WRITE

With one execption, the first word of a record is written onto tape 5 milliseconds after the tape is set into motion. When starting a write operation at the Load Point, an 81 millisecond delay is used such that the first record on tape begins 6 inches from the Load Point Marker. The remainder of each record is written at the rate of one word every 200 microseconds. Writing continues until the C(CA) = C(FA).

When the C(CA) = C(FA) condition occurs:

bit 7 of the State Register is set to one (signifying ":Addresses Equal"),
a sequence break occurs if the Sequence Break System is on,
information transfers cease, but tape motion continues, and
the address of the last word taken from memory is equal to the C(FA)-1.

If mrf and mri instructions (defined below) are executed within 100 microseconds after the C(CA) = C(FA) condition occurs, the writing operation continues. This process is called "gather write". That is, information contained in scattered areas of memory can be "gathered" and written onto tape as a single, continuous record.

If the C(CA) = C(FA) condition continues to exist for more than 100 microseconds, a longitudinal check character, defining the end-of-record, is automatically written. (each of the 7 bits of the longitudinal check character represents the even parity of all the bits of the corrsponding channel throughout the length of the record.

If a Write Command is executed with C(CA) = C(FA) initially, then one inter-record gap is written and one of the "end-of-record actions" is taken. Controlled lengths of blank tape can be written in this manner by using "Early Completion and Continue".

Each character written onto tape is read and checked 4 milliseconds after it is written. If a parity error of missing character error occurs, it is indicated by the C(SR).

The memory contents of the PDP-1 are unchanged by magnetic tape write operations.

A character written onto tape that is comprised of seven, zero-bits is defined as an illegal character. Using PDP-1 Concise Code, such a "zero character" can be generated by writing a "space" or "tape-feed" character with even parity.

Replacement of records is not allowed. It is therefore assumed that each write command is writing the last record on tape.

READ

The first word of a record is read from tape 9 milliseconds after the tape is set into motion. The remainder of each record is read at the rate of one word every 200 microseconds. Reading continues until the C(CA) = C(FA) or the end-of-record is found.

When the C(CA) = C(FA) condition occurs:

bit 7 of the State Register is set to one (signifying "Addresses Equal"),
a sequence break occurs if the Sequence Break System is on,
information transfers cease, but tape motion continues, and the address of the last word stored in memory is equal to C(CA)-1.

If mrf and mri instructions (defined below) are executed within 100 microseconds after the C(CA) = C(FA) condition occurs, the reading operation continues. This process is called "scatter read". That is, information read from a single, continuous record can be stored in scattered areas of memory.

If the C(CA) = C(FA) condition continues to exist for more than 100 microseconds, tape movement continues until the end-of-record is found. Information transfers do not occur during this time.

When the end-of-record is found:
bit 3 of the State Register is set to zero (signifying “Record Complete”,
a sequence break occurs if the Sequence Break System is on,
the selected “end-of-record action” is taken, and
the address of the last word stored in memory is equal to the C(CA) - 1.

If a parity error or missing character error is detected while reading a record, it is indicated by the C(SR). The read operation, however, is in no way affected.

READ AND COMPARE

The first word of a record is read from tape 9 milliseconds after the tape is set into motion. This word fills the Data Word Buffer, but is not transferred to the computer. At the same time, the contents of the memory location specified by the Current Address Register is transferred to the selected MTCU. The two 18-bit words are then compared, bit by bit. The remainder of each record is read and compared with memory at the rate of one word every 200 microseconds. The read and compare operation continues until the C(CA) = C(FA), the end of record is found, or a read-compare error occurs.

When the C(C)A = C(FA) condition occurs:
bit 7 of the State Register is set to one (signifying “Addresses Equal”),
a sequence break occurs if the Sequence Break System is on,
the read-compare operation ceases, but tape motion continues, and
the address of the last word taken from memory for comparison is euqal to the C(CA) - 1.

If mrf and mri instructions (defined below) are executed within 100 microseconds after the C(CA) = C(FA) condition occurs, the read-compare operation continues. This process is called “gather-read-compare”. That is, information contained in scattered areas of memory can be “gathered” and compared with information being read from a single, continuous record.

If the C(CA) = C(FA) condition continues to exist for more than 100 microseconds, tape movememnt continues until the end-of-record is found. Information is not read and compared during this time.

