Xerox 9-Track Magnetic Tape System

Models 7320/7322/7323

Reference Manual

90 09 77C

MAGNETIC TAPE ORDER CODES

Code (Hexadecimal)	Function
01	Write Data
02	Read Forward
03	Set Correction
04	Sense
0C	Read Backward
13	Rewind and Interrupt
23	Rewind Off-line
33	Rewind On-line
43	Space Record Forward
4B	Space Record Backward
53	Space File Forward
5B	Space File Backward
63	Set Erase
73	Write Tape Mark

XEROX

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Reference Manual

90 09 77C

November 1970

File No.: 1X03

Printed in U.S.A.

REVISION

This publication, 90 09 77C, is a revision of the Xerox Sigma 9-Track Magnetic Tape System Reference Manual, 90 09 77B. Changes to the previous manual are indicated by a vertical line in the margin of the affected page.

RELATED PUBLICATIONS

Title	Publication No.
Xerox Sigma 2 Computer/Reference Manual	90 09 64
Xerox Sigma 3 Computer/Reference Manual	90 15 92
Xerox Sigma 5 Computer/Reference Manual	90 09 59
Xerox Sigma 6 Computer/Reference Manual	90 17 13
Xerox Sigma 7 Computer/Reference Manual	90 09 50
Xerox Sigma 8 Computer/Reference Manual	90 17 49
Xerox Sigma 9 Computer/Reference Manual	90 17 33
Xerox Symbol/LN, OPS Reference Manual (Xerox 32-bit Computers)	90 17 90
Xerox Symbol/LN, OPS Reference Manual (Xerox 16-bit Computers)	90 10 51
Xerox Extended Symbol/LN, OPS Reference Manual (Xerox 16-bit Computers)	90 10 52
Xerox Meta-Symbol/LN, OPS Reference Manual	90 09 52
Xerox Macro-Symbol/LN, OPS Reference Manual	90 15 78

Manual Content Codes: BP - batch processing, LN - language, OPS - operations, RP - remote processing, RT - real-time, SM - system management, TS - time-sharing, UT - utilities.

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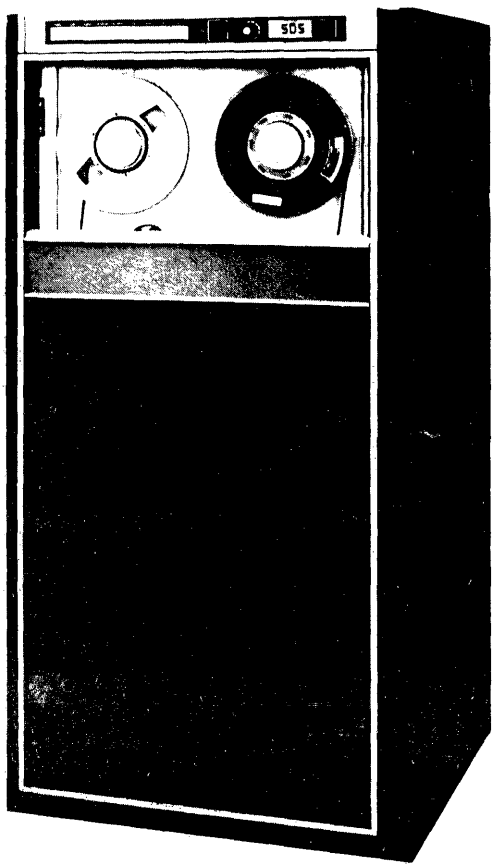
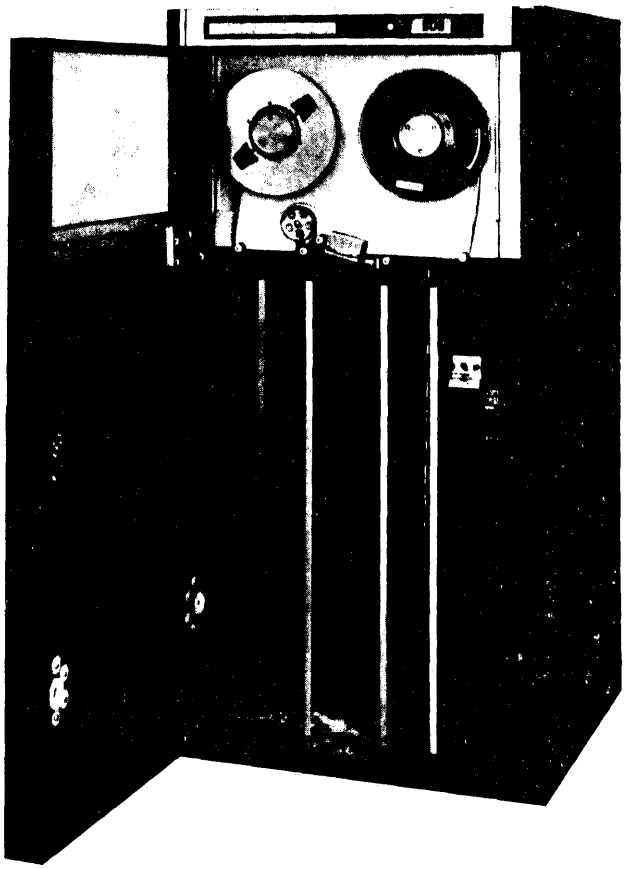


Model 7320 Controller and 7322 or 7323 Tape Transport



Tape Transport Interior View

1. GENERAL DESCRIPTION

INTRODUCTION

XDS 9-Track Magnetic Tape Systems provide medium and high speed input/output facilities for SDS Sigma computers. Data is read and written in IBM-compatible tape format at 800 bits per inch. A single capstan controls tape motion, eliminating the tape wear and dynamic skewing associated with pinch roller mechanisms. For maximum tape life, air-bearing tape guides assure that only the read/write head touches the recording surface.

Tape-handling is faster than on other systems because of the patented XDS POPO (Push-On-Pull-Off) tape hubs, simplified tape-threading path, and automatic loading sequence. The POPO design facilitates mounting and removing tape reels. A single, pushing motion places the reel on the hub and locks it in place; a single, pulling motion unlocks and removes the reel.

Immediate error detection is provided automatically by three independent (parity) checks on each record: a vertical redundancy check, a cyclic redundancy check, and a longitudinal redundancy check.

A write-protect feature prevents inadvertent destruction of data on tape files. Removal of a write-enable ring from the back of the tape reel prevents all writing operations. "Deskewing" is digitally controlled and requires no adjustment unless the read/write head is changed.

Tape units may be used for system program storage, for inputs to sorts and merges, for large data processing files, or for service as scratch or working tapes. Several tape-positioning operations are provided. Tapes can be moved forward or backward one record as well as forward and backward one file. Furthermore, tapes may be read or written while other units on the same controller are rewinding.

A device interrupt is transmitted from any tape unit to the I/O system when the unit has stopped rewinding, indicating that it is again available. When placing a new unit on-line in the system, the operator can cause the unit to generate an interrupt, notifying the controlling program that the unit is available for operation.

As information is written on tape (moving in the forward direction) the controller generates checking information that is recorded at the end of the record. Records may then be read in either the forward or reverse direction and error detection may occur. If a single track error is detected, it can be corrected by reading the record once more in a correcting mode.

An XDS Sigma 9-Track Magnetic Tape System consists of one Model 7320 Controller plus one to eight Model 7322 (75 inches per second) or 7323 (150 inches per second) transports which can be intermixed in any combination. The controller and one tape transport are in the same cabinet; additional transports are in separate cabinets.

To use this manual effectively, the reader should be familiar with the XDS Sigma Computer Reference Manual applicable to his installation, particularly the input/output instructions and operations sections.

Table 1. Characteristics

Operating Characteristics (Models 7320/7322)	
Tape speed	75 inches per second
Start/stop time	5 msec
Rewind speed	250 inches per second (less than 2 min for a 2400 ft tape)
Information transfer rate	60,000 bytes per second (1 byte transfer = 16.7 μsec)
Reel hubs	XDS POPO (Push-On-Pull-Off) reel hub standard; accommodates IBM-type, 10.5 in. reels with write-enable ring
Extremity sensing	Photoelectric sensing of both beginning and end of tape
Tape	0.5 inch wide, 2400 feet long, 1.5 mil thick Mylar base
Recording method	NRZ1 (nonreturn to zero, change on ones)
Recording format	9 channels (8 bits plus parity), binary
Recording density	800 bits per inch
Interrecord gap	0.60 in. + 0.15, -0.10
Operating Characteristics (Models 7320/7323)	
Tape speed	150 inches per second
Start/stop time	3 msec
Rewind speed	450 inches per second (approximately 1 min for a 2400 ft tape)
Information transfer rate	120,000 bytes per second (1 byte transfer = 8.33 μsec)
Note: Other operating characteristics are the same as Models 7320/7322.	

Table 1. Characteristics (cont.)

Physical Dimensions (Model 7322 or 7323)	
Cabinet dimensions	
Height	63.5 in.
Width	29.25 in.
Depth	35 in.
Weight	
Master unit (transport plus controller)	Approximately 1,050 lbs
Additional transports	Approximately 980 lbs

Table 1. Characteristics (cont.)

Environmental Conditions	
Power Requirements	
Model 7322	117 vac ± 10%, 25 amps max, 60 Hz ± 10%, single-phase, 3-wire
Model 7323	208 vac ± 10%, 25 amps max, 60 Hz ± 10%, 3-phase, 4-wire
Operating temperature	50° to 90° F
Relative humidity	5% to 80% (no condensation)

2. FUNCTIONAL DESCRIPTION

DATA REPRESENTATION

Records are written on tape in byte sequence. The eight bits of each byte correspond to the eight channels of data on a tape. An odd parity bit is developed by the controller and written in the ninth channel. Figure 1 shows how information in memory is represented on a tape; Figure 2 shows physical spacing of the elements on a tape.

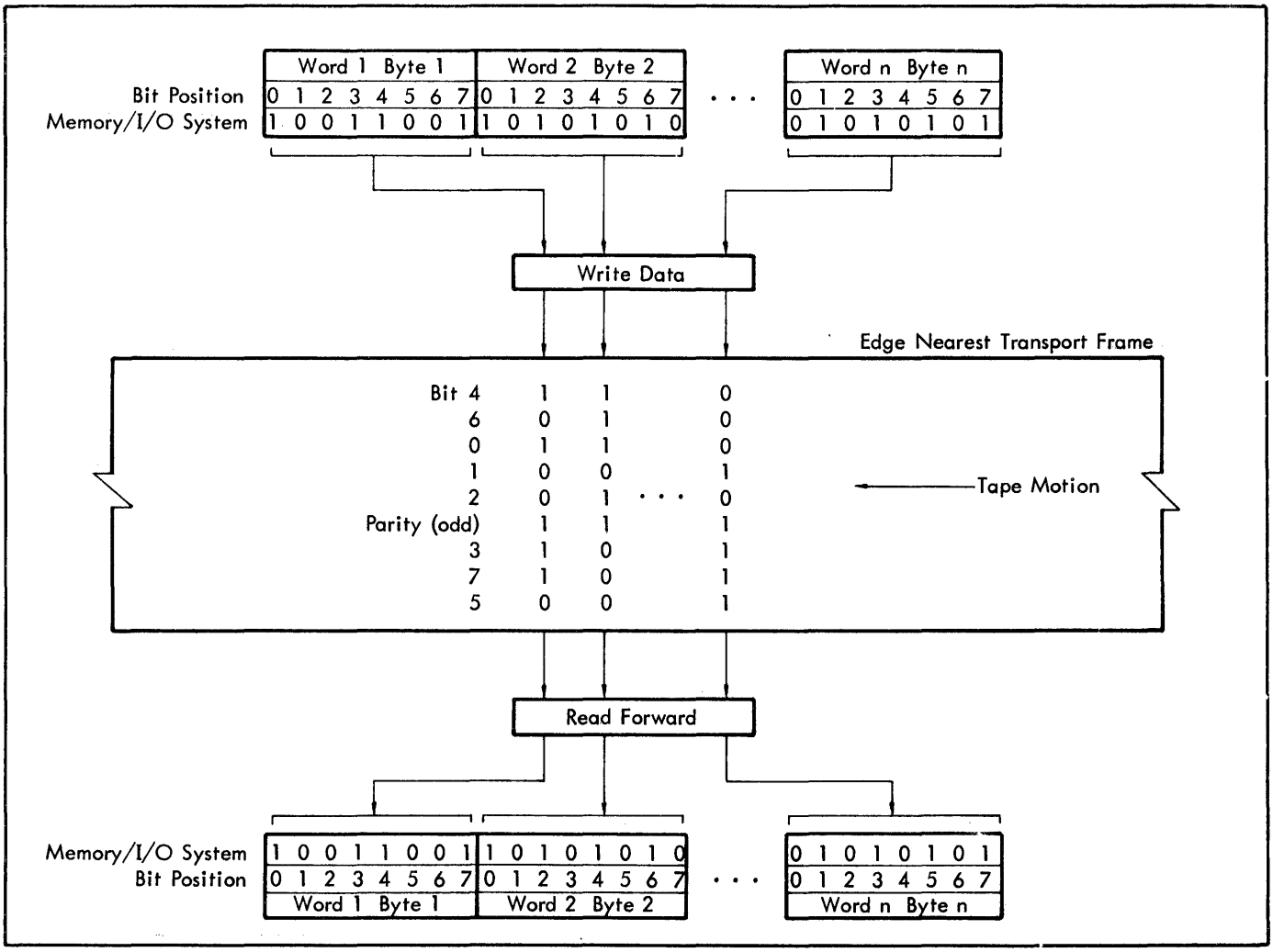


Figure 1. Data Representation on Tape

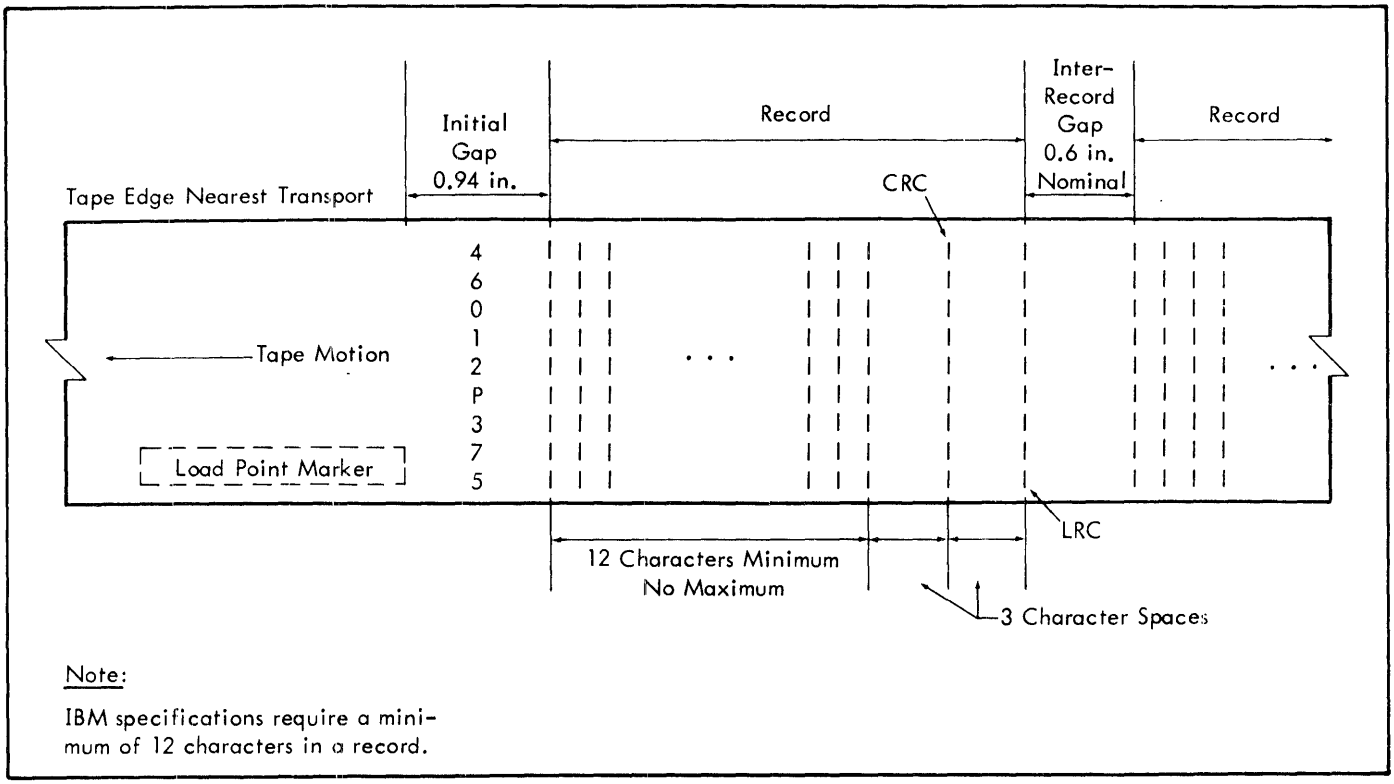


Figure 2. Physical Spacing on Tape

Data is transmitted between the I/O system and the tape unit without translation. Except for the vertical parity bit and the CRC and LRC characters, data is written on tape in byte sequence exactly as it appears in memory; conversely, data is read into memory just as it appears on tape.

The Write Data order causes the I/O system to access the address of the first byte in memory from which data is to be written. Similarly, the Read Forward order causes the I/O system to access the address of the first byte in memory into which data from tape is to be read. The Read Backward order on a Sigma 5/6/7/9 system, however, must access the address of the last byte in memory into which data from tape is to be read, because bytes are stored in memory in a descending address sequence. This procedure causes the data to be placed in memory in the same relative positions as it would be with the Read Forward order. The required address must be program-derived by adding the number of bytes to be transmitted minus one to the address of the first byte in memory that constitutes the beginning of the data area.

The Sigma 2/3 I/O system does not decrement memory addresses. For a Read Backward order on a Sigma 2/3 system, therefore, data is transmitted into memory in an ascending address sequence. The data thus appears in memory in reverse order.

CRC AND LRC CHARACTERS

As data bytes from memory are written on tape, the controller develops two check characters, a cyclic redundancy check (CRC) and a longitudinal redundancy check (LRC) character. These characters are written on tape following the data record, the CRC character being written first.

The CRC character is generated from the data bytes; it is used in the correction of single track errors. It also ensures that the LRC character is non-zero. During a Read or Read Backward operation, the CRC character is again generated from the data read and is compared with the written CRC character. The CRC check is not made during the automatic read-after-write performed during writing operations.

During writing, the parity of each track is automatically determined, up to and including the CRC character, and the LRC character is then generated to make the parity of the track even over the entire record. An LRC character is generated in the same manner during a read-after-write, Read, or Read Backward operation, and is compared with the written LRC character.

TAPE DRIVE STATES

The initial state of the tape unit depends on its power status. Complete absence of power (that is, of its prime ac power and system dc power) effectively removes the device from the system. In this state, any attempt to address the tape unit results in a response of "no input/output address recognition" to the I/O instruction, and no other status information is supplied in response to the I/O instruction.

OPERATIONAL STATES

In the absence of ac power, presence of system dc power will enable I/O address recognition, but the tape unit assumes a "not operational" state. Also, failure of internal power supply causes the device to assume a "not operational" state.

The current operational status of the addressed tape unit and its controller may be determined by examining the status response to one of the instructions, START INPUT/OUTPUT (SIO), HALT INPUT/OUTPUT (HIO), and TEST INPUT/OUTPUT (TIO). Other I/O instructions, TEST DEVICE (TDV) and ACKNOWLEDGE INPUT/OUTPUT INTERRUPT (AIO), provide additional detailed status indications (see Chapter 3, "Tape Unit Status Response").

CONDITIONS AND MODES

I/O Address Recognition. This condition exists unless device power is off, the UNIT SELECT switch on the tape console is in the OFF position, or the device address used for the I/O instruction is not recognized in the I/O system.

Device Operational. A tape unit is operational if all vacuum and interlock requirements are met. A "not operational" condition exists if the vacuum falls too low, the window or door is opened, or the tape goes off the reel or breaks.

Device Ready. A tape unit may be in either one of two conditions, "ready" or "busy". It is "busy" if it has accepted an order from the tape controller. It will not accept a new order until the current order, or chain of orders, has been completed and no device interrupt is pending. A tape unit may be "busy" while the tape controller is "ready" (since up to eight units can be connected to one controller). A tape unit is "ready" if it is "operational", "not busy", and can accept an order from the controller. It may be either in the "manual" or "automatic" mode and still be considered "ready".

Device Controller Ready. The device controller may be in either one of two conditions, "ready" or "busy". It is "busy" if an SIO instruction has been accepted, but the order has not been processed because of some condition within the addressed device. After the device is started, and conditions permit another SIO instruction to be accepted, the device controller becomes "ready".

Automatic and Manual Modes. After all other conditions are satisfied for a successful tape operation and the START switch on the tape console is pressed, a tape unit is in the "automatic" mode.

A tape unit is in the "manual" mode when the RESET switch on the tape console is pressed or if a "not operational" condition arises. The tape order, Rewind Off-line, also puts the unit in the "manual" mode. When the controller is in the "ready" condition, it can accept an SIO instruction and advance to the "busy" condition even if it is in the "manual" mode. No data transfer occurs, however, until the unit enters the "automatic" mode.

TRANSITIONS BETWEEN STATES

Table 2 summarizes the allowable state transitions and the conditions that cause them.

DATA TRANSFER

This tape device uses only one mode of data transfer; it is a direct memory-to-tape or tape-to-memory data transfer in the format shown in the preceding section, "Data Representation". The command doublewords for the Read and Write orders specify the address in memory as well as the number of bytes to be transferred. For Sigma 5/6/7/9 an incomplete word may be transferred as the last word in the record. The I/O system handles accessing of memory addresses and transfer into and out of memory (see programming example for further description of the orientation of the command doublewords for typical tape orders).

For a Write Data order, data is transmitted from memory onto tape until the byte count is decremented to zero. The proper tape gap is developed before and after the recording of data. "Channel end" is sent when the end-of-record gap is encountered. For a Read order, the data transfer ends when either the "count done" signal is detected or the end-of-record gap is sensed on tape.

An "incorrect length" response results if both the "count done" signal and end-of-record indication are not sensed together at the termination of the order. Parity checking is performed by the device controller. For a Read order, parity checking on the data being read in takes place during data transfer. For a Write order (including Write Tape Mark) parity checking on the data being written is performed by an automatic read-after-write sequence. A parity error will set the Transmission Data Error indicator.

Table 2. Magnetic Tape Controller State Transitions

Present State \ Next State	Not Operational	Ready Manual	Busy Manual	Ready Automatic	Busy Automatic
Not Operational	———	Fault condition cleared	Not possible	Not possible	Not possible
Ready Manual	Fault condition encountered	———	SIO accepted	START switch operated and no fault condition exists	Not possible
Busy Manual	Fault condition encountered	I/O reset signal, or HIO instruction, or device RESET switch operated	———	Not possible	START switch operated and no fault condition exists
Ready Automatic	Fault condition encountered	Device RESET switch operated, or manual intervention required	Not possible	———	SIO accepted
Busy Automatic	Fault condition encountered	Device RESET switch operated	Rewind Off-line order executed	Operation completed and manual intervention required, or HIO, or I/O reset signal	———

3. PROGRAM INTERFACE

MAGNETIC TAPE ORDERS

There are 14 orders that specify tape unit operations. If an invalid order is used, it is not interpreted as an error. The device may, however, attempt to substitute a read operation for an invalid order. Additional effects of certain orders are outlined in the following sections, "Unusual End Conditions" and "Tape Unit Status Response".

READ ORDERS

Read Orders	Hexadecimal Code
Read Forward	02
Read Backward	0C

Tape can be read in the forward or reverse direction. When the tape unit receives a Read order, it starts either forward or reverse tape motion, as specified by the order. Information is transferred into ascending memory locations as a series of 8-bit bytes. The Read Backward order transmits bytes into descending memory locations.[†] Reading continues until the interrecord gap is detected or the byte count is equal to zero; that is, until the entire record has been read, including the redundancy check characters. This applies to "tape mark" records, also, although no data is transmitted. If there is no further order pending, the tape comes to a stop with the read/write heads located in the interrecord gap.

Both an internal cyclic redundancy check (CRC) and a longitudinal redundancy check (LRC) character are developed while reading from tape. The resulting check characters are compared with those written on the tape. If the check characters do not match, the Transmission Data Error indicator is set. If an error occurs in more than a single track, the error is termed a "noncorrectable read error". For single track errors, an error byte is created and used in a correction read sequence (see Sense and Set Correction Orders").

WRITE ORDERS

Write Orders	Hexadecimal Code
Write Data	01
Write Tape Mark	73

There are two Write orders. The Write Data order is used for a normal data record; the Write Tape Mark order is used to write the standard tape mark or End-of-File record.

When the tape unit receives the Write Data order, it starts forward tape motion. A 9-bit character (8 bits plus parity) is written for every byte received from the computer. Tape motion and writing continue until the desired number of characters, determined when the byte count reaches zero, has been recorded. A minimum of 12 bytes per record is suggested for reliability and compatibility with other equipment.

As the bytes are transmitted, the tape controller develops two check characters, a cyclic redundancy check (CRC) and a longitudinal redundancy check (LRC) character. These two characters are written on tape (CRC, then LRC) following the data record. Also during the write operation, a read-after-write process takes place, reading each data byte just written and checking its parity. During this reading process, another LRC character is generated and compared with the LRC character written on tape. A mismatch between the two LRC characters or a parity error detection results in setting the Transmission Data Error indicator.

The Write Tape Mark order does not require a byte count. The Tape Mark is a standard End-of-File record consisting of a 3-1/2 inch gap, followed by one byte (X'13'), followed by a longitudinal check character (LRC) only (no CRC character) and is automatically written. The End-of-File indicator is set following the Write Tape Mark order. If no further orders are received after the unit has read the LRC character, the tape comes to a stop.

The only normal means for preventing a write operation is by removing the write-enable ring from the tape reel. The device then will be in the "write-protect" mode and the FILE PROTECT indicator on the tape console will be illuminated. An accidental write cannot occur in this mode (see "Unusual End Conditions").

SPACE ORDERS

Space Orders	Hexadecimal Code
Space Record Forward	43
Space Record Backward	4B
Space File Forward	53
Space File Backward	5B

Four orders permit spacing over a record or a file in either the forward or reverse direction. When the tape unit receives a Space Record order, it spaces forward (or reverse) over one record, as specified by the order. If no further order is received, the tape comes to a stop with the read/write heads located in the gap following (or preceding) the record spaced.

[†] For Sigma 2/3 computers, bytes are transmitted into ascending memory locations for both Read Forward and Read Backward. With the latter order, therefore, the bytes are in reverse sequence to that produced by a Read Forward.

When the tape unit receives a Space File order, it spaces forward (or reverse), as specified by the order, until a tape mark is encountered. The tape stops with the heads located in the gap following the tape mark. If no tape mark is encountered in the reverse direction, tape motion stops when the load point is encountered.

REWIND ORDERS

Rewind Orders	Hexadecimal Code
Rewind On-line	33
Rewind and Interrupt	13
Rewind Off-line	23

Three rewind orders permit different terminating functions. When the tape unit receives an X'33' Rewind order, it moves tape in the reverse direction, causing a device "busy" condition during the rewind. When the load point is encountered, the tape unit stops.

The X'13' Rewind and Interrupt order operates the same way as a Rewind order, except that an I/O device end interrupt is generated when the tape unit stops after reaching the load point.

The X'23' Rewind Off-line order parallels the Rewind order, except that it switches the tape unit to the "manual" mode after the rewind is started. The tape unit then requires operator intervention to be switched back on line. This order is used, for example, when the programmer has finished processing a reel of information and wants the reel changed before additional reading or writing takes place on that unit.

ERASE ORDER

Erase Order	Hexadecimal Code
Set Erase	63

When an Erase order is received, an indicator is set in the tape unit. There is no tape movement at this time; however, when the next Write order is received by the tape unit, approximately 3-1/2 inches of tape (which is standard for magnetic tape equipment) is erased preceding the record. If the next order received is other than a Write order, this indicator is immediately reset.

SENSE AND SET CORRECTION ORDERS

Sense and Set Correction Orders	Hexadecimal Code
Sense	04
Set Correction	03

A specific sequence of orders is provided for correcting data read from tape after a Read order has resulted in a transmission data error. If the Transmission Data Error indicator is set and the Noncorrectable Read Error indicator is reset, a correction can be effected. If more than one track caused the parity error, the Noncorrectable Read Error indicator will be set and the correction procedure outlined in this section will not be effective.

A vertical (byte) parity error causes the development of a track-in-error byte, containing one bit that corresponds to the track causing the parity error. Each additional parity error modifies this error byte. When the CRC character on tape is read, a shifting and comparison process takes place within the controller to match the CRC character with that developed during the read operation. Mismatches between the developed and the written CRC characters modify the error byte. If only one track caused the parity errors, the read errors are termed correctable and the track-in error byte, which is available through a Sense order, is valid.

The LRC character is then read from tape and compared with the one developed during the read operation. A mismatch between the two LRC characters, between the two CRC characters, or the detection of a vertical parity error results in setting the Transmission Data indicator.

The sequence of orders used to correct single track parity errors is: Sense, Set Correction, and Read (over the same record). For illustrative purposes, assume that a record has been read that produces a correctable parity error. This means that at least one byte in the record was in error and that only one channel caused the error. Note that all bytes in the record containing errors in the same track can be corrected in a single pass by the Sense-Set Correction-Read sequence explained below.

A Sense order extracts the error byte (from the controller) containing the bit corresponding to the track on tape in which the parity error occurred and stores it in memory.

A Set Correction order following the Sense order accesses the memory location containing the error byte. This byte is returned to the controller, which receives the signal that a correcting Read order will follow. (The orders are treated as data transfer orders; therefore, a byte count of one should be specified.)

A Read order, following the Set Correction order, reads the same record again, either in the opposite direction or by spacing over and repeating the previous Read order. As each byte is read, its parity is checked; if a parity error is detected, the bit corresponding to the indicated track-in-error is reversed and this corrected byte is transmitted to memory.

The usual CRC and LRC checks are repeated during this read-with-correction operation and a resulting error sets the Transmission Data Error indicator. The parity errors detected during the read-with-correction operation do not set any other indicators except the Noncorrectable Read Error indicator, which indicates that errors cannot be corrected. The indicator is therefore meaningless for this operation. An indicator in the controller, set by the Set Correction order, is reset if any order other than a Read follows the Set Correction order.

KEY EVENTS

The key events that occur during a magnetic tape operation are described in the following paragraphs. No chronological order should be assumed from the order of presentation.

START INPUT/OUTPUT

A tape operation is initiated with the execution of an SIO instruction by the controlling system. If I/O address recognition exists and the tape unit is in the "ready" condition with no interrupt pending, the controlling system sets its "I/O address recognition" and "SIO accepted" indicators. The tape unit then advances from the "ready" to the "busy" condition. It then requests an order byte from the controlling system and proceeds with the operation defined by the order byte.

CHANNEL END CONDITIONS

The tape unit signals "channel end" to the controlling system at the end of each order execution, except for any Rewind order (in which case "channel end" is signaled at the start of the order execution), and except under the following unusual conditions:

1. When order execution is terminated by an IOP error halt indication[†]
2. When a Read Backward, Space Record Backward, or Space File Backward order is given to a tape unit that is already positioned at the load point
3. When a Write or Write Tape Mark order is given to a tape unit that is write-protected

UNUSUAL END CONDITIONS

Detecting any of the following conditions causes the tape unit to return a device "unusual end" indication to the controlling system when the condition occurs:

1. Input/Output Processor (IOP) error halt.[†] The tape unit and controller return to the "ready" condition after reporting "unusual end" or after encountering an IOP halt.[†]
2. After an attempt to read forward or backward over a tape mark record
3. After a Space Record Forward/Reverse order causes the tape to move over a tape mark record
4. After a Read Backward or Space Record Backward order causes the tape to stop at load point
5. When a Write or Write Tape Mark order is given to a tape unit that is write-protected
6. When the tape unit switches to "manual" mode after tape motion is initiated (except for Rewind orders)
7. When the order bit configuration received by the controller is interpreted as a backward movement combined with a write operation
8. When a Read Backward, Space Record Backward, or Space File Backward order is given to a tape unit that is already positioned at the load point

[†] Not applicable to Sigma 2/3.

FAULT CONDITIONS

A fault condition is any condition that causes a peripheral device to switch to the "not operational" state. Absence or failure of ac or dc power at the device, or transport mechanism malfunctions resulting in a loss of proper vacuum are examples of fault conditions.

ERROR CONDITIONS

Several error conditions can be detected and reported to the controlling system, including: transmission data error, incorrect length, data overrun, write-protect violation and noncorrectable read error.

TRANSMISSION DATA ERROR

A transmission data error response is made at the end of a read or write operation if the device controller has detected a data overrun (see below) or data parity error or both. A data parity error may consist of a lateral or longitudinal parity error in both read and read-after-write, and also the cyclic redundancy check mismatch error during reading.

INCORRECT LENGTH

An incorrect length indication is reported to the controlling system after a read if "count done" is signaled before the entire record has been read, or if the entire record is read without sensing the "count done" signal. This indicator is also set after a read order resulting in an "unusual end" condition.

DATA OVERRUN

A data overrun (rate error) is defined as the failure of the controlling system to service the tape unit at the required data transfer rate.

WRITE-PROTECT VIOLATION

A write-protect violation error is reported to the controlling system if the last order received is a Write and the device selected is write-protected.

NONCORRECTABLE READ ERROR

A noncorrectable read error indication is reported to the controlling system if the last record read resulted in a transmission data error of the type that cannot be corrected by the Sense-Set Correction-Read sequence explained previously.

TAPE UNIT STATUS RESPONSE

The magnetic tape system can return various status flags to the controlling system in response to computer-executed instructions. Detailed explanations of the input/output instructions that request status of the tape unit are contained in the reference manuals for the Sigma computers.

The following paragraphs explain the significance of each status flag returned to the controlling system by the tape unit.

I/O INSTRUCTION STATUS BITS

The execution of an I/O instruction by the controlling system provides two bits of immediate information pertaining to the general status of the addressed I/O device and its controller. This information is retained by the controlling system in a form that allows for conditional branching based on the response to the I/O instruction. Table 3 lists the I/O instructions, the possible status bit settings provided by each I/O instruction, and the significance of each setting.

DEVICE STATUS BYTE

Eight bits of information are made available to the computer in the Device Status Byte in response to the execution of an I/O instruction, as shown in Tables 4, 5, and 6.

OPERATIONAL STATUS BYTE

In addition to the information contained in the Device Status Byte, the Operational Status Byte generated at the end of each I/O operation also provides indicators to the controlling system (see Table 7).

PROGRAMMING CONSIDERATIONS

SEQUENCE OF ACTIVITY

Figure 3 illustrates the sequential relationship of the key events that occur during a magnetic tape operation.

PROGRAMMING RESTRICTION

XDS magnetic tape units are subject to the following programming restriction: Writing should not take place after a backward tape movement unless that movement positions the tape at the load point.

Table 3. Magnetic Tape Unit I/O Instruction Execution Response

Instruction	Status Bits† CC1 or O	Status Bits† CC2 or C	Significance
SIO	0	0	I/O address recognized and SIO accepted.
	0	1	I/O address recognized, but SIO not accepted.
	1	0	Tape unit attached to "busy" Selector IOP (applicable only to Sigma 5/7).
	1	1	I/O address not recognized.
HIO	0	0	I/O address recognized and tape unit "not busy" when halt occurred.
	0	1	I/O address recognized, but tape unit "busy" when halt occurred.
	1	0	Invalid code.
	1	1	I/O address not recognized.
TIO	0	0	I/O address recognized and SIO can currently be accepted.
	0	1	I/O address recognized, but SIO cannot currently be accepted.
	1	0	Tape unit attached to "busy" Selector IOP (applicable only to Sigma 5/7).
	1	1	I/O address not recognized.

†In Sigma 2/3 Computers, the symbol "O" represents the Overflow indicator and "C" represents the Carry indicator; in other Sigma computers, "CC1" and "CC2" represent condition code bits 1 and 2.

Table 3. Magnetic Tape Unit I/O Instruction Execution Response (cont.)

Instruction	Status Bits[t]		Significance
	CC1 or O	CC2 or C	
TDV	0	0	I/O address recognized and previous operation not terminated because of "fault" condition.
	0	1	I/O address recognized, but previous operation terminated because of "fault" condition.
	1	0	Tape unit attached to "busy" Selector IOP (applicable only to Sigma 5/7).
	1	1	I/O address not recognized.
AIO	0	0	Normal interrupt condition present ("channel end" or "zero byte count").
	0	1	Unusual interrupt ("unusual end") condition present.
	1	0	Invalid code.
	1	1	No interrupt condition present.

[t]In Sigma 2/3 Computers, the symbol "O" represents the Overflow indicator and "C" represents the Carry indicator; in other Sigma computers, "CC1" and "CC2" represent condition code bits 1 and 2.

Table 4. Status Response for SIO, TIO, and HIO

Bit Position	Function	State	Meaning
0	Interrupt Pending	1	Interrupt is pending (issued but not yet acknowledged by an AIO instruction). Another SIO instruction is not accepted until the interrupt is cleared; however, command chaining may occur, producing further input or output. The interrupt can be cleared by execution of an AIO or HIO, or by manual intervention (I/O RESET or INITIALIZE switch on the respective Sigma computer control panel).
1, 2	Device Condition		A combination of these two bits indicates the current magnetic magnetic tape unit condition.
		00	Tape Unit Ready.
		01	Tape Unit Not Operational – "fault" condition exists. For example, power off, interlock open, tape unit RESET switch depressed, currently in load cycle, or in process of repositioning tape at load point at conclusion of a rewind.
		10	Device Unavailable – not applicable.
		11	Tape Unit Busy.
3	Mode	0	"Manual" mode – manual intervention required to enter "automatic" mode.

Table 4. Status Response for SIO, TIO, and HIO (cont.)

Bit Position	Function	State	Meaning
3 (cont.)		1	"Automatic" mode.
4	Unusual End	1	Execution of previous order terminated due to abnormal condition, as listed under "Unusual End Conditions".
5,6	Controller Condition		A combination of these two bits indicates the current magnetic tape controller condition.
		00	Device Controller Ready
		01	Device Controller Not Operational – not applicable.
		10	Device Controller Unavailable – not applicable.
		11	Device Controller Busy
7	Unassigned	0	Currently unassigned and always zero.

Table 5. Status Response for TDV

Bit Position	Function	State	Meaning
0	Data Overrun	1	Data overrun occurred during last read or write operation. Upon encountering data overrun during a write operation, dummy characters are written (last character written is repeated) until further bytes are available, at which time normal writing resumes.
1	Write Permitted	0	Addressed device is write-protected, that is, only reading may be performed.
		1	Both writing and reading may be performed. Note that insertion of a "write-enable" ring on the tape reel puts the device into the "write-permitted" state.
2	Write-Protect Violation Error	1	Last order received was a Write order but selected device is write-protected.
3	End-of-File	1	Either last record read or spaced over was a tape mark record, last reverse reading or spacing halted the tape at load point marker, or last order initiated was Write Tape Mark.
4	Noncorrectable Read Error	1	Last record read resulted in a transmission data error and it is the type not correctable by the Sense-Set Correction-Read sequence (see "Sense and Set Correction Orders").
5	Load Point	1	Addressed device is positioned at load point marker.

Table 5. Status Response for TDV (cont.)

Bit Position	Function	State	Meaning
6	End-of-Tape	1	Selected device has tape positioned past the end-of-tape (EOT) marker. Any tape operation may be initiated while this bit is set, but extensive forward operations might run off the end of the tape. (Note: Physical end-of-tape is 14 feet after EOT marker.) This bit remains set until backward operation encounters end-of-tape marker again or until tape unit switched from "automatic" mode.
7	Rewind On-Line	1	While addressed device is in process of rewinding ("automatic" mode).

Table 6. Status Response for AIO

Bit Position	Function	State	Meaning
0	Data Overrun	1	Data overrun occurred during last read or write operation. Upon encountering data overrun during a write operation, dummy characters are written (last character written is repeated) until further bytes are available, at which time normal writing resumes.
1	Device End	1	Last I/O interrupt generated was device end interrupt, which is generated either when tape unit completes a Rewind and Interrupt order execution or it just has been put in "automatic" mode by operator after setting ATTENTION switch (see "Attention", Chapter 4).
2	Write-Protect Violation Error	1	Last order received was a Write but selected device is write-protected.
3	End-of-File	1	Either last record read or spaced was tape mark record, last reading or spacing halted tape at load point marker, or last order initiated was Write Tape Mark.
4	Noncorrectable Read Error	1	Last record read resulted in transmission error, which is the type not correctable by Sense-Set Correction-Read sequence (see "Sense and Set Correction Orders").
5-7	Unassigned	0	Currently unassigned and always zero.

Table 7. Operational Status Byte†

Function	State	Meaning
Incorrect Length	1	Incorrect length condition occurred since previous output order received by device (also see "Error Conditions").
Transmission Data Error	1	Data overrun or parity error occurred since previous order received by device (also see "Error Conditions").
Channel End	1	Tape unit terminated operation for any reason listed under "Channel End Conditions".
Unusual End	1	Tape unit terminated operation for any abnormal condition listed under "Unusual End Conditions".

†For the bit positions of these functions in the Operational Status Byte, see the applicable Sigma Computer Reference Manual.

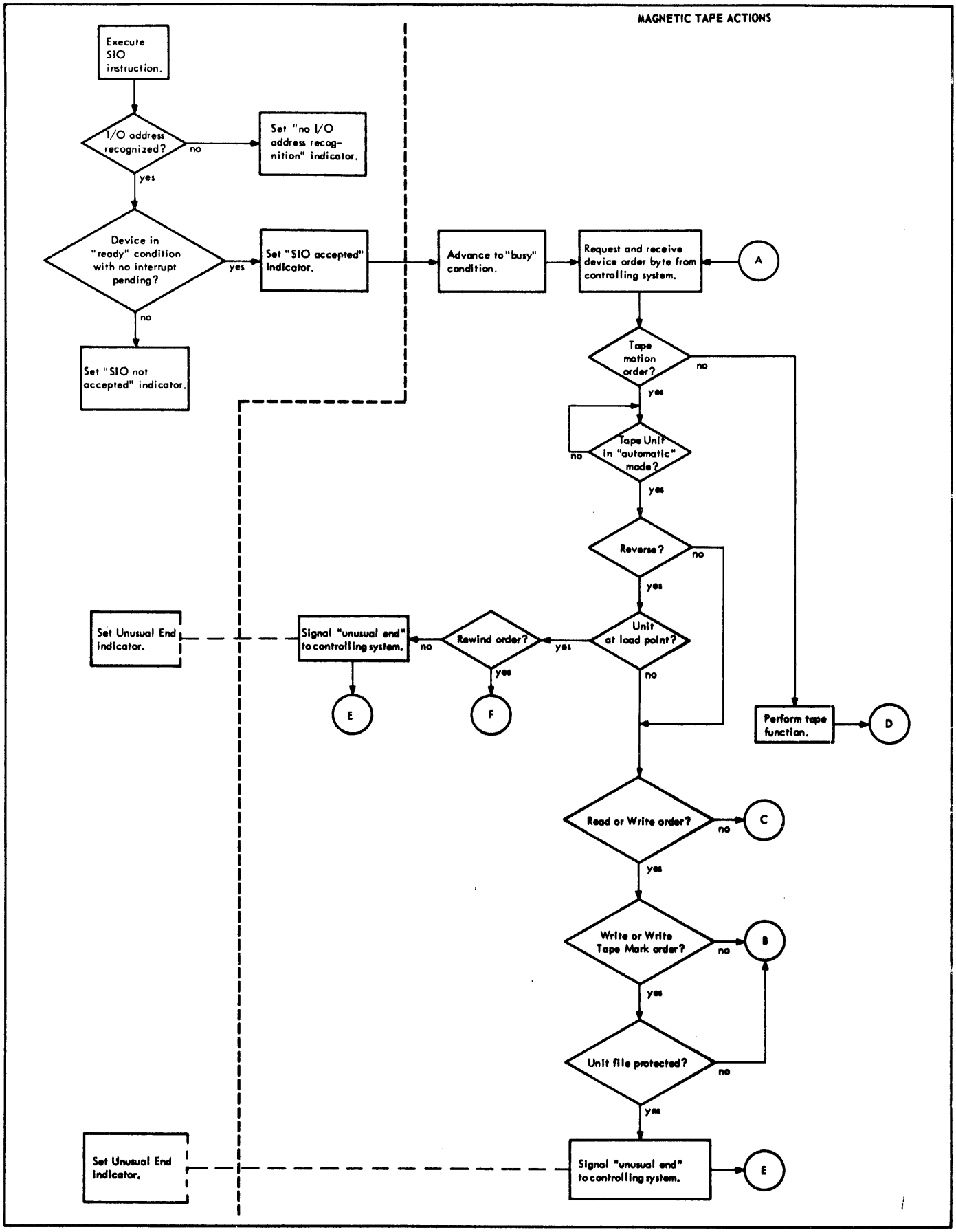


Figure 3. Controlling System/Magnetic Tape Actions

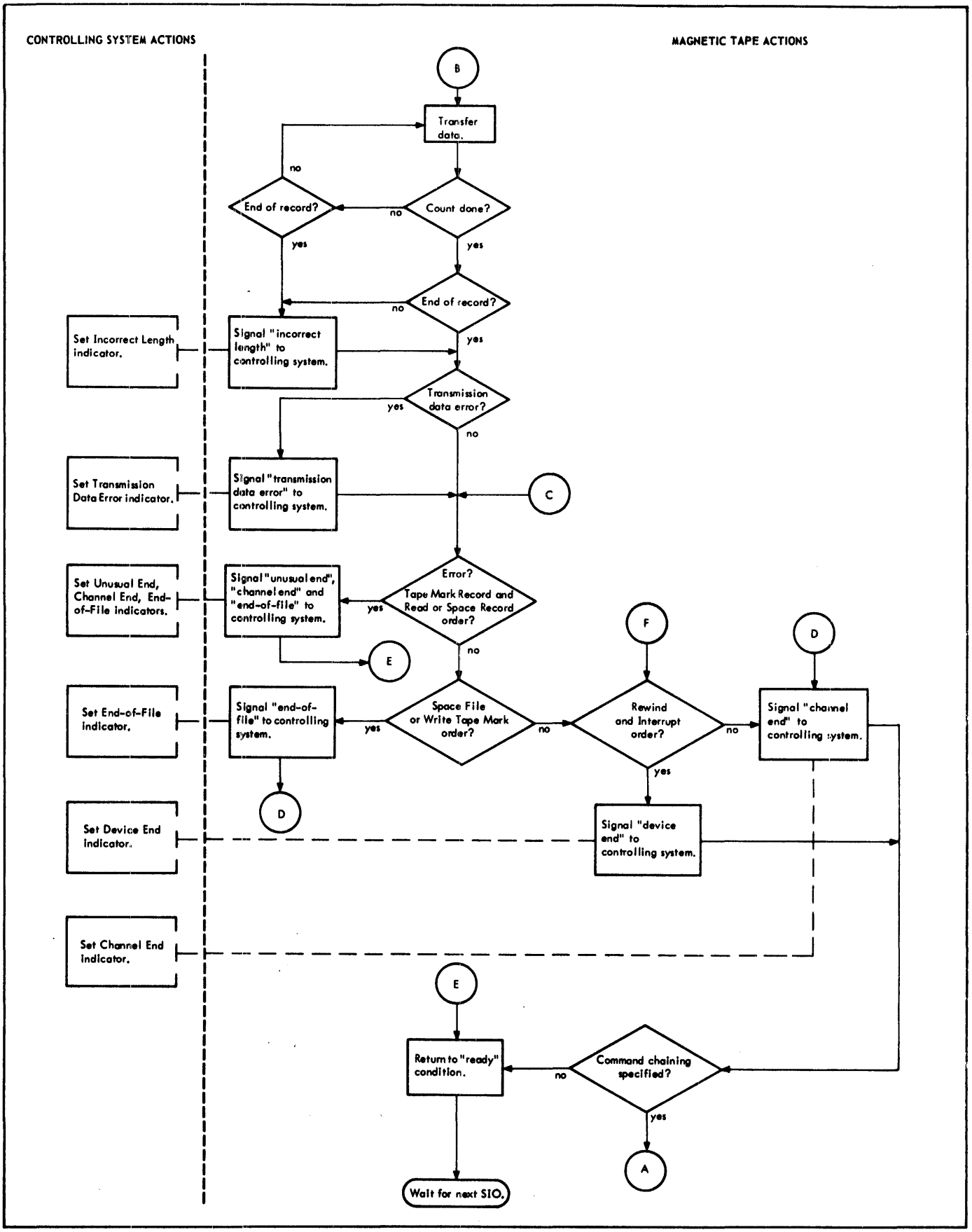


Figure 3. Controlling System/Magnetic Tape Actions (cont.)

4. OPERATIONS

OPERATOR CONTROLS

The operator control panel (see Figure 4) is located on the front of the tape unit, above the transport. Switches are provided for various manual operations and indicators display the current operational status. The control panel is both visible and accessible whether the cabinet doors are closed or open. The functions of the switches and indicators are described in this section.

POWER

Alternate Action Switch/Indicator. When this switch is on, ac power is applied to the unit and the motors and blowers are turned on. The indicator then lights.

LOAD

Momentary Action Switch/Indicator. When this switch is pressed, tape is automatically loaded. The tape is moved to the load point, at which time tape motion stops and the unit is then in the "ready" condition. The indicator lights when tape reaches the load point.

REWIND

Momentary Action Switch/Indicator. When this switch is pressed ("manual" mode only), the tape is rewound to the load point. When tape motion stops, the LOAD indicator lights. If tape is situated on the load point when the switch is pressed, the tape is unloaded onto the supply reel. The REWIND indicator lights when a rewind operation is in progress, whether initiated manually or by the computer. The indicator also lights when fast tape motion is initiated from the auxiliary (maintenance) panel. It turns off when the beginning of tape marker is detected.

ATTENTION

Momentary Action Switch/Indicator. This switch sets up the I/O interrupt signal to the controller prior to switching the unit to the "automatic" mode with the START switch. If the ATTENTION switch is pressed before the START switch, an I/O interrupt signal is generated when the unit is switched to the "automatic" mode and the "ready" condition. The ATTENTION indicator remains lighted from the time the switch is pressed until the I/O interrupt signal is generated.

START

Momentary Action Switch/Indicator. If the tape unit is in the "ready" condition when this switch is pressed, the unit enters the "automatic" mode. When the START indicator lights, the unit is in the "automatic" mode.

READY

Momentary Action Switch/Indicator. The READY indicator lights when the tape unit is in the "ready" condition (operational but not busy). The unit is operational if all voltages are present, the interlocks are closed, and no reset, load, or rewind is taking place. The unit is in the "busy" condition if it has been selected for any operation. The READY switch is used to test all the panel indicator lights except the POWER light. When the switch is pressed, all indicators except POWER and RESET should light.

RESET

Momentary Action Switch. When this switch is pressed, tape motion is stopped and the unit is placed in the "manual" mode and "ready" condition.

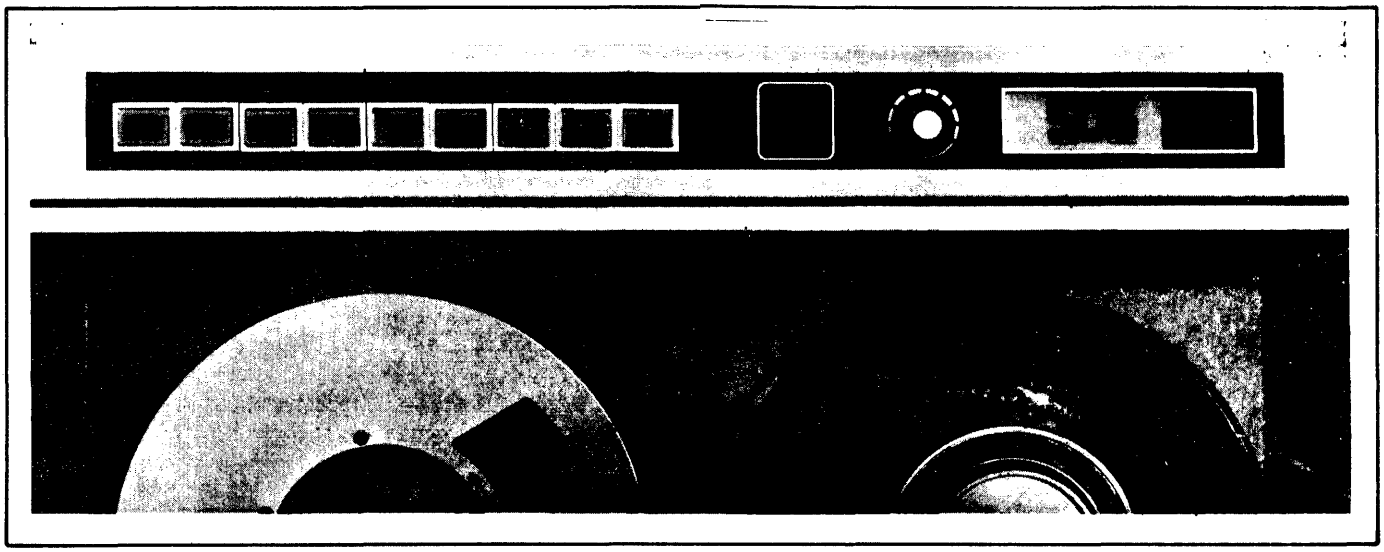


Figure 4. Operator Control Panel

UNIT SELECT

Rotary Action Switch. This switch has nine positions: the OFF position and eight unit numbers (0 through 7). The position of the switch determines the current unit number of the device. A device controller can have eight tape units connected to it, but no two units connected to a controller may have the same switch setting (except OFF).

Note: In switching from one unit number to another, it may be necessary to switch through a busy unit number. This causes an unpredictable operation on the busy unit unless the RESET switch is held down while rotating the UNIT SELECT switch.

A command from the I/O system includes a unit address number which is compared with the number specified by the UNIT SELECT switch. When the switch on a particular unit is OFF, the unit does not respond to the unit address line from the controller.

Status checks may be made on a unit that is in the "manual" or "automatic" mode by addressing the unit. The only way a unit may be taken off-line is by moving its switch to the OFF position.

FILE PROTECT

Indicator. This indicator remains lighted when the tape unit is file-protected (write-enable ring not installed in the file reel). The tape can not be written on while it is file-protected.

BUSY

Indicator. This indicator lights when the tape unit is in the "busy" condition (operational and busy). The unit is operational if all voltages are present, all interlocks are closed, and no reset, load, or tape rewind operation is in progress. The unit is busy only if it is performing an operation in response to an order from the controlling system.

PUSH-ON-PULL-OFF (POPO) HUB

The tape unit is equipped with the patented POPO reel hub, upon which is mounted the file reel. The POPO hub provides a convenient, simple procedure for mounting and removing tape reels from the transport.

To install a file reel: Hold the reel in both hands, slip it over the hub, and push it inward on the hub as far as it will go.

To remove a file reel: Pull outward while holding the reel in both hands.

AUXILIARY (MAINTENANCE) CONTROL PANEL

This panel (see Figure 5) is inset directly below the lower right hand corner of the tape unit transport. It is accessible when the front door of the unit is open. The panel contains three momentary action switches, labeled FORWARD, REVERSE, and FAST. They are used only when the unit is in the "manual" mode. The forward or reverse speed for a Model 7322 unit is 75 inches per second, and 150 inches per second for a Model 7323. When a direction switch is

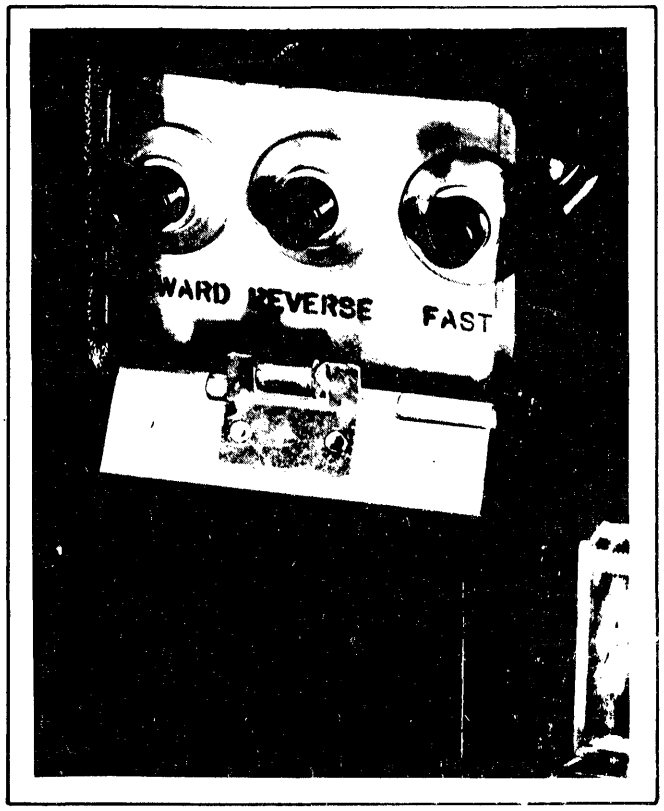


Figure 5. Auxiliary Control Panel

used in conjunction with the FAST switch, the speed is 250 inches per second on the 7322, and 450 inches per second on the 7323.

The Swinging Door Interlock switch, which must be closed to operate the above switches, is associated with the Auxiliary Control Panel. Under normal operating conditions the switch opens when the door is swung outward and closes when the door is shut. Pulling the interlock actuator rod (right side of Auxiliary Control Panel) will close the switch and enable the tape unit to be in the "ready" condition.

TAPE LOADING

The procedure for loading a magnetic tape transport is as follows (see Figure 6):

1. If the POWER indicator on the operator control panel is not lighted, press the POWER switch.
2. Close the front door if it is open.
3. Lower the sliding glass window to the fully open position (which releases the reel motor brakes).
4. After checking for the write-enable ring, push the supply reel onto the file reel hub.
5. Unwind five to six feet of tape leader from the file reel.
6. Thread the tape along the path shown in Figure 6. Wind two to four turns of tape onto the fixed reel. (Since the tape unit provides an automatic tape-loading feature, it is unnecessary to manually feed tape into the vacuum chambers.)

7. Raise the sliding window to the fully closed position. The interlocks will close and the read/write head cover will swing to its operating position.

8. Press the LOAD switch on the control panel to initiate the following loading sequence:

   a. The capstan and the reels move the tape forward, serving tape into the vacuum chamber.

   b. The moving tape arrives at the load point. Forward tape motion stops and the LOAD indicator lights.

   c. The tape loops settle to their standby positions in the vacuum chambers.

      Note: If forward motion does not stop when the load point is reached, press the RESET switch to stop the transport.

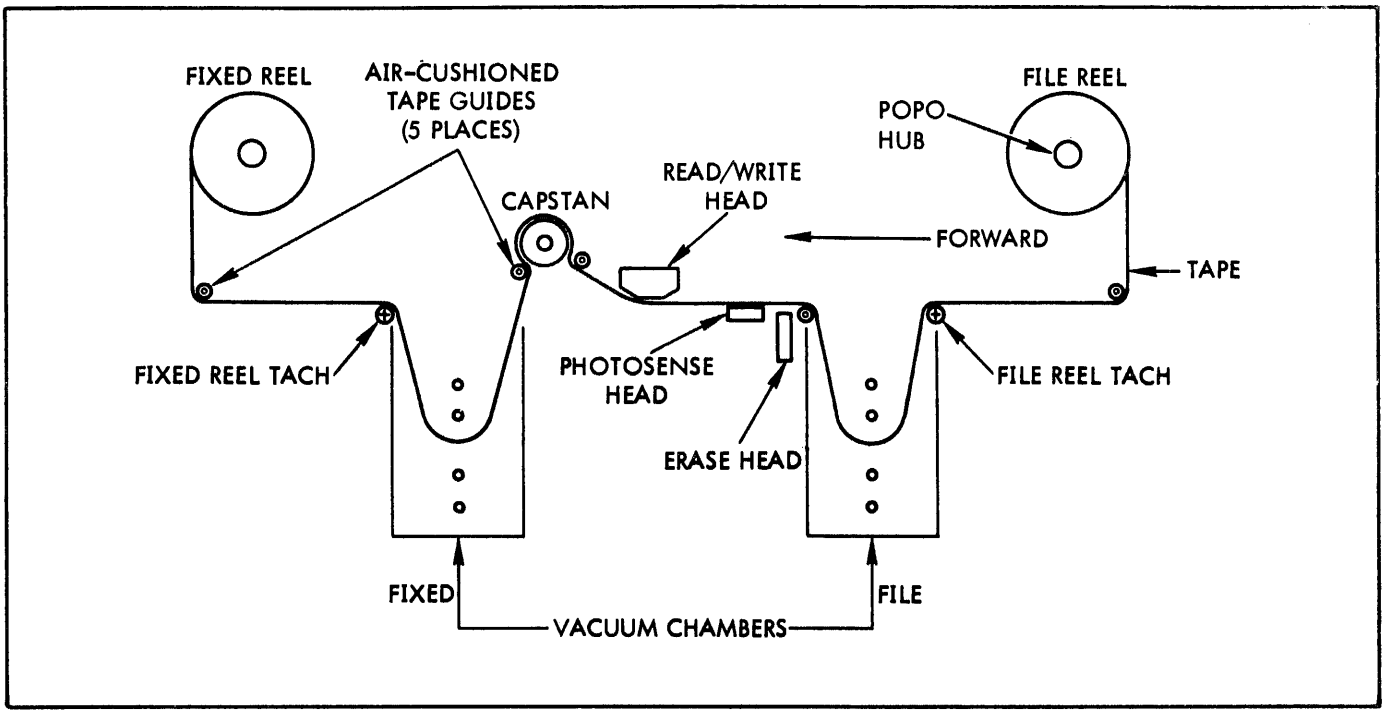


Figure 6. Magnetic Tape Transport Tape Path

APPENDIX

SIGMA 5/6/7/9 PROGRAMMING EXAMPLE

The following coding sequence is an example of a common SIO routine, entered from a program that sends a Write order to a magnetic tape unit. Typical device checks, before and after the SIO, are included. Note that assembler directives are used in some instances.

Label	Command	Argument	Comments
	:	:	
	LW,9	BUFFADR	In the Write routine, before branching to the common SIO routine, the starting address of the buffer is converted to a byte address and the Write order is added and stored in the command doubleword.
	SCS,9	2	
	AW,9	L(X'01000000')	
	STW,9	ORDW	
	:	:	
	LI,0	DA(ORDW)	This instruction loads register 0 with the doubleword address of the command doubleword for the Write order.
	BAL,15	SIOR	Branch and link to the SIO routine. At that routine's conclusion, a branch back to this routine is effected.
	:	:	
SIOR	STW,15	SIOR15	Save link address.
	TIO,1	*IOADDR	TIO to the device whose address is stored in IOADDR. The response from the TIO instruction is stored in register 1.
	BCS,8	TCC1SET	Branch if CC1 is set; CC2 will be set, not checked at this time.
	BCS,4	TCC2SET	Branch if CC2 is set; CC1 is not set.
	LW,2	L(X'10000000')	Neither condition code is set; check device for manual mode.
	LW,3	2	
	CS,2	1	
	BCR,3	MANWAIT+1	Branch if TIO response word bit 3 was set – not manual mode.
	BAL,15	xxxx	Manual mode – branch to routine to print message.
	RD,0	X'10'	Check for Sense Switch 3 being set.
	BCR,2	$+2	If set, wait until operator clears
MANWAIT	WAIT		"wait" condition from computer console.
	SIO,3	*IOADDR	Continue sequence of instructions. Issue SIO order to device whose device address is stored in IOADDR. The doubleword address of the command doubleword has previously been stored in register 0. This double word is automatically accessed upon issuing the SIO instruction.
	STW,3	SIORESP	Save the response word from above SIO, and store in register 3.
	BCS,8	TCC1SET	Branch if CC1 is set; CC2 will be set, not checked at this time.
	BCS,4	SCC2SET	Branch if CC2 is set; CC1 is not set. If CC1-2 reset (SIO accepted), continue.
	LI,5	X'20'	Arm and enable the I/O interrupt.
	WD,5	X'1200'	
	WAIT		Wait for device interrupt.

An example of a common interrupt routine is given below. The receipt of the device interrupt causes automatic branching to the interrupt routine, in which an AIO instruction is executed and subsequent checks can be performed. The I/O interrupt location 5C usually contains an XPSD instruction with the address of a doubleword. Following that doubleword is another doubleword containing the interrupt routine address. Return is made to the location following the above WAIT.

Label	Command	Argument	Comments
	XPSD, 0	IOINT	
IOINT	DATA	0	Stored with the current program status doubleword.
	DATA	0	
	DATA	INTERR	The interrupt routine's entry location.
	DATA	0	
INTERR	AIO, 1	0	Common interrupt routine.
	:	:	
	:	:	
	LPSD, 2	IOINT	Conclusion of routine resets interrupt, returns to original routine from where interrupt occurred.
End of SIO routine			
	B	*SIOR15	This branch returns program control to the link location following the BAL, 15 SIOR.
TCC1SET	xxx	xxxx	Entered if CC1 was set following a TIO or SIO and indicates "address not recognized".
TCC2SET	xxx	xxxx	Entered if CC2 was set following a TIO and indicates "SIO not possible".
SCC2SET	xxx	xxxx	Entered if CC2 was set following an SIO and indicates "SIO not accepted".
Command Doublewords			
ORD1	COM, 8, 24	AF(1), AF(2)	These instructions dictate how the final instruction word should
ORD2	COM, 8, 24	AF(1), AF(2)	be formatted, and are used for ease of setting word parameters.
	BOUND	8	This directive sets the following words on an even word boundary, necessary in doubleword addressing.
ORDW	ORD1	X'01', 0	Write order.
	ORD2	X'54', 64	

The above two lines are accepted by the assembler, and produce formatted words according to the specifications set forth above. The first 8 bits of the first word contain the tape order. In this case a Write order is desired, therefore, a hexadecimal 01 is specified. The remaining 24 bits of this word are loaded in the routine, with the byte address of the buffer from which data is to be extracted. The second word of this command doubleword indicates the flags and the byte count. A hexadecimal 54 specifies interrupts for "zero byte count", "channel end", and "unusual end". The decimal number 64 is a byte count, meaning 64 bytes are to be transmitted by this order. This byte count can be altered; the field can be loaded with a new byte count.

SIGMA 2/3 PROGRAMMING EXAMPLE

The following coding sequence shows magnetic tape programming with an XDS Sigma 2 or 3 Computer.

For interrupt processing it is assumed that the I/O interrupt location X'106' is loaded with the address of the interrupt routine, for example:

```
00106    DATA    INTERR.
```

Label	Command	Argument	Comments
INTERR	DATA	0	A doubleword reserved to store the program status doubleword when the interrupt is effected. It is followed by the coding of the routine itself.
	DATA	0	
	AIO		
	:	:	
	LDA	*WD0200	Disarms and disables the I/O interrupt. WD0200, etc., are locations that are stored with the correct configuration of data for the WD function.
	WD	*WD1100	
	WD	*WD1500	
	WD	X'D8'	This instruction signals the end of the interrupt routine and effects an exit sequence from it. The LDX instruction uses the routine's entry address, which is the location of the doubleword containing the return address of the point in the main program at which it was interrupted.
	LDX	INTERR	
WD0200	DATA	X'0200'	Word configurations for use by the Write Direct instructions above.
WD1100	DATA	X'1100'	
WD1200	DATA	X'1200'	

The following shows an example of a standard SIO routine that can be entered from any other routine, and will test the device before and after issuing the SIO for the particular tape order desired.

SIOR	RCPY	L,A	Stores link address for return to original routine. Accumulator must contain device address before issuing I/O instruction.
	STA	SIORLNK	
	LDA	IOADDR	
	TIO		
	STA	TIORESP	Saves response word from TIO.
	BNO	$+2	
	B	TOSET	Branch if overflow indicator set – address not recognized.
	BNC	$+2	
	B	TCSET	Branch if carry indicator set – SIO not possible.
	AND	=X'1000'	Accumulator still contains TIO response. Check if "automatic" bit set.
	BAZ	$+2	
	B	SIOOK	
	———	———	Branch to here if not "automatic" mode. Process manual mode message or other function.
	:	:	
	RCPYI	P,L	Sequence to effect a link branch. The current location plus one is stored in the L register. Branch to test for data switches (DSTST).
	B	DSTST	
SIOOK	LDA	IOADDR	Continue SIOR sequence
	AND	=X'0070'	IOADDR contains device address. The device controller is specified in bits 9-11. This number is extracted and shifted right (to effect a multiplication by two) and added to 8 to determine the channel register number that corresponds to that device number. This channel register number is stored, and its value plus one is stored as the second channel register to be used.
	SARS	3	
	ADD	=8	
	STA	WDWRD	
	ADD	=1	
	STA	WDWRD1	

Label	Command	Argument	Comments
	LDA STA LDA	ORDER *BUFFADR BUFFADR	The tape order currently to be used is stored in the first location of the buffer. (See Note at the end of this example.)
	WD	*WDWRD	The buffer address is stored in the first channel register by means of a WD instruction.
	LDA	=X'2000'	Bit signifying interrupt.
	ADD ADD	BYTES =1	Number of bytes to be processed plus one to include order byte.
	WD	*WDWRD1	Into second channel register.
	LDA WD	*WD0200 *WD1200	Arms and enables I/O interrupt.
	WD	X'E8'	Resets internal interrupt inhibit.
	LDA SIO	IOADDR	Device address into accumulator for SIO.
	STA	SIORESP	Saves status word for later use.
	RD	*WDWRD	Loads accumulator with operational status byte, set by device as result of SIO, and stored in first channel register.
	BNO	$+2	
	B	TOSET	Branch if overflow indicator set from previous SIO.
	BNC	$+2	
	B	SCSET	Branch if carry indicator set following SIO.
	RD AND BAZ RCPYI	X'080' =X'4000' $+3 P,L	Test for data switch 1 set (accumulator is loaded with setting of data switches).
	B	SCSET	If data switch is set, branch and link to subroutine to process condition.
	B . . .	RESPCHK . . .	Branch to routine to check response word for unusual conditions, etc.
	B	*SIORLNK	Return to original routine (see beginning of SIOR routine).

Note: For Sigma 2/3 programming, the number of bytes to be transferred for a data order determines how the tape order is to be loaded into the buffer's first word. The above example loads the order directly into the buffer word, placing it normally in the second byte of the word. This is acceptable if an even number of data bytes is to be transferred. For an odd data byte count the order is stored in the first byte of this buffer word, and the first data byte stored into the second byte of this first buffer word. The last word of the record in memory must be complete (two valid bytes).

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19015, 3.5C977, Printed in U.S.A.

XG69, Rev. 0