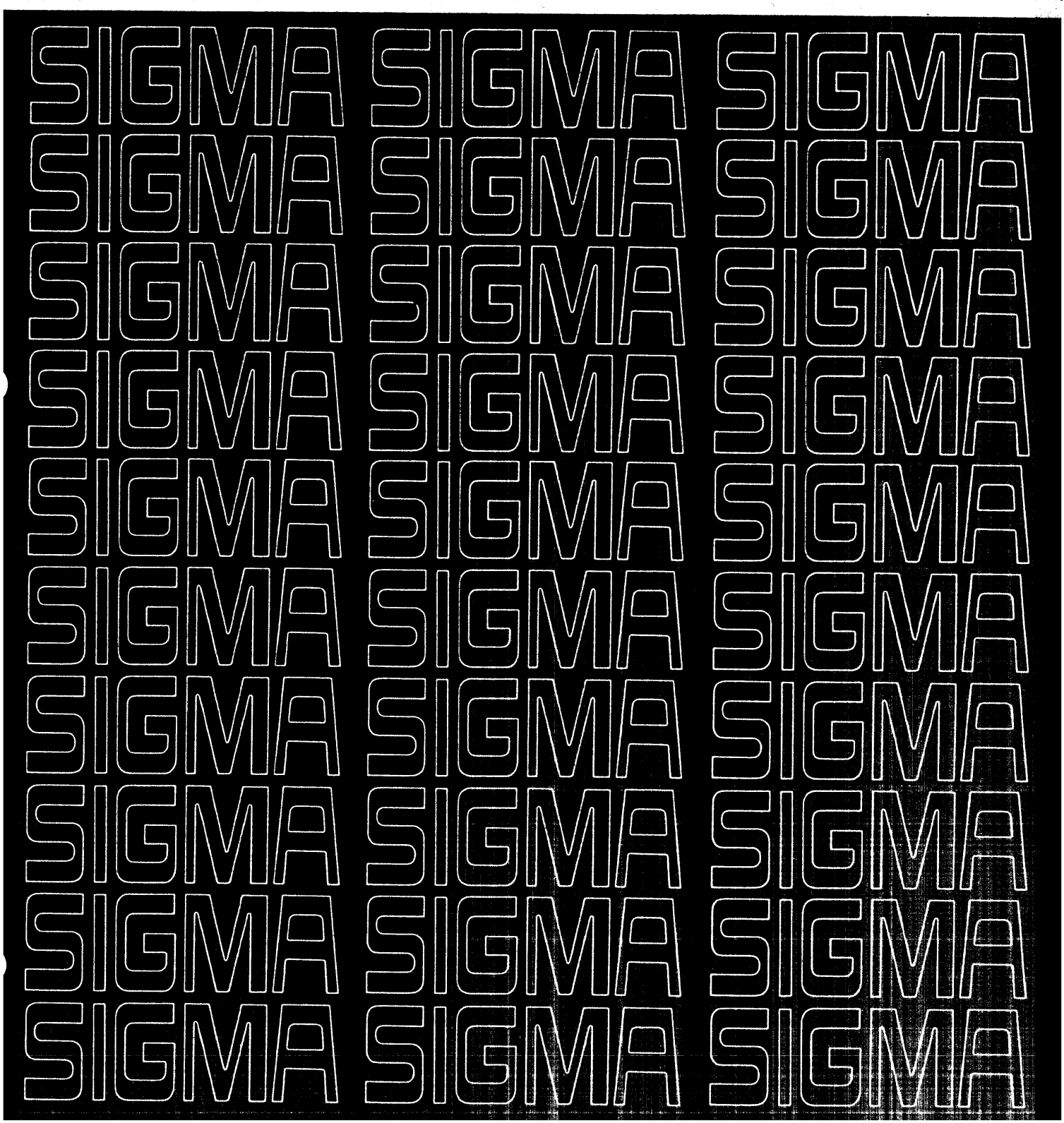
SDS SIGMA 7-TRACK MAGNETIC TAPE SYSTEMS

MODELS 7361/7362/7371/7372

Reference Manual

SCIENTIFIC DATA SYSTEMS



7-TRACK MAGNETIC TAPE ORDER CODES

Code (Hexadecimal)	Function
01	Write Tape Packed (Binary)[t]
02	Read Tape Packed (Binary)[t]
05	Write Tape Binary[tt]
06	Read Tape Binary[tt]
0D	Write Tape Decimal (BCD)[tt]
0E	Read Tape Decimal (BCD)[tt]
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

[t] Model 7374 required for use on 7371/7372.

[tt] Model 7365 required for use on 7361/7362.