When the end-of-record is found:
bit 3 of the State Register is set to zero (signifying “Record-Complete”),
a sequence break occurs if the Sequence Break System is on,
the selected “end-of-record action” is taken, and
the address of the last word taken from memory for comparison is equal to the C(CA) - 1.

When a read-compare error occurs:
bit 4 of the State Register is set to one (signifying “Read-Compare Error”),
the read-compare operation ceases, but tape movement continues until the end-of-record is found, and
the address of the last word taken from memory and successfully compared is equal to the C(CA) - 1.

The memory contents of the PDP-1 are unchaged by magnetic tape read-compare operations.

Magnetic Tape Reset Final (5 µsec)
mrf 72u067

This instruction performs the following functions:

> Bits 6 and 7 of the mrf instruction are used to select on of the three (0-2) Magnetic Tape Control Units (MTCU) attached to the PDP-1.
>
> Bits 2 through 17 of the IO Register replace the C(FA). These bits represent a memory address of the final data word to be handled, plus (should say 1 here?)

The Tape Transport and the “end-of-record action” selected by the last executed muf instruction remain selected.

Bit 5 and bits 8 through 11 of the mrf instruction should be zero.

The instruction following the mrf instruction is always executed. The C(IO) remain unchanged.

The mrf instruction is used for gather write, scatter-read, and gather-read-compare operations. To be effective, it must be given within 100 microseconds after the C(CA) = C(FA) consdition occurs. If used in a sequence with the mri instruction as is the usual case, both the mrf and mri must be given within the 100 microsecond period.

The octal digit, u, within the mrf instruction can be 0, 2, or 4 to select MTCU 0, 1, or 2, respectively.

Magnetic Tape Reset Initial (5 µsec)
mri 72Ug66

This instruction performs the following functions:

> Bits 6 and 7 of the mri instruction are used to select on of three (0-2) Magnetic Tape Control Units (MTCU) attached to the PDP-1.
>
> Bits 2 through 17 of the IO Register replace the C(CA). These bits represent the initial address of a memory location whose contents is to be manipulated in a magnetic tape operation.
>
> Bit 10 of the mri instruction replaces bit 2 of the Command Register. This bit may be used to change the tape operation in process from read to read-compare or read-compare to read. It is also used to specify continuation of a write, read, or read-compare operation.

The Tape Transport and the “end-of-record action” selected by the last executed muf instruction remain selected.

Bits 5, 8, 9, and 11 of the mri instruction should be zero.

The instruction following the mri instruction is always executed. The C(IO) remain unchanged.

The mri instruction is normally used in sequence with the mrf instruction to affect gather write, scatter read, and gather-read-compare operations. To be effective, both instructions must be given within 100 microseconds after the C(CA) = C(FA) condition occurs.

The octal digits, ug, within the mri instruction can be chosen from the following table to specify one of the allowable tape comand changes or continuations.

MRI UNIT-CHANGE (UG) TABLE

Function	Mnemonic	MTCU 0	MTCU 1	MTCU 2
Change Read-Compare to Read (Even or Odd Parity)	mgr	02	22	42
Continue to Write (Even or Odd Parity)	mcw	02	22	42
Continue to Read (Even or Odd Parity)	mcr	02	22	42
Change Read to Read-Compare (Even or Odd Parity)	mgc	00	20	40
Continue to Read-Compare (Even or Odd Parity)	mcc	00	20	40
Read to Read-Compare, Even	mrc	00	20	40
Read to Read-Compare, Odd	mrc	00	20	40
Continue to Read-Compare	mcc	00	20	40

Magnetic Tape Examine States (5 µsec)
mes 72u035

This instruction performs the following functions:

Bits 6 and 7 of the mes instruction are used to select one of three (0-2) Magnetic Tape Control Units (MTCU) attached to the PDP-1. The C(SR) replace the C(IO). The C(SR) remain unchanged.

Bit5 and bits 8 through 11 of the mes instruction should be zero.

The status of the selected MTCU and Tape Transport (TT) can be determined by programmed interrogation of the 18 binary digits transferred to the IO Register.

