MICROTAPE: ITS FEATURES AND APPLICATIONS

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ABSTRACT

DEC has recently introduced the Type 550 Microtape Control and the Type 555 Dual Microtape Transport, which have the flexibility, speed and storage capabilities of magnetic tape, but yet maintain the convenience of paper tape. This paper will describe the distinguishing features of the Microtape system, indicate what programs are available for their use, some applications that are possible, and describe some ideas for future systems.

INTRODUCTION

Most people, during their computer experience, have used and have become familiar with various types of magnetic tape storage. The Microtape system, however, has some features which make it flexible from a programming standpoint, at the same time producing an extremely reliable method of recording information, and a convenient system to use physically. Some of the features which will be described include Manchester type "polarity sensing," pre-recorded mark and timing tracks, individually addressable blocks and, in a sense, individually addressable words, bi-directional reading and writing, non start-stop operation, and the ease of loading, unloading and storing tape. In addition the technical characteristics of the Type 550 Control and some future controls will be discussed so that Microtape as a system can be more fully understood.

TYPE 555 DUAL MICROTAPE TRANSPORT

The Type 555 Transport consists of two logically independent tape drives capable of handling 260 foot reels of 3/4 inch, 1.0 mil Mylar tape. The bits are recorded at a density of 375 (±60) bits per track inch and since the tape moves at a speed of 80 inches per second, an effective information transfer rate of 90,000 bits per second is achieved. Individual 18-bit words, which are assembled by the tape control unit, arrive at the computer approximately every 200 microseconds, and therefore a block of 256_{10} words will be transferred in 53 milliseconds*. Traverse time for a reel of tape is approximately 40 seconds.

The 3-1/2 inch reels are loaded simply by pressing onto the hub, bringing the loose end of the tape across the tape head, attaching it to the take up reel and spinning a few times. Individual controls on the transport enable the user to manipulate the tape in either direction manually.

There is no capstan or pinch-roller arrangement on the transport, and movement of the tape is accomplished by increasing the voltage (and thereby the torque) on one motor, while decreasing it on the other. Braking is accomplished by applying a torque pulse to the trailing motor. The stopped condition is maintained by applying a small, equal, but opposite torque to both motors. As there is a small amount of roll on stopping or turning around, the units are not used on a start-stop basis, but rather to transfer fairly large amounts of data. In the present system the roll amounts to approximately one and one-half blocks. Start and stop time average 0.15 - 0.2 seconds and turn around time takes approximately 0.3 seconds. The reels themselves have been so designed that the ratio of outside tape diameter to inside tape diameter is a relatively low 1.3 to 1, thus keeping the torque requirements, and therefore tape tension, almost constant in either direction throughout the length of the tape. The small size of the reel makes storage or movement of many reels fairly convenient.

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*For the purposes of this paper, the term "block" will refer to a record on the tape consisting of 256_{10} eighteen bit words plus associated control words. Note, however, that there is nothing inherent in the present system, or necessarily desirable, about blocks with the indicated format.

The units can be "dialed" into a particular selection address by means of a switch on the front of the transport. Up to four Dual Transports, i.e., eight drives, can be connected to one control unit.

All of the read and write circuitry, as well as the block format detection logic, is contained in the Type 550 Control unit. The transports consist of essentially nothing more than the motor drives, tape heads, and relays necessary for selection, motion control and transfer of information.

Physical dimensions of the unit are given in Appendix C.

RECORDING TECHNIQUE

The Microtape system uses the Manchester type polarity sensed (or phase modulated) recording technique. This differs from other standard types of tape recording, where, for example, a flux reversal might be placed on the tape every time a "1" is desired. In the polarity sensed scheme a flux reversal of a particular direction indicates a "0" while a flux reversal in the opposite direction indicates a one. By using a timing track, recorded separately in quadrature phase, to strobe the data tracks, the polarity of the signal at strobe time indicates the presence of a zero or one. Using the timing track on the tape as the strobe also negates the problems caused by variations in the speed of the tape.

One disadvantage to the system is that the control must read double the number of flux reversals of other systems. However, with this type of recording one need not worry about the amplitude of the signal but only its polarity, thus removing some of the signal to noise problems, and allowing the use of read amplifiers with high uncontrolled gain . It also allows the changing of individual bits on the tape without changing the adjacent bits.

Reliability is further increased when we see that all five of the information tracks on the tape are recorded redundantly. This is accomplished by simply wiring the two heads for each information track in series, and on reading, the analog sum of the two heads are used to detect the correct value of the bit.

Therefore, a bit cannot be misread until the noise on the tape is sufficient to change the polarity of the sum of the signals being read. Noise which reduces the amplitude would simply have no effect. During testing, the tape has actually been read correctly with a piece of paper covering one half of the tape head. Tapes have also been read without loss of information in cases where the tapes were stopped by hand, and then released.

One other item affecting reliability should be mentioned, especially in a system which allows bi-directional transfer of information. That is the problem of tape skew as it passes over the head. Some tape systems will strobe on the first bit of a slot that it sees, then impose some arbitrary delay after which all signals present are then read. This produces problems in that there may be differences in the two directions. Variations in tape speed between write time and read time would result in non-compensated changes in the necessary delay. In the Microtape system the redundant heads are placed in a relationship to each other which, first of all, eliminates most of the cross-talk between the most important tracks, and second, places the timing tracks at the edges of the tape so that strobing on the analog sum of the timing track signals will guarantee that the data tracks are read when they are in the most favorable position. The data tracks are placed in the middle of the tape where the effect of skew is at a minimum in any case. The actual head arrangement is as follows:

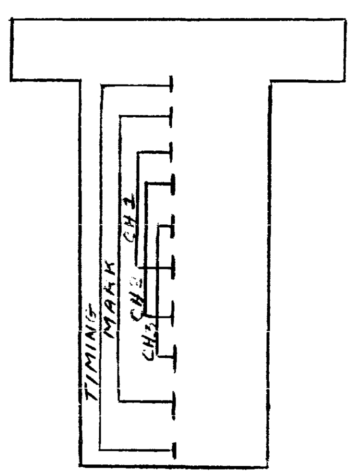

Figure 1

Placement of Microtape Tracks

The five tracks actually written consist of the timing track (used to strobe the other tracks), the mark track (used to raise flags in the program, create sequence breaks, detect block mark numbers, and protect control portions of the tape), and three data tracks. An eighteen bit word therefore uses six slots of three bits each on the tape.

TAPE FORMAT

The heart of the Microtape system is the pre-recorded timing and mark track. In the previous section the importance and use of the timing track was explained. This section will include a complete discussion of the mark track.

First, however, the reader should completely understand the meaning of the words "pre-recorded." At present, one of the programs provided with the Microtape system is one which will write the timing track and block format desired for the individual user. The Microtape system includes a programmed mode of operation called "Write Timing and Mark Track" and a manual switch which both permits writing on the timing and mark tracks and also activates a clock which produces the timing track and flags for program control. Unless both the mode and the switch are used simultaneously, it is physically impossible to write on the mark or timing tracks. A red indicator light will be lighted on all transports connected to the appropriate control when the manual switch is in the "on" position. In this mode only, information channel "one" (high order bits 0-5) is also connected to the mark track channel. Therefore, in one pass of the tape, the timing track, mark track, block format, and block mark numbers are created. Since part of the data word must be reserved to produce the mark track, it is impossible to write intelligent data in the information channels at the same time. For this reason also, only twelve of the eighteen bits are used for block mark identification, and bits 0-5 must be "anded" out when checking block mark numbers. (See figure 6 for format of bits on the tape). It is possible that the tape manufacturer may, in the future, supply tapes which will have the correct format actually pre-recorded on the tape. Once the format has been recorded the user is able to use the Microtape system for actual data storage.

The actual mark track which is written on the tape (see figure 2) was selected after careful consideration and provides many functions not readily discernible at a casual glance. Some of these are listed below and will be discussed fully.

a) Program synchronization

b) Block and detection

c) Error checking and prevention

d) Protection of control information

e) Block and word addressability

f) Automatic bi-directional compatibility

g) End of tape detection

h) Variable block format

i) Inclusion of marks to allow expansion for more automatic systems of the future

For complete understanding of the questions of program synchronization and block end detection, figures 2 through 6 should be studied closely, using the explanation which follows to clarify certain main points.

There are three main programmed modes of operation which require that the user either provide information to the Microtape system, or accept information from the Microtape system. These are the "Search," "Read," and "Write" modes. (A fourth mode, "MOVE," simply moves the tape without supplying or requesting information.) In order to indicate to the programmer that the system is ready to transfer information, certain flags are raised*. When these occur, the programmer must either load new information to be written, or unload information just read, and must do so within a specified time to prevent loss of information and error indications.

In order to produce these flags, the mark track is read by passing the bits through an 8-bit "moving window" which shifts bit by bit as the tape moves. A decoder associated with the window interprets the pattern present, and raises the

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*If the program interrupt mode is being used, assume that the raising of any of the flags mentioned also causes a sequence break in which the individual flags must be interrogated.

appropriate flags, if necessary. An 8-bit window is used, even though each mark is six bits long, to provide greater reliability, since a mark will not be recognized as legitimate unless the last two bits of the previous mark were legitimate. This is one of the reasons requiring ordering of the marks on the tape, the other will be mentioned later. Note that whether the program is reading or writing, the mark and timing tracks are always being read.

In Search mode the Data Flag will be raised when, and only when, a Block Mark mark is read (see figure 3). The program must unload the buffer within 53 ms, and bits 6-17 will contain the block mark number. Bits 0-5 will contain the mark code.

In Write mode, the Microtape system automatically writes the reverse check sum and raises Data Flags when it requires information to be written on the tape (see figure 5). The first data flag requests the first data word of the block, and the last data flag requests the last data word of the block; therefore there are a total of 256 data flags for a 256 word block. Note that the program loads each data word as the Microtape system is writing the previous one; thus a flag is raised requesting a data word when it has just passed the place on the tape two words ahead of where the word is to be written. Compare this with Read mode discussed below. Time between Data Flags is approximately 200 microseconds. When the pre-final mark is detected, a Block End Flag is raised which accomplishes two things. First it is a request for the program to load the calculated check sum (normally the complement of the 18 bit ring sum of the reverse check sum and the data words), and second, it allows the program to detect the fact that a block has been completed, without the use of any programmed counters. After the check sum is written the writers are turned off, to avoid any possible way of destroying the control portion of the block. Approximately, 1.2 ms is available to switch to Search mode if a check of the next block mark number is desired. If the control remains in Write mode the Microtape system will write the next reverse check sum and raise the next Data Flag after approximately 1.6 ms.

In Read mode, the first Data Flag is raised when the reverse check sum has been read (see figure 4). The reason for this becomes fairly obvious when one remembers that we may read a block in either direction independent of the direction in which it may have been written. The first word read, therefore, is used to set the register which the program will use to accumulate the check sum. Each successive Data Flag indicates that a data word has been read, and should be unloaded from the buffer, stored in memory and accumulated in the check sum. When the check sum mark is detected, a Block End Flag is raised indicating both the end of the block and the fact that the check sum is in the buffer. This word would normally be unloaded and added to the accumulated check sum producing a total of zero. Any other result indicates that the tape has been read incorrectly, and the programmer has the option of continuing in any manner desired. Note that when reading there are 257 Data Flags for a 256 word block, and that each flag states that the associated data word is in the buffer. Note also that in the present system, validity checks on the data portion of the tape, are done by program control only. As a matter of fact, if for some reason a check sum is not desired, the check sum word can be used as simply another data word.

Checking of the mark and timing tracks is accomplished through the hardware and the physical characteristics of the mark track itself. One check, i.e., that of checking the last two bits of the previous mark, has already been mentioned, however another interesting fact emerges if we examine figure 6 and see what happens as the tape passes by the mark detecting window, bit by bit. Close examination will show that unless the window is actually looking at a legitimate mark on the tape (except an End mark) the bits in the window will differ by at least two bits from any possible legitimate mark.* This guarantees that a one bit error any place on the mark or timing tracks can not cause an erroneous mark to be detected. It also allows checking for asynchronous marks. For example, once the window is in synchronization (normally by passing over a block mark) a Mark Track Error will

*In the rare instance where they are only 1 bit different, the window has been cleared for other control purposes, so that one bit can make no difference at all.

be indicated (and the Error Flag raised), if a legitimate mark is found in less than six shifts of the window, or if a legitimate mark is not found after each six shifts of the window. These combinations of checks makes it virtually impossible to misinterpret the mark track and thereby destroy information.

Nothing in the system prohibits the changing of modes at any time during the movement of the tape. Thus it can be seen that, with some limitations*, one might find a particular block in Search mode, count passed n words in Read mode, write one word or the rest of the block in Write mode, then switch back to Search mode to find the next block. Within those limits almost any combination of modes can be used, and because of the polarity sensed recoding technique, even individual words can be replaced.

One other unique feature of the mark track is that the six control marks before the data marks are, what we have chosen to call "complement obverses", of the six control marks after the data marks.** The data mark is the complement obverse of itself. Thus, since when reading in the reverse direction, the flux reversals on the tape are opposite to those when reading forward, and the bits are read in the reverse order, the mark track window sees exactly the same thing in both directions. With one exception, no special logic is required to distinguish the format of the tape in either direction. The one exception involves the shifting of information into the Microtape buffer. Since the assembling of the 18-bit word is done by the hardware, it is necessary to shift the buffer in opposite directions for opposite movement of the tape in order to present words to the

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*Some of the things to be careful of include the difference in counting words when switching from read to write or from write to read, the recovery of the read amplifiers after writing (about 2 word times) and the fact that writing in various locations in the block will invalidate the check sum at end of the block.

** The complement obverse of a word is defined as the complement of a word with the bits read in the reverse direction, i.e.: 010110 (26) and 100101 (45)
001000 (10) and 111011 (73) etc

computer as they were originally written. This means that if a record is read opposite to the way in which it was written, each 18-bit word will appear in the buffer exactly as it originally appeared in memory; however, the last word written would be the first one read, etc.

The End marks on either end of the tape illustrate this bi-directional ability even better. As the End marks are complement obverses of each other, only that end of tape will be recognized, at which the tape will physically come off the reel if further movement continues. Thus, here again, no special hardware is needed for opposite ends of the tape and there is no harm in coasting into or turning around in the end zones. Errors will be indicated only if attempting to go further into the end zone. The particular bit structure of the end marks is a repetitive one so that any shift of three bits in the window will appear as another end mark. This makes it virtually impossible to pull the tape off the reel in any of the normal modes. Sensing of the appropriate End mark will stop the tape and raise the Error Flag, if the tape is in any of the normal modes.*

It can be seen therefore, that although the blocks are structurally alike in terms of the types of marks on the mark track, they need not contain the same number of data words. Indeed every block on the tape can be of different length, if such a format was created originally. The system will operate in the manner outlined no matter what the length of the block. One other feature exists which

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*There are only two "abnormal" modes. One is the Write Timing and Mark Track mode mentioned previously in which no marks can be detected since they are being written. The other is the case where a tape has been left moving but not connected to the control (deselected). In this case, only the marks on the actually selected tape will be recognized. In only these two circumstances can the tape be pulled off the reel.

may prove useful, especially in future designs. If for any reason the distance between blocks must be lengthened it can be done simply by adding "01" codes between the Reverse Block Mark of block N and the Forward Mark of block N+1 (see figure 6). Since the pattern "01010101" already appears at the junction of the two marks, it may be continued indefinitely without harm.

Additional flexibility has been retained for future expansion. For example, in the future the contents of the Lock Mark might be used to determine if the block is "file protected", i.e., cannot be written on. The Final Mark could be used to request the check sum from the hardware, in a system having automatic sum checking, etc.

AVAILABLE PROGRAMMED SUBROUTINES

Three main groups of programmed subroutines are provided with the Microtape system for both the PDP-1 and the PDP-4. The first is a basic set of subroutines for searching, reading and writing; the second is a set of maintenance and diagnostic programs which can accomplish combinations of Microtape functions using the toggle switches on the console (MICROTOG); and the third is a simple routine to save programs or data on Microtape, and allow quick retrieval via the toggle switches (MICROTRIEVE). Both MICROTOG and MICROTRIEVE use the basic read, write and search subroutines as provided for the programmer, and are basically the same for both the PDP-1 and PDP-4. There are however, some differences in the basic subroutines which will be described below.

For the PDP-1, the basic subroutines are designed to read or write one block of information, in either direction, depending on the current position of the tape and the direction in which the tape must be searched. If the tape is used in the reverse direction, data will be transferred starting with the end of the block in core storage; otherwise data will be transferred normally starting with the beginning of the block in memory. This allows the direction of reading to be independent of the direction of writing without destroying the normal order of the words in memory. The search subroutine needs only the appropriate unit, block number, and an error return as parameters. The read and write subroutines, which require a unit, block number, starting address and an error return as parameters, automatically enter the search subroutine to find the block requested. All three subroutines leave the tape running when completed, to allow additional tape functions if desired. Programs have been written in MACRO for both the single channel and sixteen-channel sequence break systems. Multi-programming will occur only during searching however, as the total machine time is preempted during the actual transfer of data. Errors are detected, saved in status bits, and indicated by a special return, at which point the programmer has the option of continuing in any manner desired. Approximately 200_8 words of core storage are used.

The basic PDP-4 subroutines allow the user to specify the total number of words to be transferred irrespective of the block format on the tape. Searching will occur in either direction; however, reading and writing will be done in the forward direction only. If the number of words specified during writing is not a multiple of the block length, the final block is completed with words of plus zero (+0). On reading, only the correct number of words will be stored in memory; however, reading will continue until the end of the last block so that the final check sum can be calculated and checked. The program assumes the use of the program interrupt. One auto-index register must be defined by the main program, and "DISMIS" must be defined as a JMP to the instructions which dismiss the interrupt. Instructions to check the appropriate flags must also be included in the programmer's interrupt sequence.

The search subroutine, which requires a unit, block number and error return as parameters, will search for the specified block and either stop, remain running in the forward direction, or remain running in the reverse direction according to the subroutine entrance used. As soon as searching is started, a return is made to the main program to allow simultaneous multi-programming.

The read and write subroutines which require a unit, block number, starting and ending core addresses, and an error return as parameters, automatically enter the search subroutine to position the tape. During data transfers no multi-programming is permitted, and when the transfer is completed the tape is stopped. Errors are detected, coded numerically, saved in status bits and indicated by a special return. The programmer can decode the type of error and continue in any manner desired. Approximately 350_8 words of core storage are used.

MICROTOG for both the PDP-1 and PDP-4 is a collection of fairly short programs which allow the user to perform various Microtape functions using, as input to the program, only the toggle switches on the console. The programs available include those which will allow: creation of the mark track and desired individual block format, reading or writing specified portions of the tape, writing a "virgin" tape (tape with known block content for test purposes) in either direction, sum checking specified portions of the tape in either direction, "rocking" the tape in both directions in specified modes for indicated times or distances, generation of specified types of data blocks, and exercising the tape by writing, reading and sum checking in both directions. Errors are completely analyzed and typed out together with the number of the block causing the error, and the exact status of the Microtape at the time of the error. Detailed descriptions of the use of the various sub-programs are currently available.

MICROTRIEVE allows the user to specify via toggle switches the information necessary for the storing and retrieving of data or programs on a Microtape library tape. When storing data the program will search for the block indicated, and write the indicated area of memory on the tape together with an identification and two control words. A message is typed upon completion which includes the starting and ending block numbers used for storage and a number indicating the total check sum of the entire area written. When retrieving the information, only the unit and block number need be specified, as the control words on the tape will indicate the starting address and length of the information in memory. A check is made to guarantee that the block specified is actually the start of a storage area. Upon completion a message is typed which shows the starting and ending block numbers and the total check sum. This can be checked against the data typed during writing to insure that the correct information was read. Errors are fully analyzed and typed as in MICROTOG.

FUTURE TRENDS

As has been described, the Microtape system for the PDP-1 and PDP-4 is basically an 18-bit control operating in the program interrupt mode. Since the introduction of the PDP-5 and PDP-6 which are 12 and 36 bit computers respectively, much thought has been given to the desirability of making the tapes produced with the various systems compatible. Therefore it is expected that a control will be introduced in the future which will allow the assembling of variable length words which are a multiple of three bits. To achieve this flexibility certain changes will have to be made. For instance, the calculating and checking of the check sum will be done automatically, so that no difficulty arises in checking tapes produced on a machine with different word length. In addition the data will be placed on the tape in a slightly different manner so that the length of the word does not affect the order in which the bits are assembled.

PRESENT SYSTEM

Mark	1	1	1	0	0	0
Data	5	4	3	2	1	0
	11	10	9	8	7	6
	17	16	15	14	13	12

PROPOSED SYSTEM

1	1	1	0	0	0
0	3	6	9	12	15
1	4	7	10	13	16
2	5	8	11	14	17

Figure 7

Placement of Bits on Microtape

An Additional mode, "Write all Information Bits" will permit writing in the information channels of the control words of the block, allowing a simpler creation of the block format, and giving additional flexibility to the programmer.

Transfer of information will be in terms of full blocks; however, Data Flags will still be provided at each word so that in desired cases, the user can still address individual words of the block.

APPLICATIONS

It is of course, impossible for the writer to list all of the possible applications of the Microtape system. There are certain characteristics of the system, however, which make it particularly suitable for certain applications, and these will be covered briefly. As Microtape is used in the field, additional applications will most certainly suggest themselves and will be reported on.

The first application is simply as a storage device for programs and data. Since the tape handling is extremely simple, it is easy, and in fact, desirable to store the programs one needs on Microtape, and simply carry it to the computer for use when needed. To carry the same amount of data on either cards or paper tape would be unwieldy to say the least. Different library tapes can be changed easily if necessary, and retrieval of any portion of the tape is relatively fast. If modifications to the programs are necessary, the tape need not be either re-written entirely to preserve the order, or added to at the end. The program can be read in, modified, and re-written in the same location on the tape, providing its block length is not changed. This indicates also that many programs can be written utilizing a minimum number of drives.

On an on-line system, use of individual Microtapes to store information keyed in by individual users provides a fairly cheap and efficient way of handling data. The ability to multi-program during searching (which requires by far, the greatest amount of time) means that more than one individual can have access to the computer without appreciably affecting internal processing, and without causing an inordinate amount of waiting time for the user. An extension of this is discussed in the next application.

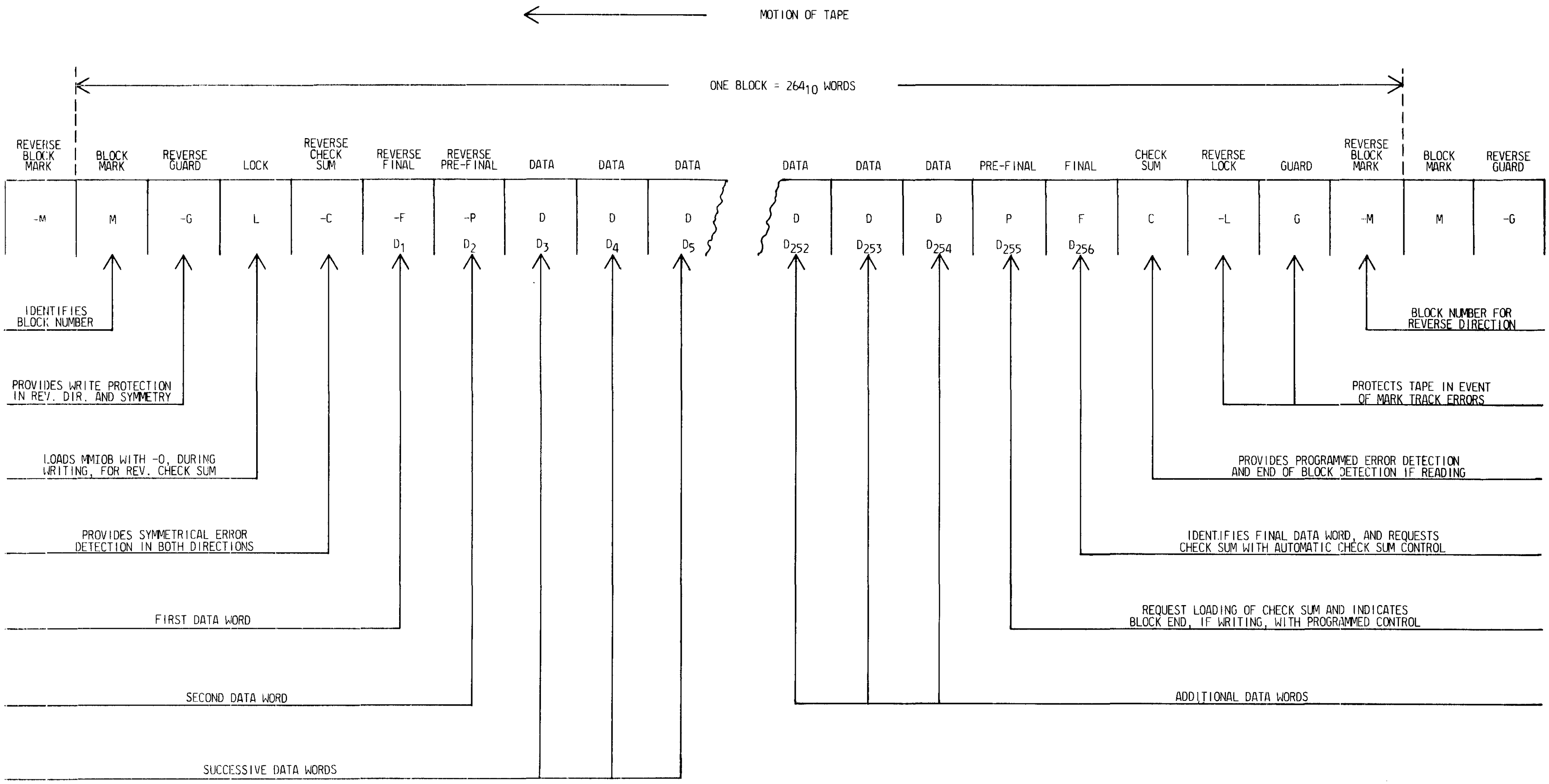
Since the Microtape reel is fairly small, and the system can read or write in both directions, random access to any point on the reel is relatively fast. A fairly large amount of data can be stored however and for example, one tape can hold more than 22 complete 4K memories. In a real-time, multiple-user, random access system, many tapes can be moving simultaneously even though data can be transferred on any one tape at a time. For example, let us imagine a system with several remote teletypes, each requiring random access to information stored on several Microtapes. When the first request occurs, the program can place the appropriate tape in Search mode and begin searching for the block. If another request occurs, the program can note the approximate position of the first tape in relation to the block requested, select the new tape (leaving the old tape moving) and start searching for the new block. A programmed clocking device or timing loop can be used to determine when to re-select the first tape, check for the correct block, and transfer the data. As new inquiries enter the system, a queue can be formed with the request for the nearest information and the time needed to reach it, at the top of the queue. As information is found, the clock is reset to the time necessary to reach the next request and so on. In this way, multiple requests for information on a single tape can be fairly easily handled, if both records can be found by searching in the same direction. There will be times, of course, when data will be reached on more than one tape simultaneously. In this case the tape searching for the later request can either be stopped before the record is reached, or can be turned around if the record has been bypassed. In terms of overall time to the user, very little difference will be noticed. Of course if two separate Microtape controls are used, data can actually be transferred on more than one tape simultaneously, providing the program is fast enough to react to the various flags.

A third type of application involves the continuous movement of the tape. There are many instances when it is desirable to store sampled data on a tape for future analysis by other programs. Memory fills up rapidly however, and during the time information is transferred onto the tape, sampling is usually stopped to avoid synchronization problems. Thus the information stored usually consists of data relating to many relatively short samples. With Microtape, one whole tape can be written with one command and therefore, an extremely long sample of fairly rapid data can be achieved. If desired the entire tape can be considered as one long block of information. Storing of information from an analog-digital converter, would be a logical use of such a system.

Some thought has been given to the question of sorting and merging using Microtapes. Though all of the problems have not yet been worked out, it appears that the continuous motion of the tape, and the ability to read and write in both directions, may make certain types of sorting very efficient. For example, in an unbalanced polyphase sort, one could continuously store information on every third or fourth block on the tape in both directions. Depending on the final position of the tape, some rewinding would have to be done to re-read the information for the next pass. However, once the information has been read, new data can be stored beginning with the current position of the tape. The tape then theoretically becomes an endless loop, and rewind time is reduced appreciably. Depending on the speed of the program, if the tape can remain moving continuously except for turn-around time, there need not be any start-stop time delays from the tape unit. It is obvious however that the relatively small size of the reels would limit the amount of data which could be sorted, and the programming necessary to compensate for the normal roll of the tape, may also become prohibitive.

MICROTAPE MARK TRACK FORMAT

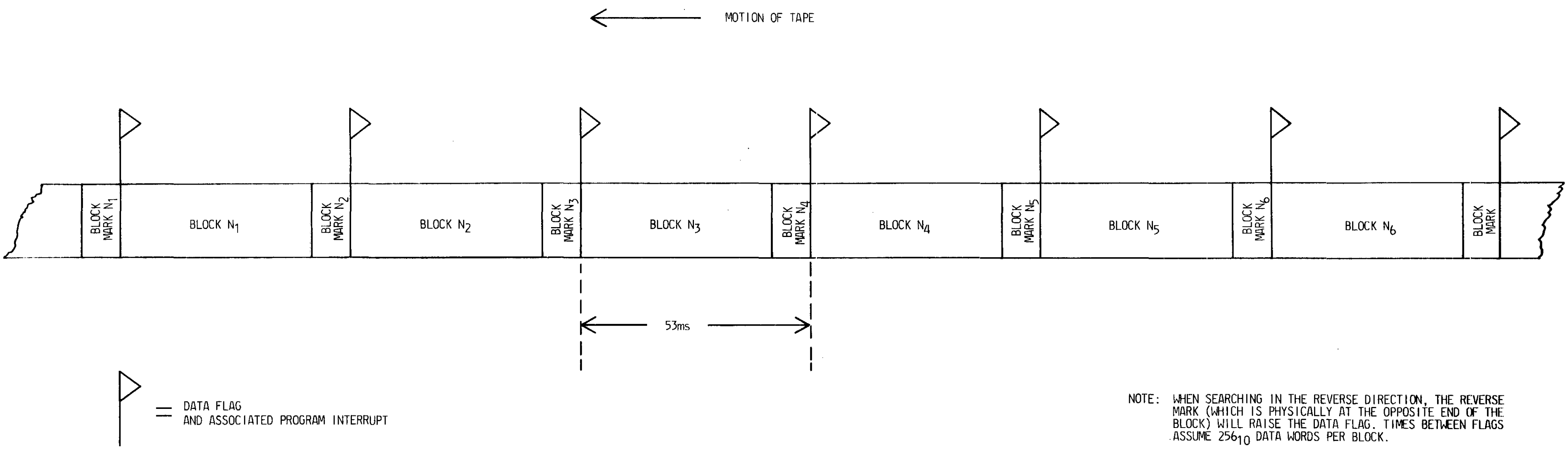
(ASSUMES 256_{10} DATA WORDS PER BLOCK)



NOTE: END MARKS WHICH IDENTIFY THE PHYSICAL ENDS OF THE TAPE, ARE THE ONLY MARKS NOT SHOWN.

FIGURE 2

FLAG RAISING, SEARCH MODE



NOTE: WHEN SEARCHING IN THE REVERSE DIRECTION, THE REVERSE MARK (WHICH IS PHYSICALLY AT THE OPPOSITE END OF THE BLOCK) WILL RAISE THE DATA FLAG. TIMES BETWEEN FLAGS ASSUME 256_{10} DATA WORDS PER BLOCK.

FIGURE 3

FLAG RAISING—READ MODE

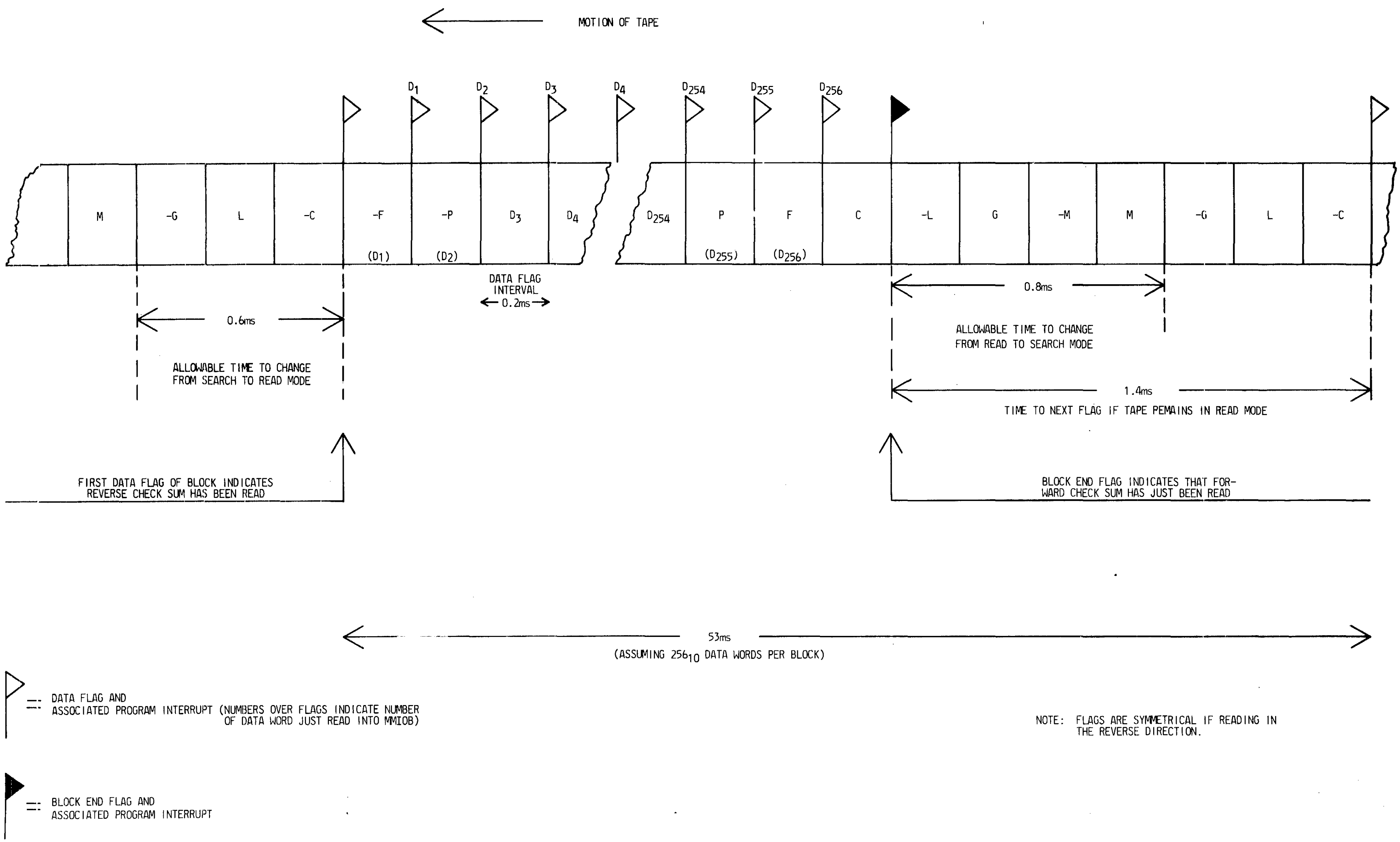
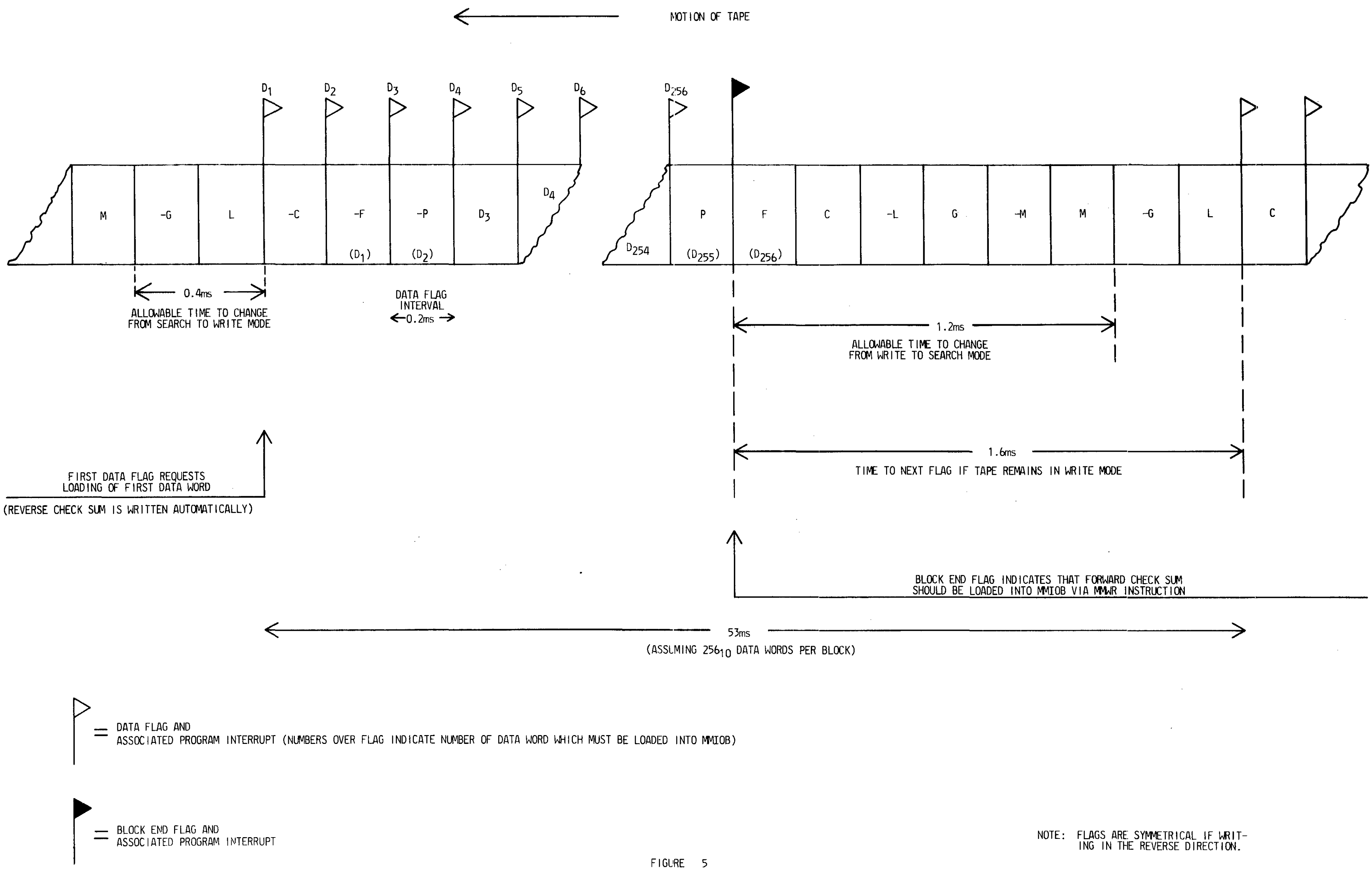


FIGURE 4

FLAG RAISING-WRITE MODE



NOTE: FLAGS ARE SYMMETRICAL IF WRITING IN THE REVERSE DIRECTION.

FIGURE 5

MARK AND INFORMATION TRACK BIT FORMAT

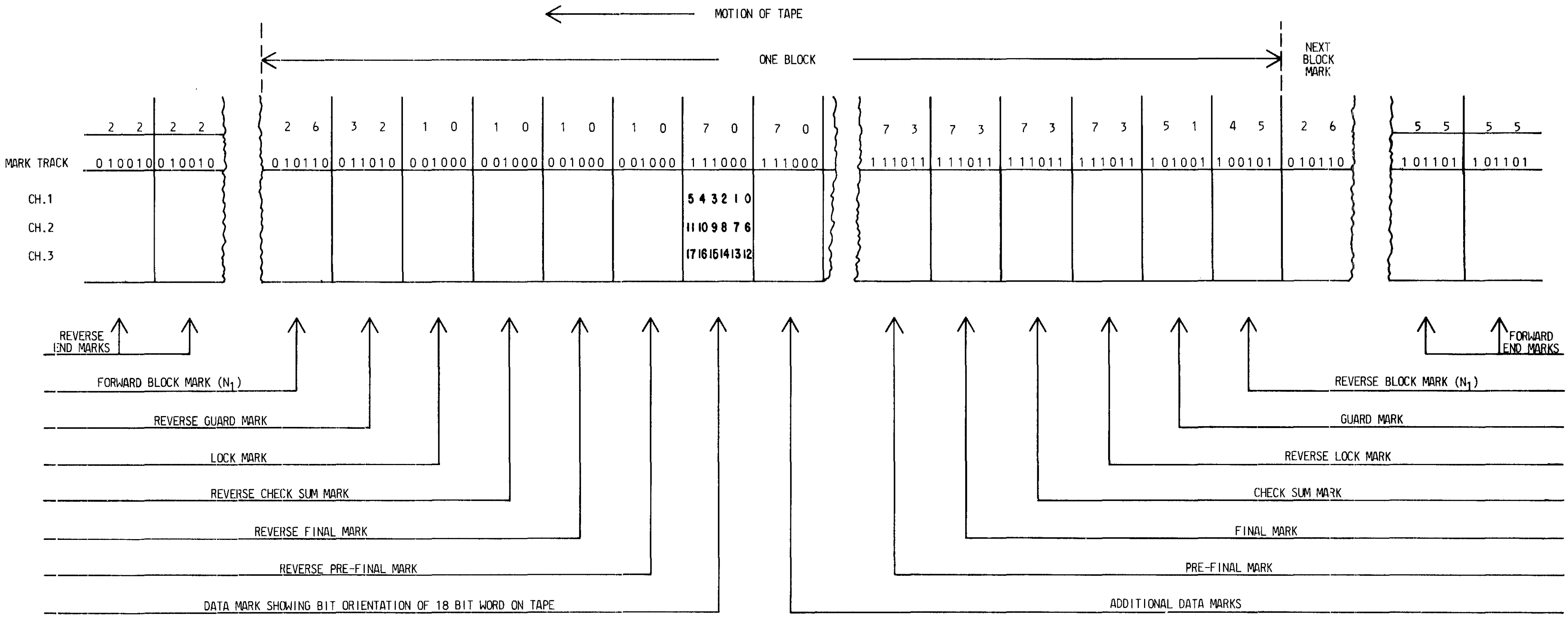


FIGURE 6

APPENDIX A

MICROTAPE INSTRUCTION LIST

PDP-1 Mnemonic	PDP-1 Binary	PDP-4 Mnemonic	PDP-4 Binary	Function
MRD	720501	MMRD	707512	READ. Clears IO or AC and transfers one word from MMIOB to bits 0-17 of IO (PDP-1) or AC PDP-4)
MWR	720601	MMWR	707504	WRITE. Transfers one word from bits 0-17 of IO (PDP-1) or AC (PDP-4) to MMIOB.
MSE	720301	MMSE	707644	SELECT. Connects the unit designated in bits 2-5 of the IO (PDP-1) or AC (PDP-4) to the Microtape Control
MLC	720401	MMLC	707604	LOAD CONTROL. Sets the Microtape Control to the proper mode and direction from bits 12-17 of the IO (PDP-1) or AC (PDP-4), as follows:

Bit 12 = Connect (Go)
Bit 13 = Reverse
Bit 14 = Spare
Bits 15-17 = Mode:

- 0 = Move
- 1 = Search
- 2 = Read
- 3 = Write
- 4 = Spare
- *5 = Read through block ends
- *6 = Write through block ends
- 7 = Write timing and mark track

i.e. 42 = Read Forward
62 = Read Reverse
43 = Write Forward
41 = Search Forward
61 = Search Reverse

*Not presently connected

MICROTAPE INSTRUCTION LIST (CONTINUED)

PDP-1 Mnemonic	PDP-1 Binary	PDP-4 Mnemonic	PDP-4 Binary	Function
MRS	720701	MMRS	707612	READ STATUS. Clears the IO or AC and transfers the Microtape status conditions into bits 0-8 of the IO (PDP-1) or AC (PDP-4) as follows: Bit 0 = Data Flag Bit 1 = Block End Flag Bit 2 = Error Flag Bit 3 = End of Tape Bit 4 = Timing Error Bit 5 = Reverse Bit 6 = Go Bit 7 = Mark Track Error Bit 8 = Tape Unable
		MMDF	707501	Skip on Microtape Data Flag In Search Mode: Block mark number should be unloaded via (M) MRD instruction In Read Mode: Data or Reverse Check Sum should be unloaded via (M) MRD instruction In Write Mode: Data should be loaded via (M) MWR instruction
		MMBF	707601	Skip on Microtape Block End Flag In Read Mode: Unload forward Check Sum via (M) MRD instruction In Write Mode: Load calculated forward Check Sum via (M) MWR instruction
		MMEF	707541	Skip on Microtape Error Flag Timing Error, Mark Track Error, End of Tape, or Tape Unable Condition has occurred. Use (M) MRS instruction to detect specific error.

NOTE: MMSE and MMLC clear the Error Flag and MMSE, MMLC, MMRD, and MMWR clear the Data and Block End Flags.

APPENDIX B

MICROTAPE OPERATION CHART (PDP-4)

FLAG	MOVE MODE	SEARCH MODE
Data Flag cleared on mmrd mmwr mmlc mmse This flag causes interrupt	No Data Flags raised. Tape motion is continuous until End marks are sensed at far end of tape.	Data Flag means that the MMIOB contains a Block Number. Write mode may be specified within 400 microseconds to transfer the block. Read mode may be specified within 600 microseconds.* Any other mode (including Stop), may be commanded at any time. Transfer of Block Number must be completed in 53 milliseconds to avoid a MISS.**
Block Flag cleared on mmrd mmwr mmlc mmse This flag causes interrupt	Should not occur	Should not occur
Error Flag cleared on mmse mmlc (also clears MISS, END, MTE) This flag causes interrupt.	Error Flag means that an error has occurred. An mmrs command will load AC bits 0-8 with status information. (END is only possible error.) END Status bit is set when tape reaches far end. Error Flag is raised. Tape stops.	Error Flag means that an error has occurred. An mmrs command will load AC bits 0-8 with status information. (END, and MISS are only possible errors.) End status bit is set when tape reaches far end. Error Flag is raised. Tape Stops. MISS Status bit is set when a Data or Block Flag has not been cleared from previous use.

* All times are nominal for forward direction. In reverse direction add ± 20%.

** MISS indicates a programmed timing error; i.e., information will be lost (missed) because the routine is taking too long to transfer data to or from the buffer.

APPENDIX B

MICROTAPE OPERATION CHART (PDP-4)

FLAG	READ MODE	WRITE MODE
Data Flag cleared on mmrd mmwr mmlc mmse This flag causes interrupt.	Data Flag means that MMIOB contains a data word. An mmrd must be given within 200 microseconds for data transfer. First Data Flag in block indicates Reverse Check Sum. Change to other modes possible within 200 microseconds. If Write mode is desired, a one word delay occurs after mmwr is given.	Data Flag means that MMIOB is ready for Data word. An mmwr must be given within 200 microseconds for data transfer. Initial (-0) Check Sum is written automatically. First flag in block is a request for first Data word. Change of mode possible within 200 microseconds. Since tape system is bidirectional the initial Check Sum written may be placed at either Forward or Reverse Check Sum location in block, depending only on direction commanded.
Block Flag cleared on mmrd mmwr mmlc mmse This flag causes Interrupt.	Block Flag means that Check Sum is in MMIOB. First Data Flag of next block will automatically occur in 1.4 milliseconds. Change to Search mode must be made in next 800 microseconds in order to catch next mark. Change to Write mode must be made within next 1.2 milliseconds in order to start new block (not recommended - Block Number should be checked by Search Mode).	Block Flag means that Check Sum should be loaded into MMIOB with an mmwr. First Data Flag of next block will occur in 1.6 milliseconds. Change of mode commanded at last Data word (D_{256}) is delayed while Check Sum is written. Change to Search mode must be made within 1.2 milliseconds to read next Block Number. Preferred method of stopping is to change to Search mode, then check succeeding Block Number for correctness before stopping.
Error Flag cleared on mmse mmlc (also clears MISS, END, MTE) This Flag causes interrupt.	Error Flag means that an error has occurred. An mmrs command will load AC bits 0-8 with status information. (END, MISS, Mark Track Error (MTE) are only possible errors.) END status bit is set when tape reaches far end. Error Flag is raised. Tape stops. MISS status bit is set when a Data or Block Flag has not been cleared from previous use. Mark Track Error (MTE) Status bit is set upon discovery of certain Mark Track and timing track Errors.	

APPENDIX C

PRELIMINARY SPECIFICATIONS

TAPE AND REEL	260 feet of 3/4 inch tape on a 3 1/2 inch reel. Tape is 1.0 mil Mylar.
WORD TRANSFER RATE	One 18-bit word each 200 (±10) microseconds. Bit rate is constant when moving forward. Although velocity varies slightly, bit density changes serve to maintain a constant bit rate due to the constant rate timing track. In reverse direction the variation in time between words becomes ± 20% depending on location along the tape.
SPEED	Varies according to reel diameter from 70-80 ips.
DENSITY	375 (±60), 3-bit characters per inch. 3 million bits per reel.
START TIME	Less than 0.2 seconds.
STOP TIME	Less than 0.15 seconds.
TURN AROUND TIME	Less than 0.3 seconds.
START AND STOP DISTANCE	Less than 8 inches.
ACCELERATION	700 (± 150) inches per second per second
COMMAND SIGNALS	Contact closures: Select, Go, Reverse, and a 10-wire Select Buss. One Two-wire write interlock loop. Two connector plugs wired in parallel for easy bussing.
INFORMATION SIGNALS	5 shielded triplets. 5 millivolt p-p normal read signal over 30 feet of cable. 120 ma nominal write current. Phase or Manchester recording used with reference to timing track zero crossing for read and write timing.
POWER REQUIREMENTS	110 to 120 volts, 60 cps, 400 watts maximum.
WEIGHT OF TRANSPORT	65 pounds.
DIMENSIONS OF DUAL TRANSPORT	19 inches wide, 16 inches deep, 11 inches high. 1 3/4 inch switch panel. Mounts in 19 inch standard rack.