Price: $1.25

7-TRACK MAGNETIC TAPE SYSTEMS

MODELS 7361/7362/7371/7372

REFERENCE MANUAL

for

SDS SIGMA COMPUTERS

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Title	Publication Number
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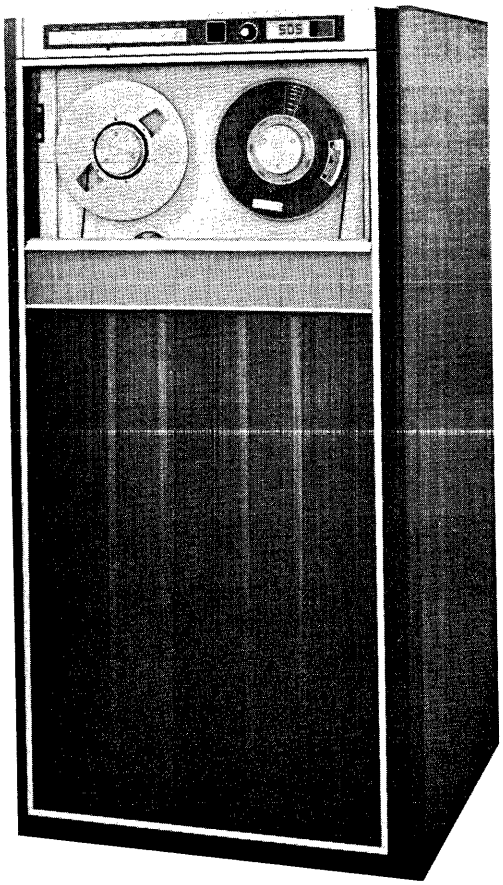
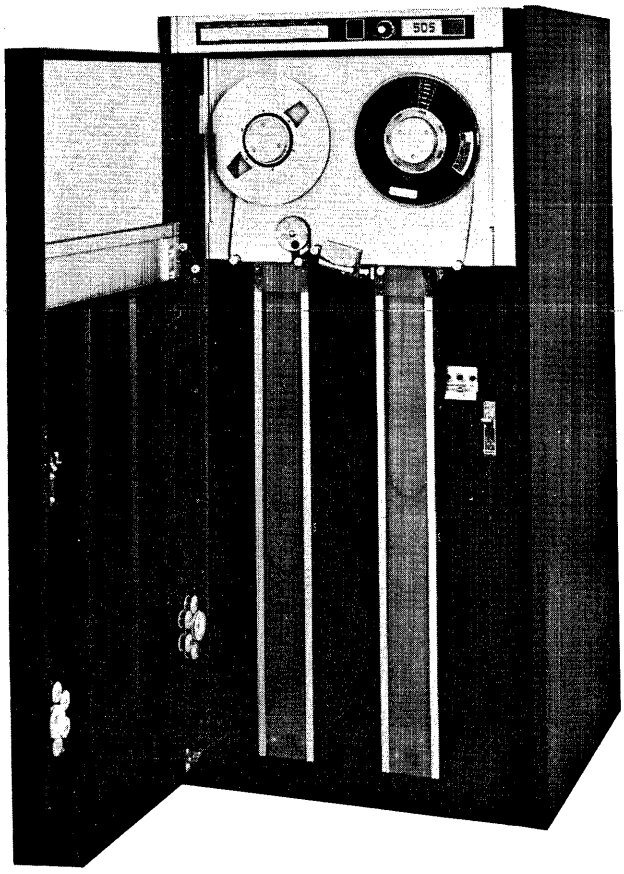


Model 7361 Controller and 7362 Tape Transport



Tape Transport Interior View

1. GENERAL DESCRIPTION

INTRODUCTION

SDS 7-Track Magnetic Tape Systems provide medium speed and low-cost input/output facilities for SDS Sigma Computers. Data is read and written in IBM-compatible tape format. 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.

Fast and convenient tape-handling is provided by the patented SDS 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.

Errors are automatically detected if either vertical parity or the longitudinal check character is incorrect. 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.

Tape units may be used for system program storage, inputs to sorts and merges, large data processing files or service as scratch or working tapes. Tape is written in the forward direction in 200, 556, or 800 bits per inch density for Models 7371/7372, and 556 bits per inch for Models 7361/7362.

Several tape-positioning operations are provided. Tapes can be moved, under program control, 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 can be transmitted from any tape unit to the I/O system when the unit has stopped rewinding, indicating that it is available again. When placing a new unit on-line in the system, the operator can cause it to generate an interrupt notifying the controlling program that the unit is available for operation.

SDS Sigma 7-Track Magnetic Tape Systems are available in the following models:

Model 7371	Controller (75 inches per second)
Model 7372	Tape unit (75 inches per second)
Model 7374	Binary packing option (75 inches per second)
Model 7361	Controller (37.5 inches per second)
Model 7362	Tape unit (37.5 inches per second)
Model 7365	Binary/BCD option (37.5 inches per second)

Model 7361 Controller controls one or two low-cost Model 7362 tape units. Model 7371 Controller controls one to eight Model 7372 tape units. (Each configuration contains one controller and one tape unit in the same cabinet; additional tape units are in separate cabinets.)

There are two standard read/write modes of operation for Models 7371/7372. They are binary and decimal (BCD); packed binary reading and writing is an optional feature (Model 7374). If the packing option is installed, packed binary read/write operations are selectable by order codes.

There is one standard mode of operation, packed binary, for Models 7361/7362. Binary and decimal (BCD) reading and writing are optional features (Model 7365). If installed, these operations are selectable by order codes.

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

SPECIFICATIONS

OPERATING CHARACTERISTICS

Tape speed	
Model 7362	37.5 inches per second
Model 7372	75 inches per second
Start/stop time	
Model 7362	10 msec
Model 7372	5 msec
Rewind speed	
Model 7362	150 inches per second (3 min 20 sec for 2400 ft reel)
Model 7372	250 inches per second (2 min for 2400 ft reel)
Information transfer rate[†]	
Models 7361/7362	20,850 bytes per second
Models 7371/7372	15,000 bytes per second (200 bits per inch)
	41,600 bytes per second (556 bits per inch)
	60,000 bytes per second (800 bits per inch)

[†]Transfer rates given for the binary and BCD modes only. Packed binary mode rates are reduced by 25%.

Reel hubs	SDS 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 in. wide, 2400 ft long, 1.5 mil thick Mylar base
Recording method	NRZ1 (nonreturn to zero, change on ones)
Recording format	7 channels (6 bits plus parity)
Recording density	
Models 7361/7362	556 bits per inch
Models 7371/7372	200, 556, or 800 bits per inch
Interrecord gap	0.75 in.

Operational modes	
Models 7361/7362	Packed binary – standard; binary/BCD – optional
Models 7371/7372	Binary/BCD – standard; packed binary – optional

PHYSICAL DIMENSIONS

Cabinet dimensions	Height - 63.5 in. Width - 29.25 in. Depth - 35 in.
Weight	Master unit (transport plus controller) – approximately 950 lbs
	Additional transports – approximately 915 lbs

ENVIRONMENTAL CONDITIONS

Power requirements	115 vac ± 10%, 25 amps max, 60 Hz ± 0.5, single phase
Operating temperature	50° to 90° F
Relative humidity	5% to 80% (no condensation)

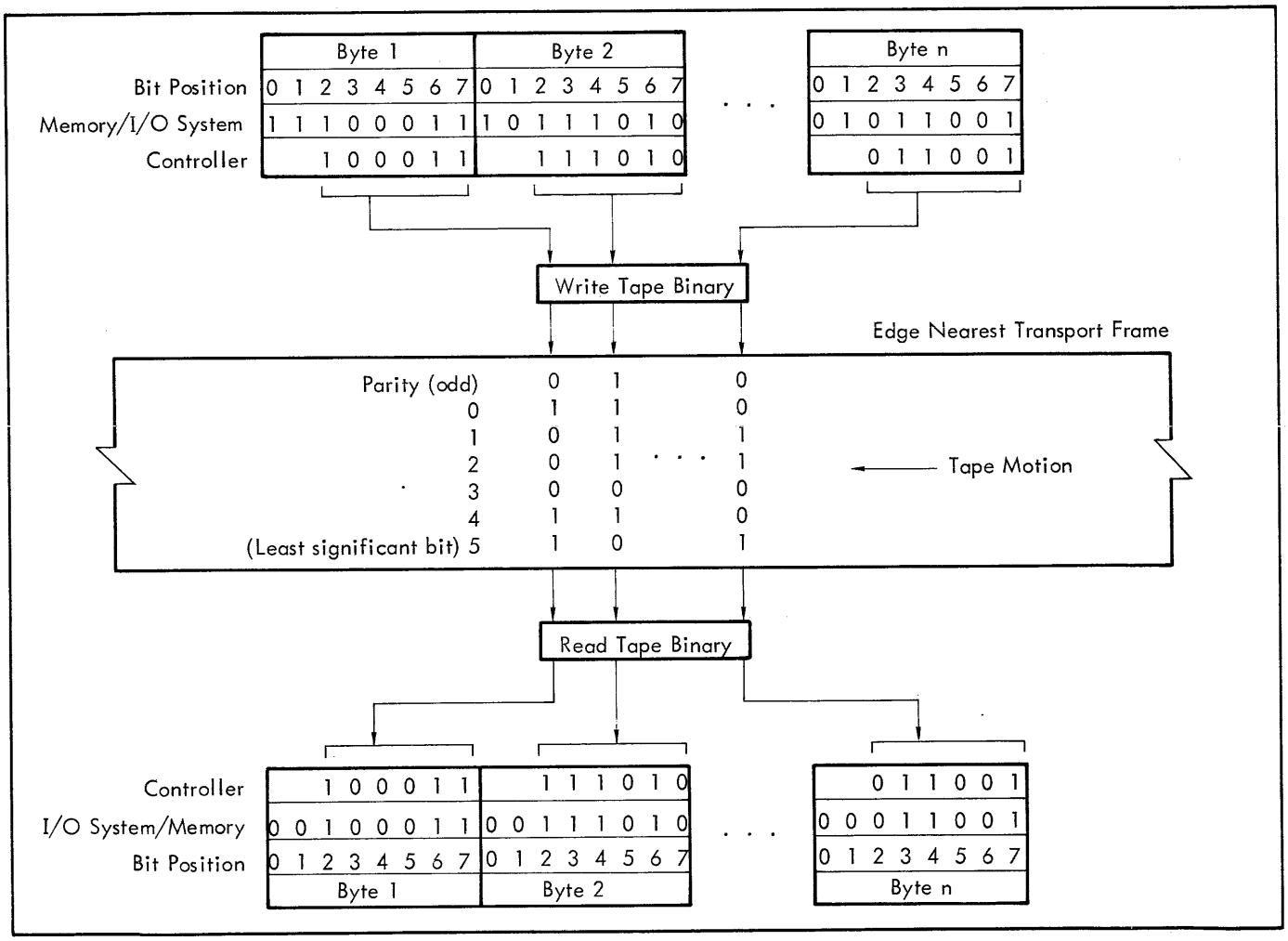


Figure 1. Data Representation on Tape – Binary Mode

2. FUNCTIONAL DESCRIPTION

DATA REPRESENTATION

In SDS 7-Track Magnetic Tape Systems (with options added, where applicable), data can be recorded and read in any of three modes of operation selectable by the program (see "Magnetic Tape Orders", Chapter 3): binary, decimal (BCD), or packed binary. Figures 1, 2, and 3 show how information in memory is represented on a tape for each mode. Figure 4 illustrates physical spacing of the elements on a tape.

BINARY MODE

During a write operation in the binary mode (see Figure 1), data is transferred to the controller as a bit for bit image of its arrangement in memory. At the controller, the two most significant bits of each byte (bit positions 0 and 1) are discarded prior to writing and, therefore, do not appear on tape. During a read operation in this mode, the 6-bit byte, as it is read from tape, is reconstructed to an 8-bit byte with the two most significant bits of each byte supplied as zeros. This 8-bit byte with its two leading zeros is then sent to the I/O system. Tape parity is always odd in the binary mode.

DECIMAL (BCD) MODE

In the decimal (BCD) mode (see Figure 2), data is transferred to and from tape in standard 6-bit BCD Interchange Code. During a write operation, the 8-bit byte from the central processor is interpreted as being in the standard 62-character set of the 8-bit Extended BCD Interchange Code (EBCDIC). This 8-bit EBCDIC format is translated in the controller to its 6-bit equivalent in BCD and then recorded on tape. During a read operation, the 6-bit BCD format is translated in the controller to the 8-bit EBCDIC format and sent to the I/O system.

Appendix A shows the 256 possible codes that could be sent by the computer on the data lines and the corresponding BCD character that is written on tape. The codes enclosed in

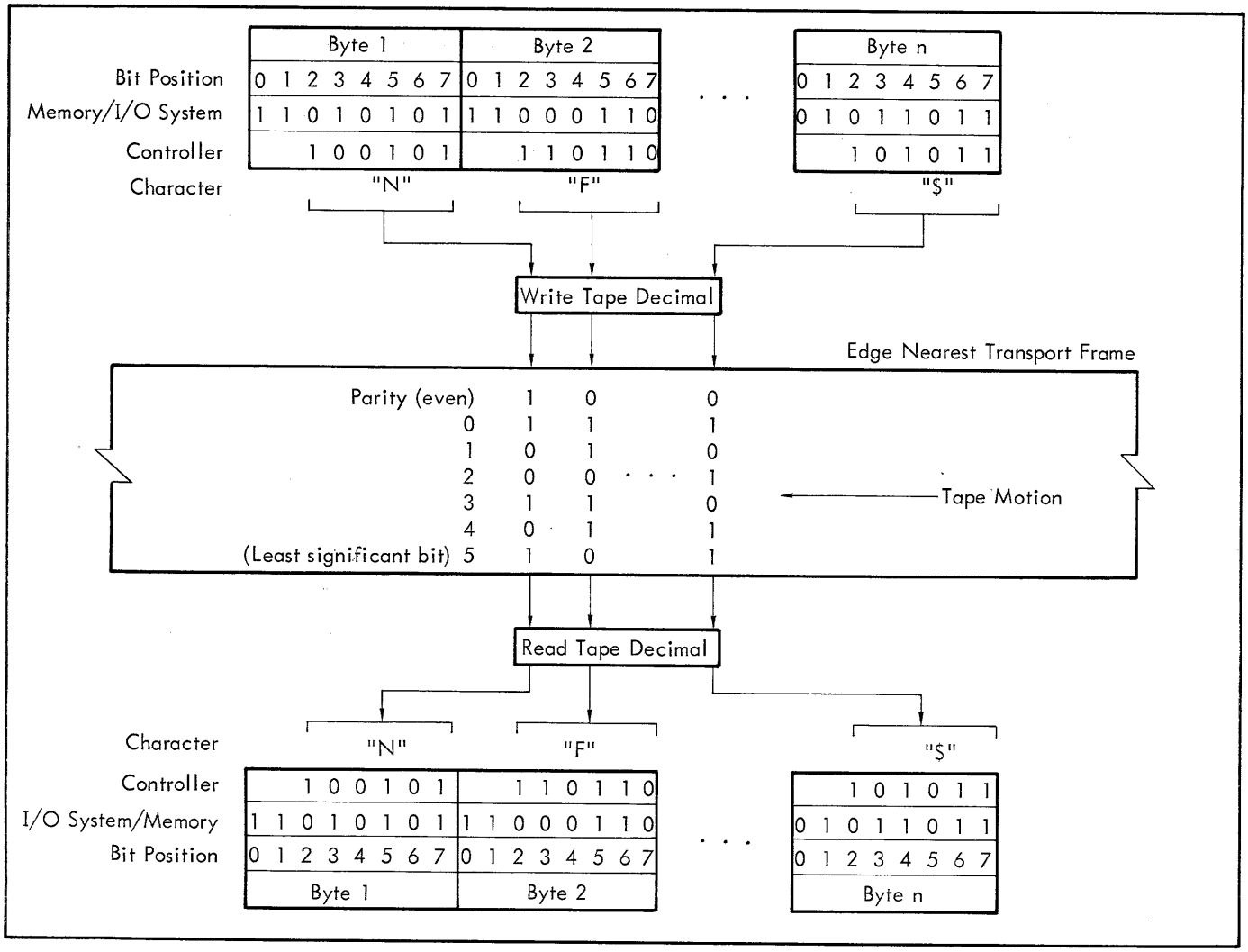


Figure 2. Data Representation on Tape – Decimal (BCD) Mode

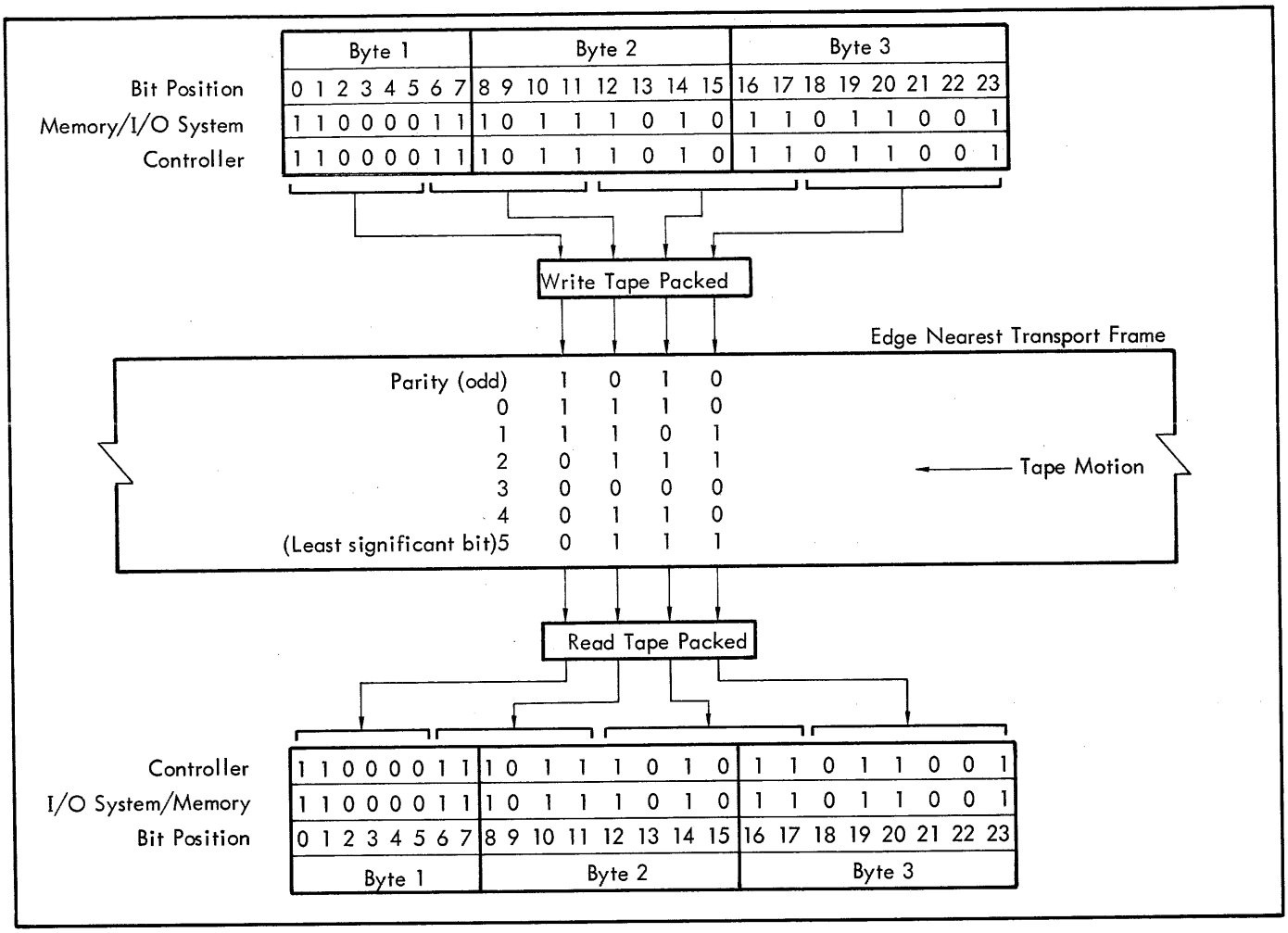


Figure 3. Data Representation on Tape – Packed Binary Mode

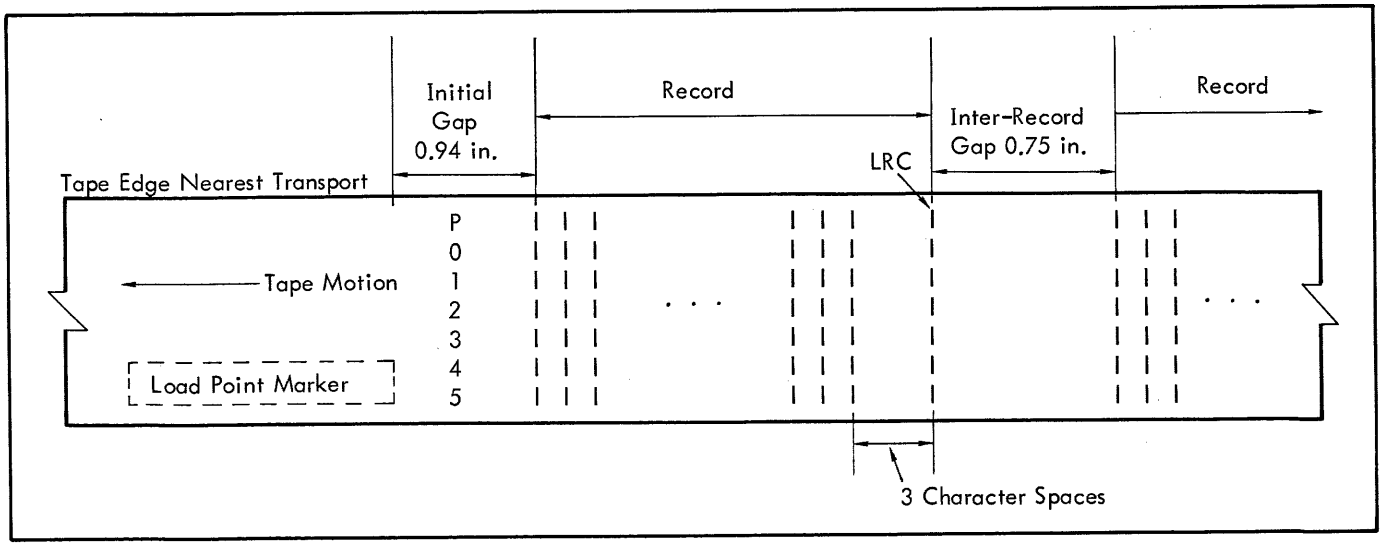


Figure 4. Physical Spacing on Tape

the heavy black lines are included in the standard EBCDIC 62-character set and, during a read operation, only those codes are sent to the I/O system regardless of which code was transmitted from the computer.

All upper case alpha and numeric EBCDIC characters are translated without character change. Lower case alpha characters are recorded and read back as upper case characters. Control codes are recorded and read back as shown in the table. Some special characters are changed to conform to the 62-character set. Parity on tape in this mode is always even.

PACKED BINARY MODE

During a write operation in the packed binary mode (see Figure 3), each three 8-bit bytes from memory will result in the recording of four 6-bit characters on tape. Each bit is preserved in its relative location. The last tape character written will be filled with zeros if the computer does not provide a multiple-of-three number of bytes.

The conditions prevailing during writing in this mode are called "Write Packed End Conditions" and are outlined as follows:

1. If the record contains 3N bytes, 4N characters will be recorded on tape.

2. If the record contains 3N+1 bytes, 4N+2 characters will be recorded, the last character containing zeros in the four least significant bit positions.

3. If the record contains 3N+2 bytes, 4N+3 characters will be recorded, the last character containing zeros in the two least significant bit positions.

During a read operation in this mode, 6-bit binary characters read from tape are packed sequentially in descending sequence (left to right) with bytes transmitted to the computer. Thus, four tape characters will be packed into exactly three bytes transmitted to memory via the I/O system.

If a multiple of four tape characters is not associated with a tape read operation, those additional few characters beyond 4N are "left-adjusted" within the proper 3-byte group in memory. The last memory byte stored will be filled with some number of zeros (2, 4, or 6, as required) if the tape record does not contain some multiple-of-four number of characters. (Note: When reading tapes that were written in this system, the last memory byte stored will always contain 8 zeros if 4N tape characters were not written.)

The conditions prevailing during reading in this mode are called "Read Packed End Conditions" and are outlined below. It is assumed that the "count done" is not sent until all the characters have been sent to the I/O system.

1. If 4N characters are read from tape, 3N bytes will be sent from the controller.

2. If 4N+1 characters are read from tape, 3N+1 bytes will be sent from the controller, the last byte containing zeros in the two least significant bit positions.

3. If 4N+2 characters are read from tape, 3N+2 bytes will be sent from the controller, the last byte containing zeros in the four least significant bit positions.

4. If 4N+3 characters are read from tape, 3N+3 bytes will be sent from the controller, the last byte containing zeros in the six least significant bit positions.

The following byte count conditions will prevail at the I/O system after writing and immediately reading that same record in the packed mode:

Bytes Sent (Write Packed)	Bytes Received (Read Packed)
3N	3N
3N+1	3N+2
3N+2	3N+3

Parity in the packed mode is always odd.

LRC CHARACTERS

As data bytes from memory are written on tape, the controller develops a longitudinal redundancy check (LRC) character. This character is written on tape following the data record.

During writing, the parity of each track is automatically determined 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 and read 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 enables I/O address recognition, but the tape unit assumes a "not operational" state. Also, failure of the 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 any one of the following 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, the tape goes off the reel, or breaks.

Device Ready. A tape unit may be in either the "ready" or "busy" condition. 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 "ready" while the tape controller is "busy" with some other tape unit (since more than one unit can be connected to one controller). Also, a tape unit may be "busy" (rewinding), yet the controller may be "ready". 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 either in the "ready" or "busy" condition. 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 satisified 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 1 summarizes the allowable state transitions and the conditions that cause them.

DATA TRANSFER

This tape device uses three modes of data transfer: binary, decimal (BCD), and packed binary (the formats are 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 and 7 only, 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.

For Write orders, 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 after the "count done" signal is encountered and the read-after-write checking is completed. For Read orders, the data transfer ends when 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 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 1. 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 15 orders that specify tape unit operations. Receipt of any invalid order will result in either the generation of an "unusual end" or an undefined operation. 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 Tape Packed (Binary)	02
Read Tape Binary	06
Read Tape Decimal (BCD)	0E

When the tape unit receives a Read order, it starts forward tape motion. Tape is read in one of three program-selected modes: Binary, Packed Binary, or BCD (see Chapter 2). The tape controller checks vertical parity as each character is read. 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 LRC character. This applies to "tape mark" records, also. If no further order is pending, the tape comes to a stop with the read/write heads located in the interrecord gap.

An LRC character is developed while reading from tape. The resulting check character is compared with that written on the tape. If the check characters do not match, the Transmission Data Error indicator is set.

WRITE ORDERS

Write Orders	Hexadecimal Code
Write Tape Packed (Binary)	01
Write Tape Binary	05
Write Tape Decimal (BCD)	0D
Write Tape Mark	73

When the tape unit receives a Write order, it starts forward tape motion. Tape is written in one of three program-selected modes: Binary, Packed Binary, or BCD (see Chapter 2). Vertical parity is generated and recorded with each 6 data bits. Tape motion and writing continue until the desired number of characters, determined when the byte count reaches zero, has been recorded.

As the data is transmitted, the tape controller develops the LRC character. It is written on tape following the data record. Also during the write operation, a "read-after-write" process takes place, reading each character just written and checking its vertical parity. During this reading process, another LRC character is generated and compared with the one written on tape. A mismatch between the two LRC characters, or a vertical parity error detection, results in setting the Transmission Data Error indicator. If no further orders are received after the tape unit has read the LRC character, the tape comes to a stop.

When the tape unit receives a Write Tape Mark order, it starts forward tape motion and writes a tape mark record (conforming to IBM 7-track standards). A "channel end" is generated as soon as the LRC character for the tape mark record has been read. The End-of-File indicator is also set following a write tape mark. A tape mark record is defined as any record containing only characters coded (17_8), even parity. This character is the BCD (√). The equivalent EBCDIC character is (").

To write a tape mark in a 7-track system, use the Write Tape Mark order, hexadecimal code 73. The tape will automatically generate a single 17_8 character (√) with even parity and the accompanying LRC character.

The only normal means for preventing a write operation is by removing the write-enable ring from the tape reel. The tape unit 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.

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 the 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 is erased preceding the record. If the next order received is other than a Write order, this indicator is immediately reset.

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 a START INPUT/OUTPUT (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 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 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 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 a Space Record Backward or Space File Backward order is given to a tape unit that is already positioned at the load point.

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, and write-protect violation.

†Not applicable to Sigma 2.

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), 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.

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.

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 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 2 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

The following 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.

STATUS RESPONSE FOR SIO, TIO, AND HIO

Bit 0: Device Interrupt Pending. If this bit is a 1, an interrupt call is pending, that is, issued but not yet acknowledged by an AIO instruction. Another SIO instruction will not be accepted until the interrupt is cleared; however,

Table 2. Magnetic Tape Unit I/O Instruction Status Bits

Instruction	Status Bits† CC1 or O	CC2 or C	Significance
SIO	0	0	I/O address recognized and SIO accepted (i.e., tape unit has advanced to "busy" condition).
	0	1	I/O address recognized but SIO not accepted (i.e., tape unit was already "busy" or device interrupt is pending).
	1	0	Tape unit is attached to a "busy" Selector IOP (not applicable to Sigma 2).
	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	1	I/O address not recognized.
TIO	0	0	I/O address recognized and SIO can currently be accepted (i.e., tape unit in "ready" condition with no device interrupt pending).
	0	1	I/O address recognized but SIO cannot currently be accepted.
	1	0	Tape unit is attached to a "busy" Selector IOP (not applicable to Sigma 2).
	1	1	I/O address not recognized.
TDV	0	0	I/O address recognized.
	1	0	Tape unit is attached to a "busy" Selector IOP (not applicable to Sigma 2).
	1	1	I/O address not recognized.
AIO	0	0	Normal interrupt (i.e., "channel end" or "zero byte count" condition present).
	0	1	Unusual interrupt (i.e., "unusual end" condition present).
	1	1	No interrupt condition present.

†The symbols "CC1" and "CC2" refer to condition code bits in Sigma 5/7 computers. The symbols "O" and "C" refer, respectively, to overflow and carry indicators in Sigma 2 computers.

command chaining may occur, producing further input or output. The interrupt can be cleared by execution of an AIO or HIO instruction, or by manual intervention. On Sigma 5/7 computers, the interrupt can be cleared manually by the I/O RESET switch on the control panel; on Sigma 2, by the INITIALIZE switch on the control panel.

Bits 1-2: Tape Unit Condition. A combination of these two flags reflects the current tape unit condition.