	IO Register	State of MTCU and Transport
	Bit 0 = 1	One or more of the conditions marked * exist
*	Bit 1 = 1	Parity Error
*	Bit 2 = 1	Missing character error
*	Bit 3 = 1	MTCU busy; if zero then Record Complete
*	Bit 4 = 1	Read-compare error
*	Bit 5 = 1	Illegal tape command
*	Bit 6 = 1	High speed channel request late
	Bit 7 = 1	C(CA) = C(FA); Addresses Equal
	Bit 8 = 1	Selected Tape Transport (TT) ready
	Bit 10 = 1	Selected TT is rewinding
	Bit 11 = 1	Selected TT is in “file-protect” (i.e., ring is out of reel)
	Bit 12 = 1	Selected TT is at Load Point (i.e., approximately 10 feet from physical end of tape)
	Bit 13 = 1	Selected TT has Full Tape Supply (i.e., approximately 100 feet of tape on take-up reel)
	Bit 14 = 1	Selcted TT has Low Tape Supply (i.e., approximately 100 feet of tape on supply reel)
*	Bit 15 = 1	Selected TT is beyond End Point (i.e., approximately 14 feet from trailing-end of tape)
	Bit 16 = 1	Early Completion and Stop has been selected
	Bit 17 = 1	Early Completion and Continue has been selected

In the above status-bit definitions, “ready” (bit 8) means that a tape transport:

has been properly selected
tape is not in motion
is in “automatic”
has it AC power on

To examine states during the processing ofa record, execute two mes instructions and accept the results only if they are equal. This avoids making an erroneous transfer of the C(SR) should it be in a dynamic state.

The octal digit, u, within the mes instruction can be 0, 2, or 4 to select MTCU 0, 1, or 2, respectively.

Magnetic Tape Examine Location (5 μsec)
mel 72u036

This instruction performs the following functions:

Bits 6 and 7 of the mel instruction are used to select one of three (0-2) Magnetic Tape Control Units (MTCU) attached to the PDP-1.

The C(CA) replace bits 2 through 17 of the IO Register. IO bits zero and one are set to zero. The address of the last word read into or compared with memory is equal to the C(CA) - 1.

Bit 5 and bits 8 through 11 of the mel instruction should be zero.

To examine the C(CA) during the processing of a record, execute two mel instructions and accept the results only if they are equal. This avoids making an erroneous transfer of the C(CA) should it be in a dynamic state.

The octal digit, u, within the mel instruction can be 0, 2, or 4 to select MTCU 0, 1, or 2, respectively.

MAINTENANCE INSTRUCTIONS

Two special instructions are available for maintenance and diagnostic operations. They by-pass all interlocks of the MTCU.

Initiate a High Speed Channel Request (5 μsec)
inr 72ur67

This instruction forces the selected MTCU to initiate a High Speed Channel request. The contents of the memory location specified by the Current Address Register are transferred to the Data Word Buffer.

The octal digits, ur, within the inr instruction can be 02, 22, or 42 to select MTCU 0, 1, or 2, respectively and to initiate the request.

Clear Command Register (5 μsec)
ccr 772s067

This instruction forces the C(CR) and the C(TU) of the selected MTCU to be set to zero and places the selected MTCU in a non-busy state. This, in turn, causes the selected Tape Transport to stop. It is the only way, under program control, to bring the tape to rest during the processing of a record. The ccr instruction is particularly useful for adjusting the start-stop characteristics of a transport.

The octal digit, u , within the ccr instruction can be 1, 3, or 5 to select MTCU 0, 1, or 2, respectively and to clear the Command Register.

AUTOMATIC MAGNETIC TAPE CONTROL (TYPE 510)

The Automatic Magnetic Tape Control Type 510 transfers information between a high-density tape transport and the computer in systems containing a Type 131 High Speed Data Control and a Type 19 High Speed Channel Control. Block transfers of data into the computer pass from a transport such as IBM Type 729 IV or 729 VI to the Data Word

Buffer of the Tape Control. The Tape Control presents the data to the One Buffer of the Data Control for transfer to computer core memory through the High Speed Channel Control. Data Transfers in this manner are interleaved with the computer program and can be made in or out of the Sequence Break mode. Up to eight transports can be operated by the Type 510 Tape Control.

The Tape Control receives command specifications from bits 6 through 12 of the computer Memory Buffer Register during specific input-output transfer (iot) instructions. The location of data deposits in the computer memory is determined by the Data Control so that the Tape Control and Data Control must operate in synchronism during data transfers to or from tape. During functions of the Tape Control which do not require data transfers, the Data Control is program-disconnected from the Control, allowing it to commnicate with other devices. While program-connected to the Data Control, the Tape Control can perform some functions not associated with data transfers, such as rewind or space.

