Five instructions are added to the PDP-1 with the installation of this option.

Magnetic Tape Select Mode (5 μsec)

msm 720073

Clears the Control Unit Command Buffer, depostis the 8 least significant bits of the Input-Output register in the Command Buffer, and selects a mode of operation based on the definition of each of the 8 bits as follows:

IO Bit Positions	If Zero	If One
10	Do not operate	Operate
11	Do not rewind	Rewind
12	Forward	Reverse
13	Read	Write
14	Odd Parity	Even Parity
15	75 inches/sec.	Not Used

Bit positions 16 and 17 represent a 2-bit number used to select one of three transports as follows:

00	No Transport
01	Transport 1
10	Transport 2
11	Transport 3

For convenience, let an 18-bit word be designated by 6 octal digits labelled x_1, x_2, x_3, x_4, x_5, x_6. The octal notation that would then correspond to the above but defintions for mode of operation would be:

x_4 (Control)	= 0 or 1	Do Not Operate (i.e., stop selected transport if not already stopped, unless rewinding)
	= 2	Operate (i.e., according to octal digits x_5 and x_6)
	= 3	Rewind (must deselect unit after Rewind command)
x_5 (Function)	= 0	Read Odd Parity Forward
	= 1	Read Even Parity Forward
	= 2	Write Odd Parity Forward
	= 3	Write Even Parity Forward
	= 4	Read Odd Parity Reverse
	= 5	Read Even Parity Reverse
	= 6	Write Odd Parity Reverse
	= 7	Write Even Parity Reverse
x_6 (transport	= 0	No Transport
	= 1	Select Transport 1 at 75 inches/sec.
	= 2	Select Transport 2 at 75 inches/sec.
	= 3	Select Transport 3 at 75 inches/sec.
	= 4	No Transport
	= 5	Not Used
	= 6	Not Used
	= 7	Not Used

Rewind constitutes a special case wherein x_5 must be 4, 5, 6, or 7 because reverse motion must be indicated.

Magnetic Tape Check Status (5 μsec)

msc 720034

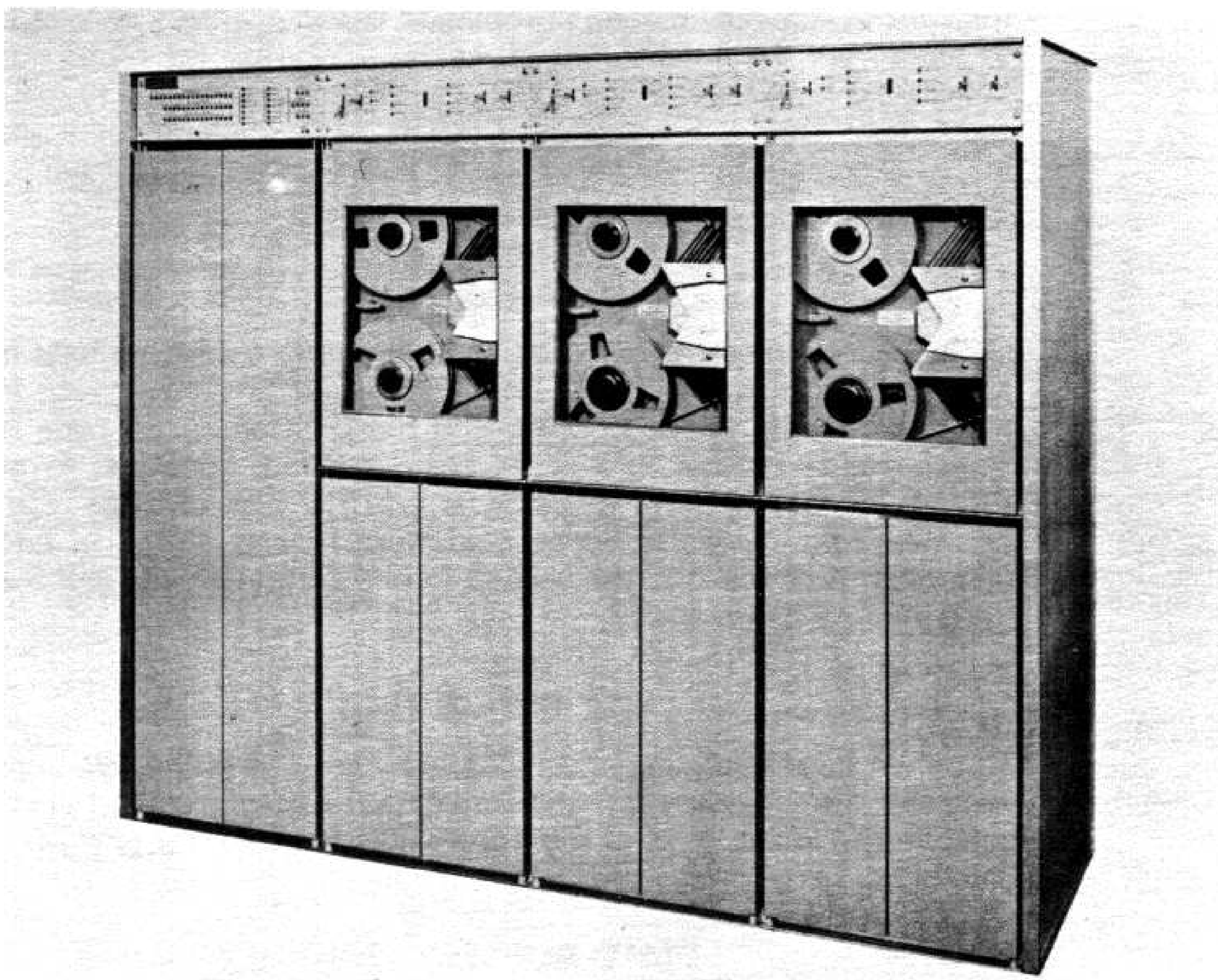
Set IO bits 0 through 5 for subsequent program interrogation as follows:

IO Bit Positions	If One	If Zero
0	Not Ready	Ready
1	Not-Rewinding	Rewinding
2	Not-In-File-Protect	In File-Protect (ring out of reel)
3	Not at Load Point	At Load Point (approx. 10 feet from physical end of tape)
4	Not Full Tape Supply	Full Tape Supply (approx. 100 feet of tape on take-up reel)
5	Not Low Tape Supply	Low Tape Supply (approx. 100 feet of tape on supply reel)
6	Not at End Point	At End Point (approx. 14 feet from trailing end of tape)
7	In Manual Mode	In Automatic Mode

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

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

Status may be checked for the transport currently in operation or the transport that was last selected, but currently operating, by executing the mcs instruction alone. To check the status of any transport, execute a msm instruction using a code which selects the transport to be checked, but does not operate that transport, then the mcs instruction. Never, however, issue a msm instruction to the Control Unit if any transport is reading or writing.



Magnetic Tape Control and Transports

Magnetic Tape Clear Buffer (5 µsec)
mcb 720070

Clears the Character Buffer and the Write Buffer. When writing IBM format, the end-of-record mark is written onto tape by executing a mcb instruction. Each of the 7 bits of the end-of-record mark represents the longitudinal parity of all all the bits of the corresponding channel throughout the length of the record. The mcb instruction should immediately follow any msm instruction which calls for tape read or tape write.

If this is not done, the Character Buffer may never detect a character read from tape or an incorrect end-of-record mark may be written because the original state of the Write Buffer was unknown.

Magnetic Tape Write a Character (5 µsec)
mwc 720071

Each mwc instruction clears the Character Buffer, transfers the 6 most significant bits of the Input-Output Register to the Character Buffer (where the correct lateral parity bit is added) and writes the final, 7-bit character onto tape.

The mwc instruction that writes the first character on tape should be executed no sooner than 3 milliseconds after the msm instruction for operate-write (to account for tape start-time). Succeeding mwc instructions should occur every 65 microseconds (to write 200 characters per inch). After the last character of a record is written, 260 microseconds should elapse (e.g., by employing a time delay subroutine) and then the mcb instruction should be executed to mark the end-of-record. The time delay of 260 microseconds spaces tape such that 3 missing characters will be interpreted at this point when reading and hence, the read operation will recognize an end-of-record.

Magnetic Tape Read Character (5 µsec)
mrc 720072

Each mrc instruction transfers the contents of the Character Buffer (six data bits ... the parity bit having been checked and dropped-out) to the 6 least significant bit positions of the Input-Output Register, clears the Character Buffer, and clears Program Flag 2.

It is generally desirable to program to read three characters from tape, assemble them in the Input-Output Register to form one computer word, and then deposit that word in a selected memory location. Since information transferred from the Character Buffer is combined with the contents of the Input-Output Register by an “inclusive or” operation, it is necessary that the Input-Output Register be cleared prior to assembling each group of three characters.

Program Flag 2 is automatically set by Tape Control Unit when the first bit of a character read from tape enters the Character Buffer. Due to tape skew, all 7 bits of a character are not read simultaneously. Instead, at a tape speed of 75 inches per second, it may require as much as 25 microseconds for 7 bits to be read and entered into the Character Buffer. To read a character into the Input-Output Register it is necessary, therefore, to continually “look” at Program Flag 2 and immediately after finding it to be set, delay 25 microseconds and then execute the mrc instruction. This procedure assures the programmer that all 6 data bits were read and transferred to the Input-Output Register.

Due to the speed of tape and the density of the characters written on it, the mrc instruction must immediately be followed by the Program Flag 2 “look” procedure to find the next character on tape. This can, indeed, be done because the mrc instruction has made the necessary preparations by clearing the Character Buffer and Program Flag 2. Of necessity, therefore, the first 6 bits transferred to the Input-Output Register cannot be manipulated by the program until the next 6 bits begin entering the Character Buffer (as indicated by Program Flag 2).

At this point, the required 25 microsecond time period that accounts for tape skew can be used to manipulate the information in the Input-Output Register and to prepare to accept the next 6 bits or information from the Characater Buffer.

The “look” for the first character of a record need not begin until approximately 3 milliseconds after the execution of the msm instruction for operate-read (to account for tape start-time). This time can be used by the programmer for any useful purpose.

The following Program Flags are used with the Basic Magnetic Tape Control Unit:

Program Flag 2

As previously described, this flag is automatically set when the first bit of a character read from tape enters the Character Buffer. It is used by the program to determine when a character is ready to be read into the IO Register.

Program Flag 4

This flag is automatically set if a parity error occurs while reading. To keep from disrupting the critical timing control provided by the program, it is generally desirable to read to the end-of-record before stopping the tape even though a parity error may have occurred within the record. Therefore, the state of Flag 4 is usually only checked at the end of a record. Corrective action usually involves backspacing one record and rereading the record. (Flag 4 is never set while writing on tape.)

AUTOMATIC MAGNETIC TAPE CONTROL (TYPE 52)

This control automatically transfers information between the computer memory and the tape in variable-length blocks of characters. It allows computation to continue while the transfer is in process by using a High Speed Channel Control Type 19 in conjunction with a special-type data channel. Special features include scatter-read and gather-write, automatic bit-by-bit read-compare with core memory, automatic parity error detection while reading and writing, and rapid tape searching through its ability to skip a pre-selected number of blocks. Tape format is standard IBM as described under Magnetic Tape Transport Type 50.

A maximum of three Tape Control Units Type 52, each capable of handling as many as eight Tape Transports Type 50, can be connected to the PDP-1.

An Automatic Magnetic Tape Control (MTCU) has nine major registers:

DATA WORD BUFFER (DW)

This is an 18-bit buffer which is filled from the Memory Buffer Register of the PDP-1 when information is being written onto tape of filled from the Read Buffer of the Type 52 when information is being read from tape. Since it requires 200 microseconds to write the C(DW) onto tape or to fill the DW when reading tape, the MTCU automatically interrupts the PDP-1 once every 200 microseconds for a 5 microsecond data word transfer.

READ BUFFER (RB)

Each 7-bit character (6-bit code and parity bit) read from tape is momentarily stored in this 7-bit buffer. Here, a parity check is made, the parity bit is dropped, and the 6-bit character code is transferred to the DW. If a parity error is found, the Parity Error Bit, bit one of the State Register, is set. The first of three consecutive 6-bit character codes read from tape is stored in bits 0 through 5 of the DW, the second in bits 6 through 11, and the third in bits 12 through 17.

WRITE BUFFER (WB)

This 7-bit buffer obtains a 6-bit character code from the DW, supplies the correct parity bit, and transfers the resulting 7-bit character to the Write Head of the Tape Transport where it is written onto tape.

STATE REGISTER (SR)

This 18-bit register contains information concerning the status of the MTCU and the selected Tape Transport, including error conditions that may have occurred with the last tape record handled by the MTCU. Under PDP-1 program control, the C(SR) can be transferred to the IO Register and there be interrogated.

FINAL ADDRESS REGISTER (FA)

This is a 16-bit register which is filled from the IO Register of the PDP-1 by a programmed instruction. It contains a core memory address equal to the address of the final data word to be handled plus one. The first four bits of this register designates one of sixteen 4096-word memory modules and the last twelve bits designates one of 4096 memory locations within that module. During read, write, compare, and space operations, this register is continually compared with the Current Address Register to determine if the operation has been completed.

CURRENT ADDRESS REGISTER (CA)

This is a 16-bit register which is filled from the IO Register of the PDP-1 by a programmed instruction. It contains the core memory address to or from which an 18-bit data word is currently being transferred. The first four bits of this register designates one of sixteen memory modules and the last twelve, one of 4096 memory locations within that module. The C(CA) is automatically increased by one after the completion of each data word transfer. During read, write, compare, and space operations, the C(CA) are continually compared with the C(FA) to determine if the operation has been completed. The C(CA) can be transferred to the IO Register by a programmed instruction.

COMMAND REGISTER (CR)

This 4-bit register is filled from the Memory Buffer Register of the PDP-1 with a code representing one of eleven tape functions such as read, write, rewind, etc. This code prepares the MTCU to carry-out the specified function.

TAPE UNIT REGISTER (TU)

This 3-bit register is filled from the Accumulator of the PDP-1 and is used to designate one of eight (0-7) Tape Transports attached to the specified MTCU.

STOP-CONTINUE REGISTER (SC)

This 2-bit register is filled from the Memory Buffer Register of the PDP-1 and is used to specify one of three end-of-record actions to be taken immediately after the tape operation has been completed.

Eight basic instructions are added to the PDP-1 with the installation of this option:

Magnetic Tape Unit and Final (5 μsec)
muf 72ue76

This instruction performs the following functions:

Bits 6 and 7 of the instruction are used to select on of three (0-2) Magnetic Tape Control Units (MTCU) attached to the PDP-1. Bits 15, 16, and 17 of the Accumulator replace the C(TU). These bits are used to select one of eight (0-7) Tape Transports (Units) attached to the specified MTCU Bits 2 through 17 of the IO Register replace the C(FA). These bits represent a memory address equal to the final data word to be handled, plus one.

Bits 10 and 11 of the muf instruction replace the C(SC). These bits are used to select one of three "end-of-record actions":

a) normal completion and stop,
b) early completion and stop, or
c) early completion and continue.

Bits 5, 8, and 9 of the muf instruction should be zero. If the selected MTCU is not busy, the muf instruction is properly executed and the next instruction in sequence is skipped. If busy, muf is performed as a nop instruction and the next instruction in sequence is executed. In either event, the C(IO) and C(AC) remain unchanged.

The "end-of-record actions" are defined as follows:

Normal Completion and Stop. After the end-of-record has been reached, the transport either writes an inter-record gap and stops or stops within an existing inter-record gap. After the 3 millsecond, transport stop-tiime has elapsed, the MTCU and PDP-1 are notified that the tape operation has been completed. Until such notification has been received, the MTCU is considered to be busy. Bit 3 of the State Register which can be examined by the computer program is a "one" if the MTCU is busy or a "zero" if the record has been completed.

Early Completion and Stop. This end-of-record action is identical to Normal Completion and Stop except that the completion notification is received by the MTCU 3 milliseconds earlier. Thus the programmer can initiate a tape operation on a different Tape Transport attached to the same MTCU while the other Tape Transport is expending the 3 millisecond stop-time period. As before, completion is indicated by Bit 3 of the State Register being set to zero.

Early Completion and Continue. This end-of-record action is identical to Early Completion and Stop, except that the selected transport continues in motion and continues to be under control of the selected MTCU. From the time Bit 3 of the State Register is set to zero (signifying "Record Complete") and up to 1.5 milliseconds thereafter, only muf and mic (not mri or mrf) can be given, and the command should be given before the specified time or not at all. If the instructions are given in time, many records can be handled without stopping tape. If the instructions are not given during this time, Early Completion and Stop occurs after (a) two consecutive inter-record gaps (blank tape) have been written if the previous tape command was "write"; (b) the next record has been spaced over (i.e., tape stops within the next available inter-record gap) if the previous tape command was "read". In either case, the control will give another early end-of-record notification.

If Early Completion and Continue have been specified (bits 10 and 11 of the previous muf instruction), the next muf instruction will not change the tape unit register, that is AC bits 15-17 will not be transferred to the tape unit register. Tape unit designation is therefore unnecessary.

Since any number of records can be "spaced" with a single tape command, Early Completion and Continue is not normally specified with space commands unless the command is certainly intended to be changed during the 1.5 millisecond period. Failure to change a space command during this time results in tape-spacing until the end-of-reel is reached.

The octal digits, ue, within the muf instruction can be chosen from the following table to specify one of the allowable functions:

MUF UNIT-END (UE) TABLE

Function	Mnemonic	MTCU 0	MTCU 1	MTCU 2
Normal Completion and Stop	mnp	00	20	40
Early Completion and Stop	mep	01	21	41
Early Completion and Continue	mec	03	23	43

Magnetic Tape Initial and Command (5 µsec)
mic 72uc75

This instruction performs the following functions:

Bits 6 and 7 of the mic 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.

Bits 8 through 11 of the mic instruction replace the C(CR). These bits are used to select one of eleven tape functions as indicated in the MIC UNIT COMMAND (UC) TABLE given below.

The C(SR) are cleared.

The selected tape transport is set into motion and begins to execute the specified tape function.

Bit 5 of the mic instruction should be zero. If the selected MTCU is not busy, the mic instruction is properly executed and the next instrcution in the sequence is skipped. If busy, mic is performed as a nop instruction and the next instruction in sequence is executed. In either event, the C(IO) remain unchanged.

The octal digits, uc, within the mic instruction can be chosen from the following table to specify one of the allowable tape command:

Function	Mnemonic	MTCU 0	MTCU 1	MTCU 2
Stop	mst	00	20	40
Rewind	mrw	01	21	41
Backspace	mbs	03	23	43
Forward Space Check Even Parity	mfe	10	30	50
Forward Space Check Odd Parity	mfo	11	31	51
Write Even Parity	mwe	12	32	52
Write Odd Parity	mwo	13	33	53
Read and Compare Even Parity	mce	14	34	54
Read and Copare Odd Parity	mco	15	35	55
Read Even Parity	mre	16	36	56
Read Odd Parity	mro	17	37	57

STOP

The stop command should not be used in any action except the Early Completion and Continue, and even then it should be avoided if possible. If it is used, the following points should be observed. The command should be given only when the tape is moving in the forward direction. The programmer must wait 3 milliseconds after the command is given before attempting to reverse the direction of the tape (on the same drive); i.e., at early completion on writing and stop given, the programmer would wait 3 milliseconds before giving the backspace command. Ten milliseconds must elapse after the stop command is given before attempting to continue in the same direction on the same drive.

In stop after reading, the following rules should be followed:

a) Stop command must be given within 100 microseconds of early completion pulse request if next command is write;

b) If stop is given after more than 100 microseconds but less then a.5 milliseconds, the commands, read, read and compare, or forward space may be given. If then-ext command is to be write, the tape must be repositioned by backspacing one record and forward spacing one record (read, read and compare, forward space) before writing;

c) If stop is given after more than 1.5 milliseconds, it is suggested that the tape be backspaced two records and the position determined by programming.

In stop after writing, the following rules should be observed:

a) Stop should be given within 200 microseconds if possible. All delays from early completion add to the size of the end of record gap.

b) If stop is given after 200 microseconds, it is suggested that the tape be repositioned with one backspace, one forward space, then writing.

SPACE

For Backspace and Forward Space Commands the number of records to be spaced (or skipped over) is equal to C(FA) - C(CA) + 1. To space 5 records, for example, set C(FA) = 4 and C(CA) = 0. In addition to spacing, the Forward Space Commands check for missing characters and for even or odd parity. Errors, if any, are indicated by the C(SR).