</td>
</tr>
<tr>
<td>Number of Drums</td>
<td>4</td>
</tr>
<tr>
<td>Capacity With 4 Drums</td>
<td>1,382,300 36-bit words</td>
</tr>
<tr>
<td>Method of Transfer</td>
<td>36-bit parallel</td>
</tr>
<tr>
<td>Positioning Time</td>
<td>None (fixed head)</td>
</tr>
<tr>
<td>Latency</td>
<td>8.3 ms at 60 Hz</td>
</tr>
<tr>
<td>Minimum Word Transfer Time</td>
<td>4.1 µs at 60 Hz</td>
</tr>
<tr>
<td>Maximum Word Transfer Time</td>
<td>240K words/sec at 60 Hz</td>
</tr>
<tr>
<td>Character Type</td>
<td>7 bit ASCII</td>
</tr>
<tr>
<td>Transfer Rate</td>
<td>1.2 million char/sec at 60 Hz</td>
</tr>
<tr>
<td>Rotational Speed</td>
<td>3600 RPM at 60 Hz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organization:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of heads</td>
</tr>
<tr>
<td>Number of tracks</td>
</tr>
<tr>
<td>Number of sectors per track</td>
</tr>
<tr>
<td>Sector size</td>
</tr>
</tbody>
</table>

* Performance figures for 60 Hz are based on a rotational speed of 3600 RPM; figures to 50 Hz are based on 3000 RPM.
RP02, RP03 DISK SYSTEMS

System Features
- Fast access
- 1.96 billion 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 1.9 billion characters.

The RP10C disk controller operates with any combination of two types of 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.

RP10C Disk Drive Controller

The RP10C disk drive controller provides control for as many as eight disk drives: RP02, RP03, or a combination of RP02s and RP03s. Through the DF10 data channel, both drives transfer data directly to and from memory, allowing simultaneous I/O and computational operations.

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.

RP02, RP03 Disk Drives

DECsystem-10 disk drives provide fast access. 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. The RP02s and RP03s transfer up to 66,666 words in a single access at a rate of 15 usec per 36-bit word. A dynamic disk brake facilitates operation by reducing disk pack changing time. Each disk drive includes one removable disk pack, RP02P, for both the RP02 and the RP03.

<table>
<thead>
<tr>
<th>Drive Specifications</th>
<th>RP03</th>
<th>RP02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk Pack Capacity</td>
<td>10,240,000 36-bit words</td>
<td>5,120,000 36-bit words</td>
</tr>
<tr>
<td>Data Transfer Rate</td>
<td>66,666 words (15 μs/word)</td>
<td>66,666 words (15 μs/word)</td>
</tr>
<tr>
<td>Access Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Track-to-Track:</td>
<td>7.5 ms</td>
<td>12 ms</td>
</tr>
<tr>
<td>Average</td>
<td>29 ms</td>
<td>35 ms</td>
</tr>
<tr>
<td>Maximum</td>
<td>55 ms</td>
<td>60 ms</td>
</tr>
<tr>
<td>Rotational Speed</td>
<td>2400 rpm</td>
<td>2400 rpm</td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>128 words/sector</td>
<td>128 words/sector</td>
<td></td>
</tr>
<tr>
<td>10 sectors/track</td>
<td>10 sectors/track</td>
<td></td>
</tr>
<tr>
<td>20 tracks/cylinder</td>
<td>20 tracks/cylinder</td>
<td></td>
</tr>
<tr>
<td>400 cylinders/disk pack</td>
<td>200 cylinders/disk pack</td>
<td></td>
</tr>
<tr>
<td>Number of Heads</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Number of Recording Surfaces</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Number of Disks</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>
TU40 MAGNETIC TAPE SYSTEM

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 columns during rewind, providing constant tape tension to produce a uniform tape pack in the rewind reel.