The eight major registers of the Type 510 Tape Control are:

DATA WORD BUFFER (DWB)

An 18-bit register that assembles three 6-bit characters read from tape into an 18-bit computer word when reading. When writing it distributes a full computer word into three 6-bit tape characters. The division of the computer word is: Bits 0-5 contain the first character, bits 6-11 contain the second character, and bits 12-17 contain the third character. This buffer receives a computer word from the Data Control during reading.

DENSITY, UNIT, AND REWIND REGISTER (DUR)

A 6-bit register that specifies which one of the eight transports is to be operated, and at what density. This register also specifies which of the eight transports is to be rewound. It is filled from the Memory Buffer Register busses at a specific iot time.

MAGNETIC TAPE FUNCTION REGISTER (MTF)

A 6-bit register that is filled from the Memory Buffer Register busses at a specific iot time to specify the function that is to be carried out.

CHARACTER COUNTER (CHC)

A 2-bit, three-position counter, used to specify which character of a computer word is presently being read or written.

LONGITUDINAL PARITY CHECK CHARACTER BUFFER (LPCC)

A 7-bit buffer that stores the number of transitions read, on a track basis, and provides the necessary logic to determine the validity of the LPCC.

READ BUFFER (RB)

A 7-bit buffer, used to collect the asynchronous bits of a given character as they are read from tape. Depending on the state of the CHC the contents of this buffer is read into the first, second, or third position of the DWB.

WRITE CLOCK (WC)

A 6-bit counter, operated from a 1.233-μsec crystal clock. Its configuration is altered according to the bit density selected under program control.

STATE REGISTER (STR)

An 18-bit register that may provide information concerning the conditions present in the Tape Control and the selected tape transport which can be interrogated by the program. All IO bits are 1 for the event described unless otherwise state. Bit assignments are as follows:

IO Bit	Name	Description
0	Select & Ready	Selected tape unit is not interlocked, density is ok, and the unit is ready for operation
1	Error	Inclusive OR of STR bits 0 and 2 through 7
2	Illegal	Function given last was illegal i.e. a) write and not select ready write b) rewind or backward and at load point c) read type and not select ready read
3	LTPE	Lateral parity error reading, writing, or forward spacing
4	LNPE	Longitudinal parity error
5	CSKE	Character skipped error
6	DXLE	Data transfer late error
7	TIOE	Tape indicate on error. Write Get End Point.
8	TCNF	Tape control not free
9	ODD	Odd parity (1) even (0)
10	556	Density 556 cpi
11	800	Density 800 cpi
12	SRLP	Tape unit selected, ready, and at load point
13	ERF	End of record flag
14	EOF	End of file marker
15	PCP	Proceed condition present
16	LSLR	Low slice level read
17	RND	Tape unit rewinding

To operate the control alone (no data transmission), three iot instructions are required. The first is a microprogrammed instruction combining sfc, rsr, crf, and cpm, as described in the instruction list below. The second is dur and the third is mtf, with bit assignments as described below.

To operate the Tape Control with the Data Control connected for data transmission functions, the same instructions Are used, and in addition, a standard computer instruction connects the Data Control to the Tape Control. The instructions also transfers the contents of the IO Register bits 2 through 17 to the Initial Location Counter in the Data Control. A second instruction is used to transfer the contents of the IO Register bits 0 through 17 to the Data Control.

Bits 2 through 17 of the IO Register are transferred to the Word Counter, and Memory Buffer Register bits 6 through 8 are transferred to the Device Register.

Seven basic input-output transfer instructions are added to the PDP-1 with the installation of the Tape Control. The octal format of these instructions is 72xxyy, where

72	indicates the specified in-out transfer instruction
xx	are used in microprogramming of iot pulses
yy	specify which Tape Control is selected

Skip if Tape Control is Free
sfc Address 0072

One is added to the contents of Program Counter in the computer and the next instruction is skipped.

Read State Register
rsr Address 0172

The contents of the State Register in the Tape Control are transferred to the IO Register of the computer.

Clear ERF
crf Address 0272

The End Of Record flip-flop is reset to 0 in the Tape Control.

Clear Proceed Mode
cpm Address 0472

The Proceed flip-flop is reset to 0 and the Tape Control is dismissed after it completes its present function.

Set DUR
dur Address xx70

Bits 6 through 11 of the MEmory Buffer Register busses are transferred to the Tape Control DUR Register. The xx bits are decoded as follows: