## MAGNETIC TAPE OPTIONS

The External Bus Magnetic Tape Options include:

a. The TU56 Dual DECtape Transport and TC08 DECtape control,
b. The TU10 DECMAGtape Transport and TC58 Automatic Magnetic Tape Control.

### DECtape

The DECtape system is a standard option for the PDP-8/E that serves as an auxiliary magnetic tape data storage facility. The DECtape system stores information at fixed positions on magnetic tape, as in magnetic disk or drum storage devices, rather than at unknown or variable positions, as in conventional magnetic tape systems. This feature allows replacement of blocks of data on tape in a random fashion without disturbing other previously recorded information. In particular, during the writing of information on tape, the system reads format (mark) and timing information from the tape and uses this information to determine the exact position at which to record the information to be written. Similarly, in reading, the same mark and timing information has a number of features to improve its reliability and make it exceptionally useful for program updating and program editing applications. These features are: phase or polarity sensed recording on redundant tracks, bidirectional reading and writing, and a simple mechanical mechanism utilizing hydrodynamically lubricated tape guiding (the tape floats on air over the tape guides while in motion).
Four basic DECtape configurations are identified in the following table.

| SYSTEM DESIGNATION | DECtape | CONTROL | PREREQUISITE | REMARKS |
|---|---|---|---|---|
| None | TU56 (Dual Drive) | TC08 | KA8-E<br>KD8-E<br>PDP-8/E | Up to 4 Dual TU56's per control. (8 drive units) |
| None | TU56 (Single Drive) | TC08 | KA8-E<br>KD8-E<br>PDP-8/E | Up to 4 single DECtape drive units. |
| TD8-EM | TU56 (Dual Drive) | TD8-E | PDP-8/E | Up to 4 Dual Drive TU56's per control.<br>(8 drive units)<br>Control plugs into OMNIBUS. |
| TD8-EA | TU56H (Single Drive) | TD8-E | PDP-8/E | Up to 4 single drive units. Control plugs into OMNIBUS. |

Magnetic tape options operated on the external bus of the PDP-8/E require the use of the KA8-E Positive I/O Bus Interface module and the KD8-E Data Break Interface module as prerequisites.

**DECtape Format**

DECtape utilizes a 10-track read/write head. Tracks are arranged in five nonadjacent redundant channels: a timing channel, a mark channel, and three information channels. Redundant recording of each character bit on nonadjacent tracks materially reduces bit dropouts and minimizes the effect of skew. The series-connection of corresponding track heads within a channel and the use of Manchester phase recording techniques, rather than amplitude sensing techniques, virtually eliminate dropouts.

The timing and mark channels control the timing of operations within the control unit and establish the format of data contained on the information channels. The timing and mark channels are recorded prior to all normal data reading and writing on the information channels. The timing of operations performed by the tape drive and some control functions are determined by the information on the timing channel. Therefore, wide variations in the speed of tape motion do not affect system performance. Information read from the mark channel is used during reading and writing data to indicate the beginning and end of data blocks and to determine the functions performed by the system in each control mode. During normal data reading, the control assembles 12-bit computer-length words from four successive lines read from the information channels of the tape. During normal data writing, the control disassembles 12-bit words and distributes the bits so they are recorded on four successive lines on the information channels. A mark-channel error-check circuit ensures that one of the permissible marks is read in every six lines on the tape. This 6-line mark-channel sensing requires that data be recorded in 12-line segments (12 being the lowest common multiple of 6-line marks and 4-line data words) which correspond to three 12-bit words.

A tape contains a series of data blocks that can be of any length which is a multiple of three 12-bit words. Block length is determined by information on the mark channel. A uniform block length is usually established over the entire length of a reel of tape by a program that writes mark and timing information at specific locations. The ability to write variable-length blocks is useful for certain data formats. For example, small blocks containing index or tag information can be alternated with large blocks of data. (Software supplied with DECtape allows writing for fixed block lengths only.)

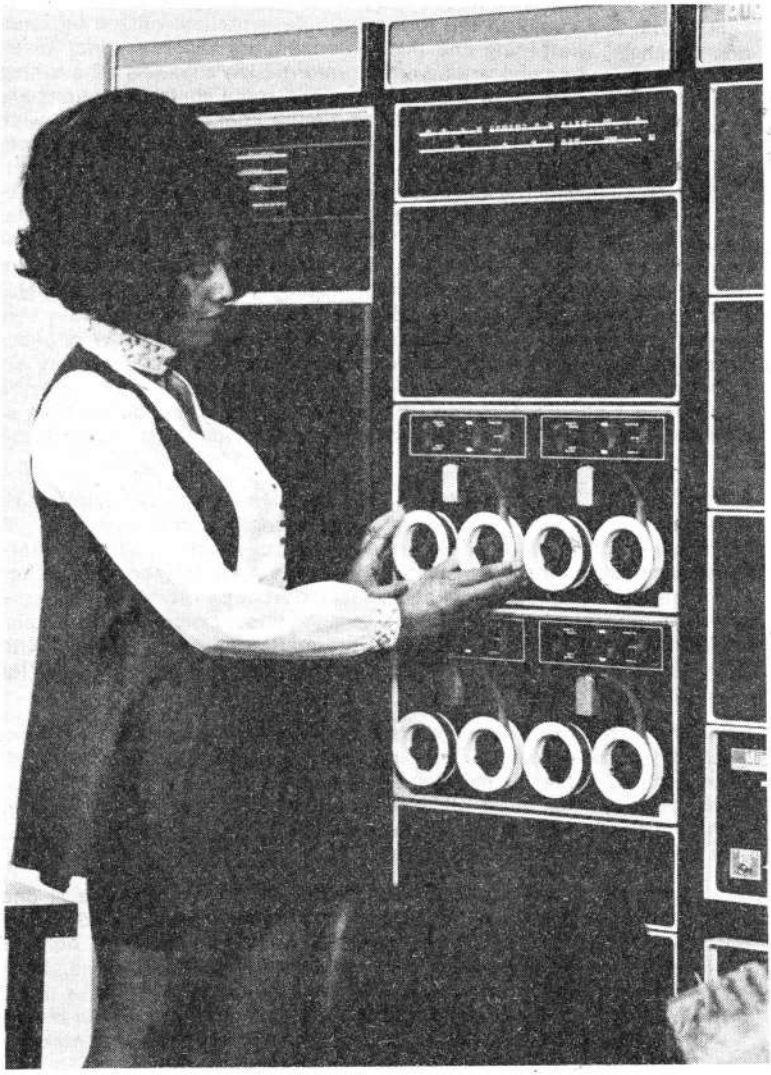
Between the blocks of data are areas called interblock zones. The interblock zones consist of 30 lines on tape before and after a block of data. Each of these 30 lines is divided into five 6-line control words. These 6-line control words allow compatibility between DECtape written on any of DEC's 12-, 18-, or 36-bit computers. As used on the PDP-8/E, only the last four lines of each control word are used.

Block numbers normally occur in sequence from 1 to n. There is one block numbered 0 and one block n + 1. Programs are entered with a statement of the first block number to be used and the total number of blocks to be read or written. The total length of the tape is equivalent to 849,036 lines, which can be divided into any number of blocks up to 4096 by prerecording of the mark track. The maximum number of blocks is determined by the following equation in which n(b) equals number of

blocks and n(w) equals number of words per block (n(w) must be divisible by 3).

$$n(b) = \frac{212112}{n(w) + 15} - 2$$

DECtape format is illustrated in Figures 7-17 through 7-20.



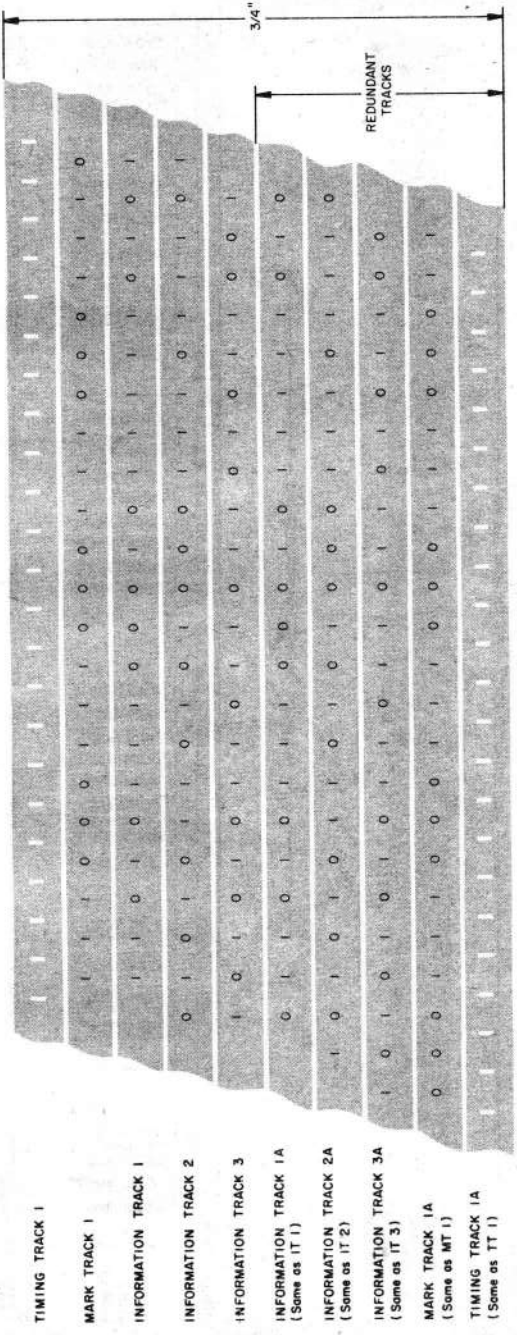



Figure 7-17 DECtape Track Allocations

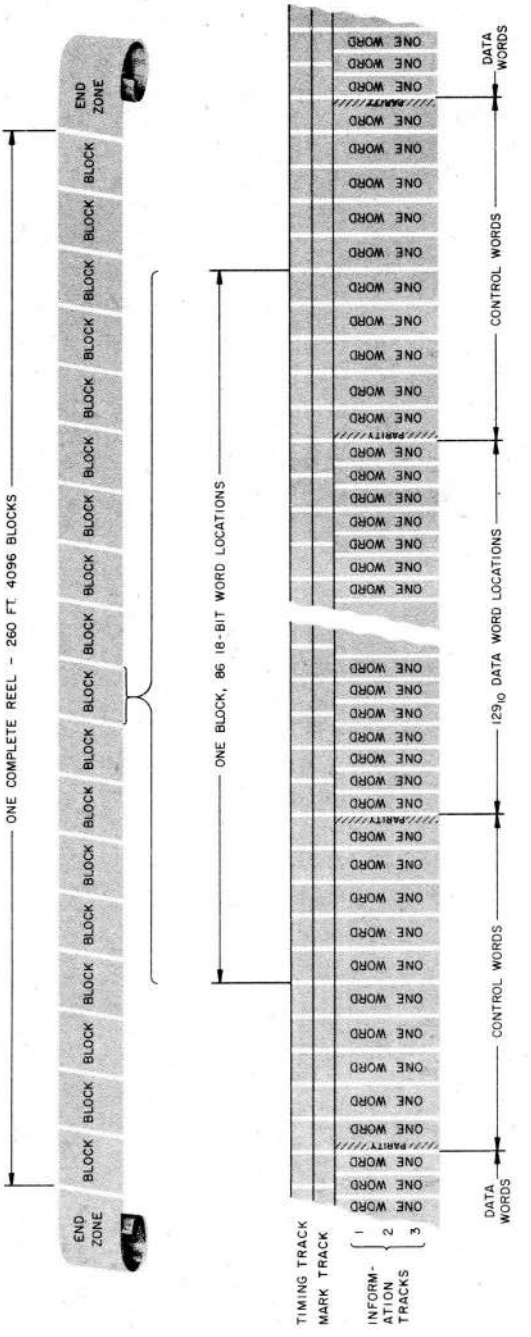



Figure 7-18 DECtape Mark Channel Format

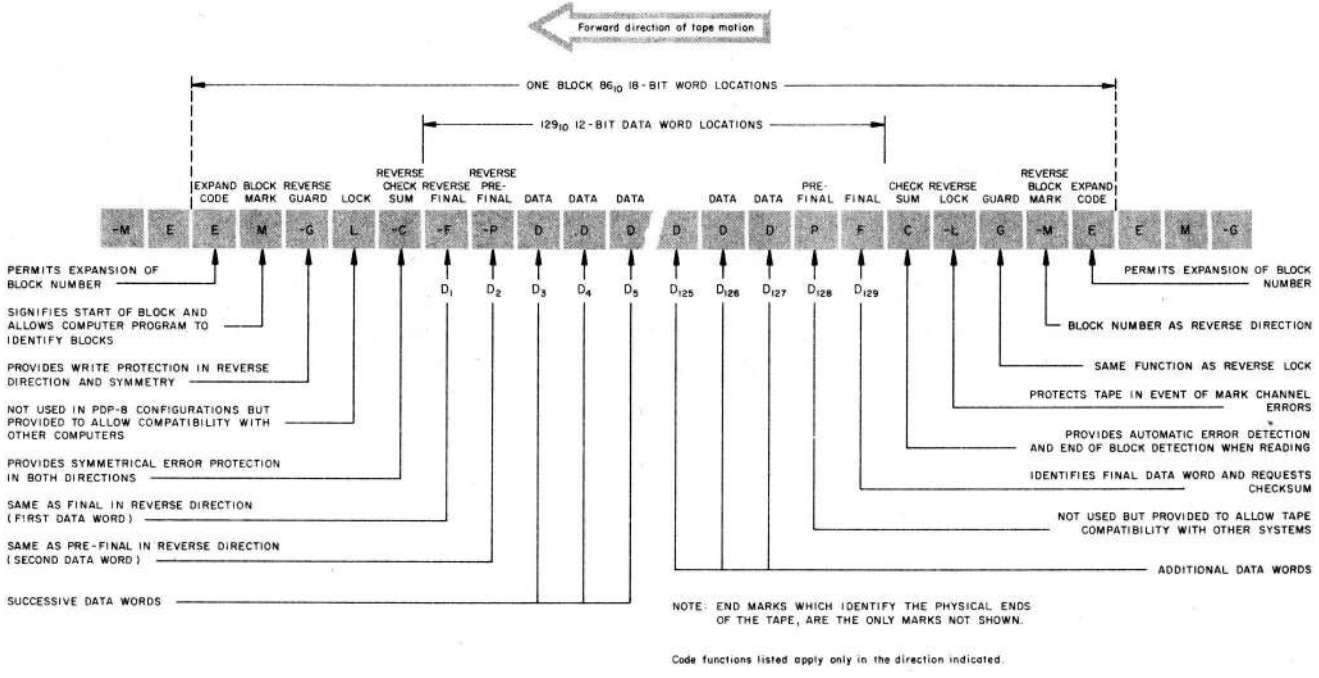



Figure 7-19 DECtape Control Word and Data Word Assignments

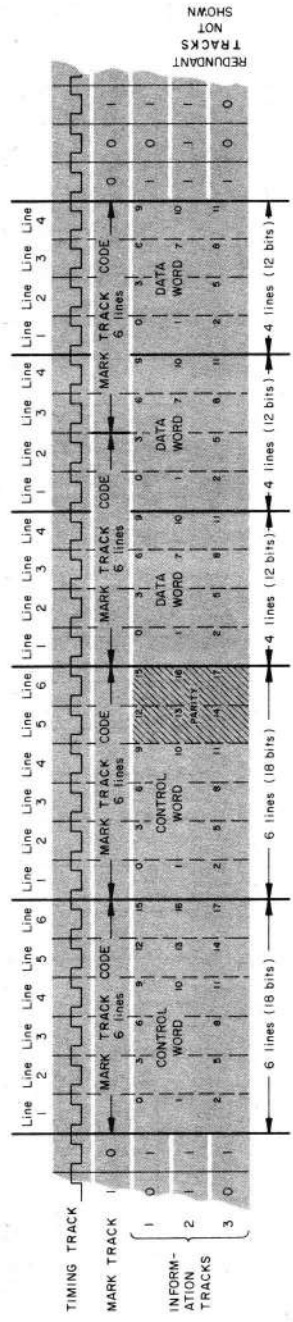



Figure 7-20 DECtape Format Details

**TU56 Dual DECtape Transport and TC08-P DECtape Control**

A DECtape system on the external bus can contain up to four TU56 Dual DECtape transports (the equivalent of up to eight single tape transports) controlled from one TC08-P unit. Data transfers between the computer and tape are implemented using the three-cycle data break facilities of the computer (refer to Chapter 10 for three-cycle data break description). Thus, the KA8-E Positive I/O Bus Interface and KD8-E Data Break Interface units are prerequisites.

Data is stored on tape in the form of three-bit words (refer to tape format) and is transferred between the tape and computer in the form of 12-bit words. A 12-bit read/write buffer in the TC08 assembles and disassembles the information for transfer. For transfers to the computer, data is read from four consecutive lines of tape and assembled into a 12-bit word. When transferred to the computer, the 12-bit word is supplied via external bus lines DATA00-11 to the KD8-E Data Break Interface. This unit, in turn, provides the word to OMNIBUS lines DATA0-11 under data break control. For transfers to tape, the KA8-E unit buffers the 12-bit words and provides them to the TC08 via external bus lines BMB00-11. The TC08 disassembles these words and supplies them to the tape transport for the writing of four tape lines. Transfer of command and control signals is effected by IOT instructions. These instructions are provided to the TC08 via the BMB00-11 external bus lines.

The TC08 contains registers and control flip-flops that form two status registers (designated A and B) for transfer of information to and from the computer accumulator.

**TU56 Dual DECtape Transport**

The TU56 provides the PDP-8/E user with a compact, high-reliability dual-reel tape transport in just 10½ inches of rack space. When used with the TC08-P control, the TU56 provides two fixed-address, magnetic tape facilities for high-speed loading, readout, and updating of programs and data. The TU56 transport contains the tape read/write heads, drive mechanisms, and switching circuits for tape drive and direction. All transport operations (except local) are controlled by the TC08 from program instructions. The TC08 selects the transport, controls tape motion and direction, selects a read or write operation and buffers data transferred. Information is stored in the form of three-bit words on a one-mil Mylar tape with ten tracks. This tape, ¾ inches in width and 260 feet in length, is contained on a reel that is less than four inches in diameter. Information can be recorded or read for either direction of tape motion.

Redundant recording (each bit of data and timing is recorded on two tracks) ensures high reliability and eliminates the need for parity checking. Data words are recorded on six of the ten tracks and four tracks are allotted for mark and timing channels. Other features include TTL logic, dynamic braking for shorter turnaround time, and DC motor drive to eliminate line frequency dependency. Connections from the read/write head are made directly to the external control, which contains the read and write amplifiers.

The logic circuits of the TU56 transport control tape movement in either direction over the read/write head. Tape drive motor control is com-

pletely through the use of solid-state switching circuits to provide fast, reliable operation. These circuits control the torque of the two motors that transport the tape across the head according to the established function of the device: i.e., go, stop, forward, or reverse. In normal tape movement, full torque is applied to the forward or leading motor and a reduced torque is applied to the reverse or trailing motor to keep proper tension on the tape. Since tape motion is bidirectional, each motor serves as either the leading or trailing drive for the tape, depending upon the forward or reverse control status of the TU56.

Tape movement can be controlled by commands originating in the computer or by manual operation of switches on the front panel of the transport. Manual control is used to mount new reels of tape on the transport, or as a quick maintenance check for proper operation of the control logic in moving the tape.

Since DECtape is a fixed address system, the programmer need not know accurately where the tape has stopped. To locate a specific point on tape he must only start the tape motion in the search mode. The address of the block currently passing over the head will be automatically transferred to core where it can be compared with the desired block address and tape motion continued or reversed accordingly. TU56 typical time characteristics are provided below, but are not accurately controlled.

| | |
|---|---|
| Start Time | 150 ms* |
| Stop Time | 100 ms* |
| Turnaround Time | 200 ms* |

*Also, see control specifications. These times are frequently lengthened by the particular control.

**Specifications**

| | |
|---|---|
| Transfer rate | 33,300 three-bit characters per second |
| Information capacity | 2.7 million bits per reel |
| Density | 350 + or — 55 bits per inch |
| Tape speed | 93 + or — 12 inches per second |
| Tape motion | Bidirectional |
| Start time | 150 + or — 15 ms |
| Stop time | 100 + or — 10 ms |
| Turn around time | 200 + or — 50 ms |
| Reel capacity | 250 ft. of ¾ inch, 1 mil Mylar tape |
| Reel size | 3.9 inches in diameter |
| Mounting | Mounts in a standard 19-inch equipment rack |
| Size | 10½ in. high, 19 in. wide, 9¾ in. deep |
| Cooling | Internally mounted fans provided |
| Power requirements | a. + 10V @ 0.53 amps or + 5V @ 0.55 amps<br>b. — 15V @ 0.45 amps<br>c. 115/220 VAC + or — 10% @ 2.85/1.43 amps 47-63 Hz |
| Environmental | Temperature: 40 degrees F to 90 degrees F<br>Humidity: 15% to 80% Relative Humidity<br>Internal Temp Rise: 10% F above ambient |
| Reliability | Recoverable Error Rate-less than 1 part in 2.5 x 10 ↑ 10 transfers |

**TC08 DECtape Control**

The TC08 control buffers and controls information transfers between one to eight TU56 transports (one to four TU56 Dual DECtape transports) interfacing with the external bus of the PDP-8/E. Transfers are implemented using the three-cycle data break facilities of the computer; thus, the KA8-E Positive I/O Bus Interface and the KD8-E Data Break Interface modules are prerequisites.

During both input and output operations, the TC08 receives data and control information from the processor and generates the appropriate signals to the selected transport to execute the programmed commands. Binary information is transferred between the tape transport and the computer as one 12-bit computer word every 133⅓ μs. When writing, the TC08-P disassembles the 12-bit word into four successive three-bit words to be written on tape. During read operations, the TC08 assembles the four successive three-bit words into one 12-bit word for transfer to the computer. Transfers between the computer and the control always occur in parallel for a 12-bit word. Data transfers use the three-cycle data-break (high speed channel) facility of the computer. (Refer to Chapter 10 for details of 3-cycle data-break transfers.)

The TC08 contains the following primary control and data processing circuits:

a. Device selector and IOT decoding logic to command a transport from program instructions.
b. A 12-bit buffer register for assembling tape inputs and disassembling computer data.
c. A command and status register (designated Status Register A) for defining: (1) the active transport, (2) direction of tape, (3) tape motion, (4) operating mode, (5) function (read/write, search, etc.), (6) interrupt enable, and (7) clearing of flags.
d. A status register (designated Status Register B) for indicating error status and other status.
e. Flag circuits that provide the program with conditional indications and requests.
f. Tape motion and direction control circuits.
g. Mark track generation and detection circuits with error detectors.
h. Longitudinal parity generation and checking circuits.
i. Data break request circuits.

Programmed IOT instructions are generated to clear, read, or load Status Register A and to read or load Status Register B. An IOT skip instruction is also provided to test the status of flag circuits. These instructions are provided to the TC08-P control via the KA8-E Positive I/O Bus Interface and external bus lines BMB-00-11.

A control and indicator panel is also provided with the TC08. A single control, NORMAL/WRTM, places the TC08 in the write timing and mark track mode (WRTM), or else in the NORMAL mode. The indicators denote the current status of the control including the tape transport selected, motion, function, interrupt status, error flags, and other status indications.

Three program flags in the TC08-P control serve as condition indicators and request originators.

a. DECtape Flag (DT): This flag indicates the active/done status of the current function.
b. Data Flag (DF): This flag requests a data break to transfer a block number into the computer during a search function, or when a data word transfer is required during a read or write function.
c. Error Flag (EF): Detection of any nonoperative condition by the control sets this flag in status register B and stops (except for parity errors) the selected transport. The error conditions indicated by this flag are:
   (1) Mark Track Error: This error occurs any time the information read from the mark channel is erroneously decoded.
   (2) End of Tape: The end zone on either end of the tape is over the read head.
   (3) Select Error: This error occurs 5 $\mu$s after loading status register A to indicate any one of the following conditions:
   (a) Specifying a unit select code which does not correspond to any transport select number, or which is set to multiple transports.
   (b) Specifying a write function with the WRITE ENABLED/WRITE LOCK switch in the WRITE LOCK position on the selected transport.
   (c) Specifying an unused function code (i.e., AC6-8 = 111).
   (d) Specifying any function except write timing and mark track with the NORMAL/WRTM switch in the WRTM position.
   (e) Specifying the write timing and mark track function with the NORMAL/WRTM switch in the NORMAL position.
   (4) Parity Error: This error occurs during a read data function if the longitudinal parity or check sum over the entire data word, the reverse check character, and the check character is not equal to 1.
   (5) Timing Error: This error indicates a program fault caused by one of the following conditions:
   (a) A data break did not occur within 17 $\mu$s (+ or − 30%) of the data break request.
   (b) The DT flag was not cleared by the program before the control attempt to set it.
   (c) The read data or write data function was specified while a data block was passing the read head.

Three-cycle data break locations: The TC08-P uses location 7754 of field 0 for word count and 7755 of field 0 for current address.

**Control Modes**—The DECtape system operates in either the normal or continuous mode, as determined by bit 5 of status register A during a DTXA command. Operation in each mode is as follows:

a. Normal (NM): Data transfers and flag settings are controlled by the format of information on the tape.

b. Continuous (CM): Data transfers and flag settings are controlled by a word count read from core memory during the first cycle of each three-cycle data break, and by tape format.

**Functions**—The DECtape system performs one of seven functions, as determined by the octal digit loaded into status register A during a DTXA command. These functions are:

a. Move: Initiates movement of the selected transport tape in either direction. Mark channel decoding is inhibited in this mode except for end of tape.
b. Search: As the tape is moved in either direction, sensing of a block mark causes a data transfer of the block number. If the word count overflows in either NM or CM, the DT flag is set and causes a program interrupt. After finding the first block number, the CM can be used to avoid all intermediate interrupts between the current and the desired block number. This makes a virtually automatic search possible.
c. Read Data: This function is used to transfer blocks of data into core memory with the transfer controlled by the tape format. In NM, the DT flag is set at the end of a block and causes a program interrupt. In CM, transfers stop when the word count overflows, the remainder of the block is read for parity checking, and then the DT flag is set.
d. Read All: Read all is used to read tape in an unusual format, since it causes all lines to be read. In NM, the DT flag is set at each data transfer. In CM, the DT flag is set when WCO occurs. In either case, the DT flag causes a program interrupt.
e. Write Data: This function is used to write blocks of data with the transfer controlled by the standard tape format. After word count overflow occurs, zeros are written in all lines of the tape to the end of the current block. Then the parity checksum for the block is written. The DT flag rises as in the read function.
f. Write All: The write all function is used to write an unusual tape format (e.g., block numbers). The DT flag assertions are similar to the read all function.
g. Write Timing and Mark Track: This function is used to write on the timing and mark tracks, permitting blocks to be established or block lengths to be changed. The DT flag assertions are also similar to the read all function. This function is illegal unless a manual switch in the control is positioned to WRTM.

**Programmed Operation**—Prerecording of a reel of DECtape, prior to its use for data storage, is accomplished in two passes. During the first pass, the timing and mark channels are placed on the tape. During the second pass, forward and reverse block mark numbers, the standard data pattern, and the automatic parity checks are written. These functions are performed by the DECTOG program. Prerecording utilizes the write timing and mark channel function, and a manual switch on the control, which permits writing on the timing and mark channels, activates a clock, which produces the timing channel recording pattern and enables flags for program control. Unless this control function and switch are used simultaneously, it is physically impossible to write on the

mark or timing channels. An indicator lamp on the control panel lights when the manual NORMAL/WRTM switch is in the WRTM position. Under these conditions only, the write register and write amplifier, used to write on information channel 1 (bits 0, 3, 6, and 9), are used to write on the mark channel. This prerecording operation need only be performed once for each reel of DECtape.

There are two registers in the TC08 DECtape Control that govern tape operation and provide status information to the operating program. Status register A contains three unit selection bits, two motion bits, the continuous mode/normal mode bit, three function bits, and three bits that control the flags. Status register B contains the three memory field bits and the error status bits. PDP-8/E IOT microinstructions are used to clear, read, and load these registers. In addition, there is an IOT skip instruction to test control status.

Since all data transfers between DECtape and the computer memory are controlled by the data break facility, the program must set the WC and CA registers (locations 7754 and 7755, respectively) before a data break. After initiating a DECtape operation, the program should always check for error conditions (a program interrupt would be initiated if the error flag is enabled and if the program interrupt system is enabled). The DECtape system should be started in the search function to locate the block number selected for transfer; when the correct block is found, the transfer is accomplished by programmed setting of the WC, CA, and status register A.

When searching, the DECtape control reads block numbers only. These are used by the operating program to locate the correct block number. In NM, the DECtape flag is raised at each block number. In CM, the DECtape flag is raised only after the word count reaches zero. The current address is not incremented during searching and the block number is placed in core memory at the location specified by the content of the CA. Data is transferred to or from the computer core memory from locations specified by the CA register which is incremented by one before each transfer.

Each time the DECtape system is ready to transfer a 12-bit word, and when the start of the data position of the block is detected, the data flag is raised to initiate a data break request to the data break facility. Therefore, the main computer program continues running, but is interrupted approximately every 133⅓ $\mu$s for a data break to transfer a word. Transfers occur between DECtape and successive core memory locations specified by the CA. The initial transfer address minus one is stored in the CA by an initializing routine. The number of words transferred is determined by the tape format in NM, or by tape format and the word count in CM. At the conclusion of the data transfer, the DT flag is raised and a program interrupt occurs. The interrupt subroutine checks the DECtape error bits to determine the validity of the transfer, and either initiates a search for the next information to be transferred or returns to the main program.

During all normal writing transfers, a check character (the six-bit logical equivalent of the words in the data block) is computed automatically by

the control and is recorded automatically as one of the control words immediately following the data portion of the block. This same character is used during reading to determine that the data playback and recognition take place without error.

Any one of the eight tape transports may be selected for use by the program. After using a particular transport, the program can stop the transport currently being used and select another transport, or can select another transport while permitting the original selection to continue running. This is a particularly useful feature when rapid searching is desired, since several transports may be used simultaneously. Caution must be exercised, however; although the original transport continues to run, no tape-end detection or other sensing takes place. Automatic tape-end sensing that stops tape motion occurs in all functions, but only in the selected tape transport.

The following is a list of timing considerations for programmed operations. (These times are based on 129 12-bit data words per block.)

n(s) = the number of block numbers to be read in the search function and CM, counting through the one causing the word count overflow. Only the block number causing the word count overflow requests a program interrupt.

n(d) = number of words transferred divided by the number of words per block. If the remainder does not equal 0, use the next larger whole number.

n(A) = number of words transferred.

| OPERATION | TIMING |
|---|---|
| Answer a data break request | Up to 17 μs + or − 30% |
| Word transfer rate | One 12-bit word every 133 μs + or − 30% |
| Block transfer rate | One 129-word block every 18.2 ms + or − 30% |
| Change funtcion from search to read data for the current block after DT flag from block number | 400 μs + or − 30% |
| Change function from search to write data for current block after DT flag from block number | 400 μs + or − 30% |
| Change function from read data to search for the next block after DT flag from transfer completion | 1000 μs + or − 30% |
| Change function from write data to search for next block after DT flag from transfer completion | 1000 μs + or − 30% |
| DECtape flag rises in continuous mode | |
| Move function | Never |
| Search function | (n(s)) x (18.2 ms + or − 30%) |
| Read data function | (n(D)) x (18.2 ms + or − 30%) |
| Read all function | (n(A)) x (133 μs + or − 30%) |

| OPERATION | TIMING |
|---|---|
| Write data function | (n(D) ) x (18.2 ms + or − 30%) |
| Write all function | (n(A) ) x (133 μs + or − 30%) |
| Write T & M function | (n(A) ) x (133 μs + or − 30%) |
| In normal mode | |
| Move function | Never |
| Search function | Every 18.2 ms + or − 30% |
| Read data function | Every 18.2 ms + or − 30% |
| Read all function | Every 133 μs + or − 30% |
| Write data function | Every 18.2 ms + or − 30% |
| Write all function | Every 133 μs + or − 30% |
| Write T & M function | Every 133 μs + or − 30% |

**Programming**

The following instructions are associated with TC08-P operation:

**Read Status Register A (DTRA)**

Octal Code: 6761
Execution Time: 2.6 μs
Operation: Transfers content of Status Register A to the AC. ORs AC0-9 with Status Register with the result appearing in AC. The AC is not cleared before the transfer. AC bit assignments are defined in Figure 7-21.

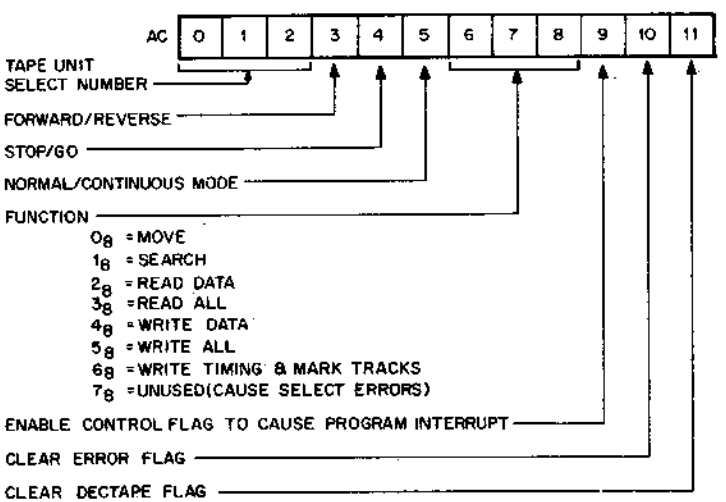



Figure 7-21 Status Register A Bit Assignments

**Clear Status Register A (DTCA)**

Octal Code: 6762
Execution Time: 2.6 μs
Operation: Clears Status Register A; DECtape and Error flag are undisturbed.

**Clear and Load Status Register A (DTLA)**

Octal Code: 6766
Execution Time: 3.6 μs
Operation: Clears Status Register A, then EXCLUSIVE ORs content of AC0-9 into Status Register A. Samples AC10 and 11 to control clearing of DECtape and error flags, then clears AC.

**Load Status Register A (DTXA)**

Octal Code: 6764
Execution Time: 2.6 μs
Operation: EXCLUSIVE ORs content of AC0-9 into Status Register A. Samples AC bits 10 and 11 to control clearing of Error and DECtape flags, then clears the AC.

**Skip On Flag (DTSF)**

Octal Code: 6771
Execution Time: 2.6 μs
Operation: If either DECtape or Error flags is set, skips the next instruction.

**Read Status Register B**

Octal Code: 6772
Execution Time: 2.6 μs
Operation: ORs content of Status Register B into AC. The AC is not cleared before transfer; AC bit assignments are defined in Figure 7-22.

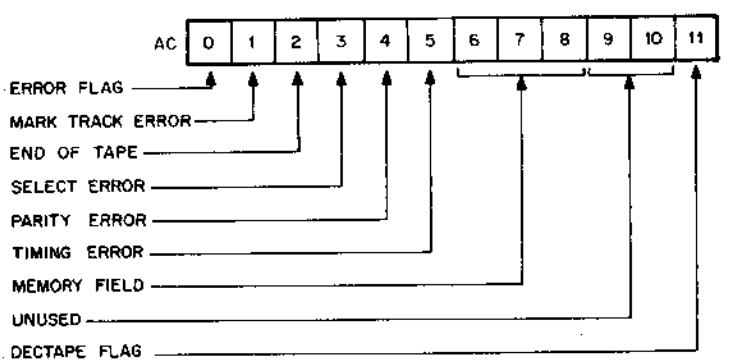



Figure 7-22 Status Register B Bit Assignments

**Load Status Register B**

Octal Code: 6774
Execution Time: 2.6 μs
Operation: Loads memory field portion of Status Register B with content of AC6-8, then clears the AC.

An elementary subroutine for reading or writing DECtape is given below. This routine does not use the interrupt, and exits with the DECtape drive halted.

The format for calling the subroutine is:

```
JMS (IDTAPE)    Effective JMS to IDTAPE, i.e., indirect JMS if IDTAPE
                  is not on same page as calling sequence.
WORD 1,         Bits 0-2, unit number
                Bit 3, start search (0=forward 1=reverse)
                Bits 6-8, memory field for transfer
                Bit 10, error return (0=JMP WORD 5)
                                     (1=JMP I WORD 5)
                Bit 11, function (0=READ 1=WRITE)
WORD 2,         Block number for start of transfer
WORD 3,         2's complement of the number of words to transfer
WORD 4,         Memory address of first transfer minus 1
WORD 5,         Error return or address for error return (to correspond
                  to Bit 10 of Word 1)
RETURN,         Transfer completed, return with AC cleared
```

```
ID7400,  7400
                        /AND MASK (MUST BE FIRST CELL IN
                        /PAGE)
IDTAPE,  0              /ENTRY TO SUBROUTINE
         CLA
         TAD    I IDTAPE    /SAVE WORD 1
         DCA    IDCODE
         ISZ    IDTAPE      /ADVANCE TO BLOCK NUMBER (WORD
                            /2)
         TAD    IDCODE
ID0200,  AND    ID7400      /UNIT NUMBER AND DIRECTION BIT
         TAD    ID0010      /PUT INTO SEARCH MODE
         DTCA   DTXA
         DTLB               /CLEAR FIELD BITS
         TAD    IDWC
         DCA    I IDCA      /SET UP CURRENT ADDRESS (7755)

/ERROR WHILE SEARCHING . . . NORMALLY ENTERED WITH B
/STATUS REGISTER IN THE AC, PERFORMS TURN AROUND IF END
/ZONE ERROR, AND FORCES THE STOP-GO BIT TO GO

IDSERR,  RTL
         RAL            /MOVE END ZONE FLAG TO LINK
         CLA    CML
         TAD    ID0200  /GET DECTAPE GO FLAG

/CHANGE DIRECTION IF AND ONLY IF THE LINK IS ZERO,

IDCONT,  SNL            /CHECK DIRECTION AND SIGN
         TAD    ID0400  /REVERSE DIRECTION
         DTXA           /ENTER AND GO IN SEARCH MODE
         DTSF   DTRB    /IDLE . . AND LOAD ERROR FLAG
         JMP    .-1     /WAIT UNTIL FLAG COMES UP
         SPA            /TEST ERROR FLAG
         JMP    IDSERR
```

```
        DTRA            /GET DIRECTION BIT
        RTL
        RTL             /DIRECTION BIT GOES TO LINK
        SZL     CLA
        TAD     ID0002  /REVERSE . . . GET "BLOCK TO FIND"
                        /-2
        TAD     I IDWC  /ADD IN LAST BLOCK SEEN
        CMA             /COMPLEMENT
        TAD     I IDTAPE /ADD IN "BLOCK TO FIND"
        CMA
        SZA     CLA     /BLOCK NUMBERS MATCH?
        JMP     IDCONT  /REENTER SEARCH LOOP
        SZL             /CHECK DIRECTION BIT
        JMP     IDCONT+1 /TURN AROUND IF REVERSE

/END OF SEARCH LOOP, TAPE IS NOW AT DESIRED BLOCK
/TRAVELING IN A FORWARD DIRECTION,

        ISZ     IDTAPE
        TAD     I IDTAPE /GET WORD COUNT
        DCA     I IDWC
        ISZ     IDTAPE
        TAD     I IDTAPE /GET TRANSFER ADDRESS
        DCA     I IDCA
        TAD     IDCODE
        DTLB            /LOAD FIELD BITS
        IAC             /GET READ-WRITE FLAG
        AND     IDCODE
        RTL     CLL     /MULTIPLY BY 20 (OCTAL)
        RTL
        TAD     ID0130  /BUILD INSTRUCTION
        DTXA            /START UP READ OR WRITE
        DTSF    DTRB    /WAIT . . AND LOAD ERROR FLAG
        JMP     .-1
        ISZ     IDTAPE  /ADVANCE TO WORD 5
        SMA             /SKIP IF ERROR FLAG SET
        ISZ     IDTAPE  /ADVANCE TO WORD 6 . . . NORMAL
                        /EXIT
        SPA     CLA     /SKIP FOR NORMAL EXIT
        TAD     IDCODE  /GET INDIRECT RETURN BIT
        RTR             /MOVE TO LINK
        SNL     CLA     /SKIP IF JMP I <WORD 5>
        JMP     .+3
        TAD     I IDTAPE /MAKE DOUBLE INDIRECT RETURN
        DCA     IDTAPE
        DTRA
        AND     ID0200  /GET STOP-GO BIT
        TAD     ID0002  /PRESERVE DECTAPE ERROR FLAGS
        DTXA            /STOP TAPE
        JMP     I IDTAPE /EXIT
IDWC,   7754            /WORD COUNT FOR DATA BREAK
IDCA,   7755            /CURRENT ADDRESS FOR DATA BREAK
ID0010, 10              /SEARCH FUNCTION BIT
```

```
ID0400,  400          /FORWARD-REVERSE BIT
ID0130,  130          /USED TO BUILD READ AND WRITE
                      /CODE
ID0002,  2
IDCODE,  0
```

**Software**

Four types of programs have been developed as DECtape software for the PDP-8/E:

a. Subroutines which the programmer may easily incorporate into a program for data storage, logging, data acquisition, data buffering (queuing), etc.
b. A library calling system for storing named programs on DECtape and a means of calling them with a minimal size loader.
c. System software which provides for storing, assembling, and editing of programs on DECtape, thereby greatly increasing the versatility and flexibility of the PDP-8/E.
d. Programs for preformatting tapes controlled by the content of the switch register to write the timing and mark channels, to write block formats, to exercise the tape and check for errors, and to provide each of maintenance.

Program development has resulted in a series of subroutines which read or write any number of DECtape blocks, read any number of 129-word blocks as 128 words (one memory page), or search for any block (used by read and write, or to position the tape). These programs are assembled with the user's program and are called by a JMS instruction. The program interrupt is used to detect the setting of the DECtape flag, thus allowing the main program to proceed while the DECtape operation is being completed. A program flag is set when the operation has been completed. Thus, the program effectively allows concurrent operation of several input/output devices along with operation of the DECtape system. These programs occupy two memory pages (400 (octal) = 256 (decimal) words).

The library system has the following features: First, the computer state remains unchanged when it exits. Second, the library calls programs by name from the keyboard and allows for expansion of the program file stored on the tape. Finally, the library conforms to existing system conventions, namely, that all of memory except for the last memory page (7600 (octal)—7777 (octal)) is available to the programmer. The PDP-8/E DECtape library system is loaded by a 17 (decimal)—instruction bootstrap routine that starts at address 7600 (octal). This loader calls a larger program into the last memory page, whose function is to preserve on the tape the content of memory from 6000 (octal) through 7577 (octal), and then load the INDEX program and the directory into those same locations. Since the information in this area of memory has been preserved, it can be restored when operations have been completed. The basic system tape contains the following programs:

a. INDEX: Typing this word causes the names of all programs currently on file to be typed out.

b. UPDATE: Allows the user to add a new program to the files. UPDATE queries the operator about the program's name, its starting address, and its location in core memory.

c. GETSYS: Generates a skeleton library tape on a specified DECtape unit.

d. DELETE: Causes a named file to be deleted from the tape.

Starting with the basic library tape, the user can build a complete file of his active programs and continuously update it. One of the uses of the library tape may be illustrated as follows:

The programmer may call the PDP-8/E FORTRAN compiler from the library tape and with it compile the program, obtaining the object program. The FORTRAN operating system may then be called from the library tape and used to load the object program. At this time the library program UPDATE is called, the operator defines a new program file (consisting of the FORTRAN operating system and the object program), adn adds it to the library tape. As a result, the entire operating program and the object program are now available on the DECtape library tape.

The DECtape system software is permanently stored on DECtape, from which it can be rapidly loaded. Any systems programs such as the assemblers (XPAL and XMACRO), the Symbolic Editor (XEDIT), or the Binary Loader (XLOAD), can be loaded in less than one minute.

The system software uses a standard DECtape format. There are 128 (200 (octal)) words per block and 1464 (2701(octal)) blocks, so the user has the remaining 1336 blocks for rapid access storage of his own programs.

The primary advantage for users are:

a. Efficient use of high-speed transfer rates between DECtape and core memory.

b. Symbolic programs may now be stored, edited, and assembled on DECtape, greatly increasing the versatility and flexibility of the PDP-8/E.

c. The computational workload can be more than doubled, compared to high-speed paper tape systems.

User's programs are written exactly as before for assembly by the PAL or MACRO-8 Assemblers. Using the Symbolic Editor, source programs are typed directly onto DECtape. After assembly, fast symbolic debugging can be done with DDT-8—after loading the program symbol table into DDT with the symbolic loader, XSYM.

The Binary Loader (XLOAD) can load the assembled binary program directly from the DECtape for program execution. Source files, symbol table, and program listings can be stored on DECtape and listed later, if desired. A duplicating program, XDUP, is available for copying programs.

This DECtape system also includes system calls to load any program from DECtape, to update or delete source files, and to restore the system for use by another programmer.

Although the system operates with one DECtape, a two DECtape configuration is strongly recommended as it will permit duplication of programs and saving of back-up master tapes. In a single DECtape system, if the system library is accidentally destroyed, the stored data cannot be replaced immediately because there is no means of recovery.

The last group of programs, called DECTOG, is a collection of short routines controlled by the content of the switch register. It provides for the recording of timing and mark channels and permits block formats to be recorded for any block length. Patterns may be written in these blocks and then read and checked. Writing and reading is done in both directions and checked. Specified areas of tape may be "rocked" for specified periods of time. A given reel of tape may thus be thoroughly checked before it is used for data storage. These programs may also be used for maintenance and checkout purposes.