Supplementary Specifications

| Transfer rates   | 120K char/sec at 800 bits/inch |
|                 | 83.4K char/sec at 556 bits/inch, and 30K char/sec at 200 bits/inch |

| Tape Speed       | 150 inches per second |
| Nominal inter-record gap | 0.6 inch, 9-track |
|                  | 0.75 inch, 7-track |

| Load Time        | 7 seconds |
| Start/Stop Time  | 2.5 milliseconds |
| Rewind Speed     | 500 inches/second average |
| Rewind Time (2400-foot reel) | 66 seconds maximum |

| Data Checking | Read after write parity checking of characters; Longitudinal Redundancy check 7 & 9-track; Cyclic Redundancy check 9-track only |

System Features

- Transfer rates—120K char/sec at 800 bits/inch, 83.4K char/sec at 556 bits/inch, and 30K char/sec at 200 bits/inch
- 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 800 bpi 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 DIGITAL TU40 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: 5" mini-reels, also 8½" and 10½", 1200 and 2400-foot reels. In addition, TU40s accept industry-standard magnetic tape cartridges.

TU40A MAGNETIC TAPE SYSTEM
System Features

- Transfer rates—36K char/sec at 800 bpi
- Selectable recording densities on both 7 and 9-channel drives of 200, 556, or 800 bpi NRZI
- Single capstan drive and air bearings at point of wear provide reliability and trouble-free operation
- TU10A 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 TU10A is a low cost, industry-compatible magnetic tape transport. From one to eight TU10A transports may be interfaced by a TM10 control unit. Each transport is mounted in a standard 19 inch cabinet.

The TU10A accepts all standard tape reels—5" mini reels, also 8½" and 10½", 1200 and 2400 foot reels.

The tape path of the TU10A is constructed to provide gentle tape handling characteristics. The TU10A features direct-drive reel motors, servo-controlled single capstan and vacuum tape-buffer chambers to provide constant tape winding tension. There are no dancer arms to cause non-uniform tape tension and stretching.

Supplementary Specifications

| Transfer rates | 36K char/sec at 800 bpi/inch 
| Tape Speed | 45 inches/sec |
| Nominal inter-record gap | 0.6 inch, 9 track; 0.75 inch, 7 track |
| Rewind speed | 150 inches/second |
| Data Checking | Read after write parity checking of characters; Longitudinal Redundancy check, 7 and 9-track; Cyclic Redundancy check, 7-track only |

TU56 DECTAPE TRANSPORT

- Bi-directional
- Block addressable storage
- Not sensitive to dirty environments
- Replacement for punched card equipment

Digital Equipment Corporation's popular computer peripheral, DECTape, is available in a dual transport version.

This fixed address, bi-directional magnetic tape storage system provides random access for high-speed reading or writing of files on 260 feet of ½ inch wide magnetic tape, contained on a reel less than 4 inches in diameter which can be conveniently carried. Redundant recording (each bit of data is recorded on two separate tracks) assures high reliability and eliminates the need for character parity checking.

DECTape does not require the rewind and count record operations or the writing of separate header records typical of ordinary magnetic tapes. The high reliability and convenient size make DECTape the ideal medium for program storage and transportation. The dual unit allows for the mounting of two transports in just 10½ inches of a standard 19 inch equipment cabinet.

Supplementary Specifications

| Transfer rate | 925 36-bit words/sec |
| Information Capacity | 2.7 x 10^6 bits/reel |
| Density | 350 bits/inch |
| Tape Speed | 93 ± 12 inches/second |
| Tape Motion | Bi-directional |
| Reel Capacity | 578 blocks of 128 36-bit words |
| Reel Size | 3.9 inches in diameter |
| Reliability | Recoverable error rate—less than 1 error in 2.5 x 10^9 transfers |

CR10D, CR10E, CR10F CARD READERS

Features

- Low price form of magnetic tape
- Pocket sized reels
- Redundant recording for highest reliability
- Not sensitive to line voltage or frequency variation
- Storage equivalent to 10,000 average punched cards
- File index storage and retrieval
Features
- 1200, 1000 and 300 card/minute rates
- "Rifle 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
- Quiet operation
- Permits 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 EIA/ANSI 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 cards per minute) 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 "rifle 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 "rifle 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 excellent 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.
VT05 Features
- Speeds up to 2400 baud
- Completely interchangeable with Teletype (20 mA current loop)
- EIA RS-232C compatible communications interface
- 20 lines, 72 characters/line
- Direct cursor addressing
- Easy-to-read characters
- Raster Scan
- 128-character (Full ASCII) 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 full-duplex mode with or without local copy at rates up to 2400 baud. For users, the VT05 serves as a non-mechanical terminal that handles data speeds many times faster than that of conventional Teletypewriters.

VT05 Alphanumeric Terminal Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen Size</td>
<td>10 1/8 x 7 5/8 inches</td>
</tr>
<tr>
<td>Character Display Area</td>
<td>8 3/4 x 6 5/8 inches</td>
</tr>
<tr>
<td>Characters/Line</td>
<td>72</td>
</tr>
<tr>
<td>Number of Lines</td>
<td>20</td>
</tr>
<tr>
<td>Characters Displayable</td>
<td>1440</td>
</tr>
<tr>
<td>Contrast Ratio</td>
<td>12:1</td>
</tr>
<tr>
<td>Type of Phosphor</td>
<td>P4 (white)</td>
</tr>
<tr>
<td>Deflection Type</td>
<td>Magnetic</td>
</tr>
<tr>
<td>Deflection Method</td>
<td>Raster Scan</td>
</tr>
<tr>
<td>Character Generation Method</td>
<td>5 x 7 Dot Matrix</td>
</tr>
<tr>
<td>Character Generation</td>
<td>Read Only Memory</td>
</tr>
<tr>
<td>Refresh Buffer</td>
<td>MOS Memory</td>
</tr>
<tr>
<td>Memory Size:</td>
<td></td>
</tr>
<tr>
<td>ROM</td>
<td>2240 Bits</td>
</tr>
<tr>
<td>Refresh Buffer (self refreshing)</td>
<td>9816 Bits</td>
</tr>
<tr>
<td>Display Refresh Rate:</td>
<td>60/50 Hz (Power Line Freq.)</td>
</tr>
<tr>
<td>Display Character Set</td>
<td>Upper Case ASCII</td>
</tr>
<tr>
<td>Character Size</td>
<td>.23 x .11 inch</td>
</tr>
<tr>
<td>Cursor</td>
<td>Non-destructive, blinking</td>
</tr>
<tr>
<td>Keyboard/Control Type</td>
<td>Electronic</td>
</tr>
<tr>
<td>Character Set</td>
<td>Selectable (upper case, standard ASCII; upper/lower case, full ASCII)</td>
</tr>
<tr>
<td>Controls:</td>
<td></td>
</tr>
<tr>
<td>Cursor</td>
<td>Up, down, left, right, home up, direct addressing, horizontal tab</td>
</tr>
<tr>
<td>Erase Lock</td>
<td>Prevents inadvertent erasure</td>
</tr>
</tbody>
</table>

VT05 Alphanumeric Terminal Specifications (Continued)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erase</td>
<td>To end of line, to end of frame</td>
</tr>
<tr>
<td>Power</td>
<td>On, off</td>
</tr>
<tr>
<td>Mode</td>
<td>Remote, local</td>
</tr>
<tr>
<td>Transmission</td>
<td>Full, half-duplex (local copy)</td>
</tr>
<tr>
<td>Data Transmission</td>
<td>Crystal Controlled,</td>
</tr>
<tr>
<td></td>
<td>Selectable send/receive</td>
</tr>
<tr>
<td></td>
<td>110, 150, 300, 600, 1200, 2400</td>
</tr>
<tr>
<td></td>
<td>110/1200, 150/1200, 110/2400,</td>
</tr>
<tr>
<td></td>
<td>150/2400 baud</td>
</tr>
</tbody>
</table>

LA30 DECWRITER

The LA30 DECwriter is a 30 character/second teleprinter. Data entry is made from a 128 character keyboard. The unit prints from a set of 64 characters. Each character is derived from a 5 x 7 dot matrix. The DECwriter makes a hard-copy original plus one copy on a standard 9 1/2-inch wide, tractor-driven continuous form. The high readability of the characters produced, the quietness of operation and high speed of the DECwriter make it a viable alternative to the conventional Teletype.

GT40 GRAPHICS SYSTEM

The GT40 is a computer level graphics system consisting of a graphical display system and a general purpose mini-computer. The mini-computer fetches and executes its own instructions and data from memory thereby minimizing Central Processor Unit overhead. Information may be displayed as straight lines, vectors, characters or single random position points. Seven programming modes are available including character mode, long vector, short vector, point mode, relative point mode and X and Y graph-plot modes. Hardware drawn vectors employ a constant velocity technique and have four line types. Eight intensity levels are standard as is hardware blink.
DATA COMMUNICATION SYSTEMS
The DECSysytem-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 DECSysytem-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. DECSysytem-10 data communication systems also link a network of computers together from both local and remote sites. Data collection stations, remote control stations, and remote concentrators are easily tied into a single data network.

A complete range of data communications equipment is available on the DECSysytem-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 stations—remote card and line printer equipment, including remote terminal concentration through the remote station.

ASYNCHRONOUS COMMUNICATIONS

Asynchronous communications equipment and terminals cover a broad range of application within the DECSysytem-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 and 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 LA30 DECVriter and CRT terminals (such as the VTO5). Local terminals, within 1500 feet of the computer site, can be 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 speeds of from 10 to 240 characters per second, depending on their communications interfaces.

Interactive terminals on the DECSysytem-10 use the 7-level ASCII code (ISO R646; CCITT Alphabet No. 5) as a standard format. Computer-based communications interfaces may be programmed to handle non-standard communications codes.

Asynchronous terminal line speed is described in baud units, a measure of the speed of data transmission. For example, 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 DECSysytem-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 is the most common mode of operation used with DECSysytem-10 terminals. It provides the most efficient and reliable method of transferring data between the user's terminal and the central system.

Full Duplex With Local Copy—There are independent communications paths, but input typed by the user is copied (printed, etc.) directly by the terminal. User type-ahead goes correctly to the computer but may interfere with the printed output. Commonly used in the TWX and Telex networks 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 DECSysytem-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 the user can continue to type despite fluctuations in the system response.

Features of DECSysytem-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 prompting messages to call for input. Through the SEND command, terminals may communicate with the Systems Administrator at the central site as well as another terminal.

DC10 DATA LINE SCANNER

- System supports up to 64 interactive terminals.
- Terminals may include paper tape reader or punch. The reader must be equipped to respond to the X-ON and X-OFF reader control characters.
- Standard speeds are 110, 150, 300, 600, 1200 or 2400 baud.

The data line scanner provides a two-way interface between the -10 and a maximum of 64 Teletype-like terminals. 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.
The DC10 Data Line Scanner is modular in form to provide the user with his specific needs and still have the flexibility required for future expansion. The DC10A Control Unit is the heart of the DC10. It provides the necessary interface between the central processor and up to 8 line groups. The DC10B Line Group Unit provides the necessary interface between the control unit and 8 Teletype-like devices. The optional DC10C Telegraph Relay Assembly provides relay buffering for half duplex long or full duplex circuits. Power to operate telegraph lines associated with the telegraph relay assemblies can be provided by the DC10D Telegraph Power Supply. The DC10E Expanded Data Set Control provides status and operational controls for 8 standard data sets (Two may be provided with automatic calling equipment). Additional cabinet space for larger data line scanner systems is provided by the DC10F Expander Cabinet.

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 DC10Bs 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 with standard software 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.

SYNCHRONOUS COMMUNICATIONS

The DECSystem-10 synchronous communications systems provide error-free, high-speed paths between the central computer and remote 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. 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 DC72 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 (hardware 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, and remote stations and 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 similar 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 as in keeping 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**

<table>
<thead>
<tr>
<th>Type</th>
<th>Single line synchronous modem interface to EIA RS-232B or C modems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>9,600 bits per second (software supported)</td>
</tr>
<tr>
<td></td>
<td>20,000 bits per second (maximum)</td>
</tr>
<tr>
<td>Number per system</td>
<td>Two (Note: Speed limits are total rates for 1 or 2 DS10 units)</td>
</tr>
<tr>
<td>Method of Attachment</td>
<td>I/O bus</td>
</tr>
</tbody>
</table>

**DC75 SYNCHRONOUS COMMUNICATIONS MULTIPLEXER**

- Full duplex, bi-directional, simultaneous transmission
- Card reader, 300 cards per minute
- Line printer, 132 columns, speeds from 165 characters per second up to 245 lines per minute
- Up to 16 local terminals at speeds of 110, 150, 300 or 2400 baud
- Split terminal speed possible 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
- Interface to EIA-RS-232-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 and terminals 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 teleprinter. 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.

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 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.

**Remote Batch Station**

```
<table>
<thead>
<tr>
<th>TERMINAL</th>
<th>CONCENTRATION PACKAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TERMINAL</td>
<td></td>
</tr>
</tbody>
</table>
```

The DC72 remote station provides a card reader, a line printer, and a teleprinter console for batch processing. 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 entered from the remote station are multiprogrammed and may operate concurrently with other or jobs from other remote stations. The simultaneous operation of card reader and printer improves the operating efficiency of the remote station.

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 processor. 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 DC72 must be hard-wired (up to 1500 feet) and meet the EIA or 20 mA 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.

**DC72L**

The DC72L Terminal Concentration Package provides for the concentration of up to 8 lines through the DC72 to the DECsystem-10. Two such units may be added to each DC72 system. Terminals of varying speeds may be attached to a single DC72L.

**Modems**

A 4800-baud modem is recommended for the DC72B or C system, (2400 baud is adequate for the DC72A) particularly if multiple terminals are to be concentrated using the DC72L. Modems (not supplied by DIGITAL) should meet the EIA-RS232-C standard and be equivalent to the Bell 201 or 203 modems.

**DC72 SUMMARY**

<table>
<thead>
<tr>
<th>Modem Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC72A</td>
<td>165 char/second, 132 column, 64 character set printer</td>
</tr>
<tr>
<td></td>
<td>300 card/minute reader</td>
</tr>
<tr>
<td></td>
<td>10 char/second operator console</td>
</tr>
<tr>
<td>DC72B</td>
<td>245 line/minute, 132 columns, 64 character set printer</td>
</tr>
<tr>
<td></td>
<td>300 card/minute reader</td>
</tr>
<tr>
<td></td>
<td>10 char/second operator console</td>
</tr>
<tr>
<td>DC72C</td>
<td>173 line/minute, 132 columns, 96 character set printer</td>
</tr>
<tr>
<td></td>
<td>300 card/minute reader</td>
</tr>
<tr>
<td></td>
<td>10 char/second operator console</td>
</tr>
<tr>
<td>DC72L</td>
<td>Terminal concentration package for 8 lines. Two may be added to each DC72A, B or C.</td>
</tr>
</tbody>
</table>
CUSTOM EQUIPMENT
• Interprocessor Buffers
• Bus Switches
• Analog to Digital Systems
• High Availability Systems
• Graphics Systems
• Peripheral Devices
• Network Systems

With the increased complexity of applications, a need has arisen to provide users with a variety of special products and services. To meet these demands, DIGITAL has within its structure, two groups dedicated to meeting these goals. DIGITAL's Computer Special Systems organization is dedicated to serving 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. In addition to its one-time design and manufacture capability, CSS produces a limited product line. Several custom products have been developed and are offered as options on the DECSYSTEM-10.

The Advanced Systems Group, formed within the -10 Product Line, is dedicated to providing high availability system capabilities. Such a system provides a redundant system as "back-up" for the critical task system, and usually performs additional functions when not involved in "critical task" processing. The second function of Advanced Systems is in the development of turnkey systems, taking special customer projects and developing them into standard supported products.

INTERPROCESSOR BUFFERS

PDP-15 to DECSYSTEM-10 MEMORY LINK—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.

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.

DECSYSTEM-10 to Small Computer Interface-DA28

The DA28 facilitates high-speed block transfer between one DECSYSTEM-10 and up to 16 small computers. Any combination of small computer types may be used. All computers interface to a common bus. Interfaces exist for the PDP-11 (DA28-F) and the PDP-8 (DA28-A). The DA28 bus connects all of these peripheral interfaces to one DECSYSTEM-10 interface (DA28-C). The DA28-C can transfer data via either the I/O bus, or the memory bus. The maximum transfer rate depends on the length of the DA28 bus, and may be manually adjusted to the required rate.

DECSYSTEM-10 to PDP-11 Memory Link Interface-DM10

The DM10 Memory Link Interface forms a high-speed transfer link between a DECSYSTEM-10 computer memory and the UNIBUS of up to eight PDP-11 computers. The interface appears, once control parameters have been arranged, to be transparent to the PDP-11; the PDP-11 may use the DECSYSTEM-10 memory in the same manner as it uses its own memory. The DM10-C is the memory link interface for the -10 side of the connection, while the DM10-F is the memory link interface for the PDP-11 side of the system.

DUAL PROCESSOR BUS SWITCHES

Universal Bus Switch DT02-C

The DT02-C Universal bus switch provides facilities for switching one or a group of memories or controllers from one DECSYSTEM-10 bus to another while maintaining the transmission-line characteristics of the bus. It can be used on a DECSYSTEM-10 I/O Bus, Memory Bus, Channel Bus, or, with slight modifications, a Memory Multiplexer Bus. The switching is provided by reliable, inert-gas-filled, reed switches controlled from a local or remote control switch. No delay is introduced due to the cable needed to connect the buses to the switch.

I/O Bus Switch DT03-CS

The DT03-CS I/O Bus switch allows either of two PDP-10 central processors to control peripheral devices connected to a switched I/O. The gated drivers and receivers in the DT03-CS which determine the active data path are controlled by local or remote contact closures. The DT03-CS can be modified to support the extended features of the KI10 I/O Bus. Three modes are provided: Switched I/O Bus connected to bus A, to bus B, or disconnected.

I/O Bus Switch DT05-CS

The DC05-CS Memory Bus switch allows either of two memory buses (or two memory multiplexor buses) to be driven by a KA10 processor or a direct to memory controller such as the DF10 channel or DL10 (PDP-10/ PDP-11) interface. The gated drivers and receivers in the DT05-CS which determine the active path are controlled by local or remote contact closures. The DT05-CS provides
18 bits of memory address data and would require modification for switching a K10. Three modes are provided: Switch processor or controller connected to Bus A, to Bus B, or disconnected. The DT05-CS can be slaved to a DT03-CS for total switching of a peripheral subsystem.

**Switch Controller and Interprocessor Buffer DT03-CC**

The DT03-CC provides the means for two processors to control up to eight DT03-CS or DT05-CS Bus switches by program. In addition, it provides an alternate simplex 36-bit parallel communications path between the two processors. Each processor can attach (if free) or detach each device to or from its memory and I/O buses. If the requested device is not free, it will switch when it becomes free.

**ANALOG TO DIGITAL CONVERTERS**

**Single ADC Subsystem—AD01C**

The AD01C is a low-cost, multi-channel analog subsystem which provides users with a basic controller for inputting high-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 20 kHz.

**ADC System—AD10**

The DIGITAL 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 ±10 mV to ±10 V with stepped or automatic range features. Can be expanded up to 192 channels with direct address or scan addressing controls.

**HIGH AVAILABILITY SYSTEMS**

**Typeset-10**

Utilizing and expanding DECsystem-10's 1044 configuration, (dual 1040 systems) Typeset-10 is designed to achieve the high reliability requirements of the graphics industry. Typeset-10 provides a single system to accomplish any and all typesetting requirements simultaneously without the separate and discrete tasks required by smaller typesetting systems. It provides, through the use of a DC44, the necessary interfaces to drive special typesetting equipment used in the publishing environment.

Software packages specifically designed to optimize throughput of the interactive publishing tasks are also available in the Typeset-10 Systems.

Some of these are:
- Classified Ad Package
- Display Ad Package
- Justification and Hyphenation Package

**Wire Service Package**

Reports and Manifest Package

Other special hardware offered in the Typeset-10 System, includes a "Watch Dog Timer" which is intended to notify an operator of a "stalec" system so he may initiate appropriate measures to correct the non-productive situation.

Typeset-10 users require a high level of system reliability and system up time must approach 100 percent for primary job streams. This prompted the design of an easily switchable hardware configuration. The system will normally take advantage of the increased processing speed utilizing the dual configuration. If a malfunction occurs however, the system will be capable of being reconfigured by an operator employing the manual switches provided; eliminating the need of a field engineer to re-cable a system.

As previously stated, Typeset-10 provides a single utility to accomplish the many tasks associated with newspaper production, billing for ads, payroll, circulation, providing galleys for paste-ups, editing stories, accepting or deleting ads, accounts receivable and other business functions can be carried out utilizing the system's timesharing monitor.

Typeset-10 is not just a newer, larger computerized typesetting system. It is a system which offers the newspaper industry a totally new method of operation... one which not only simplifies operations, but also speeds up production.

**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

Both drives are equipped with power window and automatic threading capability. Data is recorded at either 800 or 1600 bits/inch in a format consistent with industry standards.

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 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 cards/min. and handles industry-standard cards.

**TSU42/TSU43 PHASE ENCODED MAGNETIC TAPE SYSTEMS**

Phase encoded only (1600 bits/inch) and dual density (800 or 1600 bits/inch) magnetic tape drives are now available for use with the DECSYSTEM-10. The complete system consists of the TC10-C controller, one or two TC10-P formatter electronics package and up to eight TSU42 (phase encoded only) and/or TSU43 (dual density) drives. The TC10-C controller connects directly to memory through a DF10 data channel thereby allowing simultaneous I/O and computation operations. Speeds for the TSU42 and TSU43 range up to 200 inches/second.

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 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.
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, DIGITAL 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

Education

In addition to formal classes offered by DIGITAL's Educational Services Department, DIGITAL offers the customer a number of seminars that can be taught on site or in local DIGITAL offices by qualified Software Specialists. Some of these courses include: system architecture, operator training, system administrator's seminar, executive seminar and a data base management seminar.

Installation Support

This is an on-site service provided to insure a smooth, trouble-free installation. The service is provided by a qualified Software Specialist who will, after consulting with the customer's staff, configure and initialize the necessary software facilities to run the DECsystem-10.

Advisory Support

DIGITAL provides two software support packages tailored to the user's operating requirements. The Standard System Support Package is an on-site and/or phone service designed to provide the education and consulting services needed in order to gain full utilization of the DECsystem-10 as related to individual requirements. The Data Processing Support Package is designed for customers with administrative and/or business data processing requirements. As such it has been tailored to provide additional service in the following three areas: education, conversion assistance and applications design assistance.

Remedial Support

Remedial support is an on-site and/or telephone service provided to insure continued reliability of the software system. It is provided by highly trained Software Specialists whose services are available on a scheduled or response basis. These services include both preventive and corrective maintenance as well as systems programming assistance.

Service Agreement

DIGITAL has provided several types of service agreements to best fit the needs of the individual customers. A Resident Service Agreement provides the services and expertise of a full-time DIGITAL Software Specialist at the customer's location. Scheduled consulting provides for periodic visits to the customer's location by Software Specialists.

A Per-Call Agreement is also provided for those customers who wish to take advantage of Software Consulting Services on an unscheduled basis but do not require a guaranteed time.

CUSTOMER TRAINING

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

DOCUMENTATION

DIGITAL supplies two types of documentation, Software Notebooks and Handbooks. A DECsystem-10 customer receives two copies of a 9-volume looseleaf Software Notebook; a complete reference source that is amended monthly 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 a supply of each handbook when the order is placed. Additional handbooks may be purchased according to each customer's needs.
To receive further information simply complete and mail this card. It is pre-addressed and stamped for your convenience.

<table>
<thead>
<tr>
<th>NAME/TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSTITUTION/COMPANY</td>
</tr>
<tr>
<td>ADDRESS</td>
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<tr>
<td>CITY</td>
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</tbody>
</table>

I am interested in:
- [ ] DECsystem-10 in Education
- [ ] DECsystem-10 in Industry
- [ ] DECsystem-10 in Science
- [ ] DECsystem-10 in Publishing
- [ ] Timesharing
- [ ] General Commercial Applications
- [ ] Other (Please specify)