Flags	Condition
00	Tape Unit Ready – the tape unit is operational and not connected to the device controller for an operation; it can accept an SIO instruction if no device interrupt is pending.
01	Tape Unit Not Operational – a fault condition exists in the tape unit; for example, power is OFF, tape unit has an open interlock, its RESET button is depressed, it is in the load cycle, or it is in the process of repositioning tape at the load point, at the conclusion of a rewind.
10	Not used – this condition is not applicable to the magnetic tape system.
11	Tape Unit Busy – the unit is operational; it has accepted an SIO instruction, it is currently executing a previous order, or it is rewinding.

Bit 3: Mode – Automatic or Manual. If this bit is a 1, the tape unit is in the "automatic" mode and, therefore, it is under program control. If this bit is a 0, the unit is in the "manual" mode and requires operator intervention to enter the "automatic" mode. An SIO can be accepted in either mode but execution of an order requiring tape movement will be delayed until the unit is in "automatic" mode.

Bit 4: Device Unusual End. A 1 in this bit position indicates that the device controller has encountered an "unusual

end" condition since accepting the last order (see "Unusual End").

Bits 5-6: Device Controller Condition. A combination of these two flags reflects the current magnetic tape controller condition.

Flags	Condition
00	Device Controller Ready – the controller, if on-line (I/O address recognition), is in standby state (but may have an interrupt pending) and is not under Peripheral Equipment Tester (PET) control.
01	Not used.
10	Not used.
11	Device Controller Busy – the controller is on-line and currently performing an operation.

Bit 7: Not Used. This bit is not used and is always reset to zero.

STATUS RESPONSE FOR TDV

Bit 0: Data Overrun. If this bit is a 1, the device controller detected a data overrun during the last read or write operation. This condition is caused either by equipment malfunction or by the I/O data rate exceeding the controlling system limits. Upon encountering a data overrun during a write operation, erroneous information is written. For reading or writing, a data overrun is a fault condition and the complete operation must be repeated.

Bit 1: Write Permitted. If this bit is a 1, both writing and reading may be performed. If it is a 0, the addressed device is write-protected, i.e., only reading may be performed. Insertion of a "write-enable" ring on the tape reel puts the device into the "write-permitted" state.

Bit 2: Write-Protected Violation Error. A 1 in this position indicates that the last order received was a Write order but the selected device is write-protected.

Bit 3: End-of-File. A 1 in this bit position either indicates that the last record read or spaced over was a tape mark record, the last reverse spacing halted the tape at the load point marker, or the last order initiated was a Write Tape Mark.

Bit 4: Not Used. This bit is not used and is always reset to zero.

Bit 5: Load Point. If this bit is a 1, the addressed device is positioned at the load point marker.

Bit 6: End-of-Tape. If this bit is a 1, the selected device has the tape positioned past the end-of-tape (EOT) marker. Any tape operation may be initiated while this bit is set, but extensive forward tape operations might run off the end of the tape†. Bit 6 remains set until a backward operation encounters the end-of-tape marker again or until the tape unit is switched from the "automatic" mode.

Bit 7: Rewind On-Line. This bit is a 1 while the addressed device is in the process of rewinding ("automatic" mode).

†Physical end of tape is 14 feet after EOT marker.

STATUS RESPONSE FOR AIO

Bit 0: Data Overrun. A 1 in this bit position indicates that the addressed device controller has detected a data overrun during the previous read or write operation. This condition is caused either by equipment malfunction or by the I/O data transfer rate exceeding controlling system limits. Upon encountering a data overrun during writing, erroneous information is written. For reading or writing, a data overrun is a fault condition and the complete operation must be repeated.

Bit 1: Device End. A 1 in this bit position indicates that the last I/O interrupt generated was a device end interrupt. A device end interrupt is generated either when a tape unit has just completed a Rewind and Interrupt order execution or it has just been put in the "automatic" mode by an operator after setting the ATTENTION switch (see "Attention", Chapter 4, Operations).

Bit 2: Write-Protect Violation Error. If this bit is a 1, the last order received was a Write but the device selected is write-protected.

Bit 3: End-of-File. If this bit is a 1, either the last record read or spaced was a tape mark record, the last reverse spacing halted the tape at the load point marker, or the last order initiated was a Write Tape Mark.

Bits 4-7: Not Used. These bits are not used and are always reset to zeros.

OPERATIONAL STATUS BYTE

In addition to the information contained in the Device Status Byte, the following indicators are made available to the controlling system in an Operational Status Byte transmitted at "channel end".

INCORRECT LENGTH

If this flag is a 1, an incorrect length condition has occurred since the previous command or command chain was received by the device, i.e., since the last SIO instruction (also see "Error Conditions").

TRANSMISSION DATA ERROR

If this flag is a 1, a data overrun or a parity error has occurred since the previous command or command chain was received by the device, i.e., since the last SIO instruction (also see "Error Conditions").

CHANNEL END

If this flag is a 1, the device has released the channel for any of the reasons listed under "Channel End Conditions".

DEVICE UNUSUAL END

If this flag is a 1, execution of the previous order was terminated due to an abnormal condition, as listed under "Unusual End Conditions".

PROGRAMMING CONSIDERATIONS

Figure 5 illustrates the sequential relationship of the key events that occur during a magnetic tape operation.

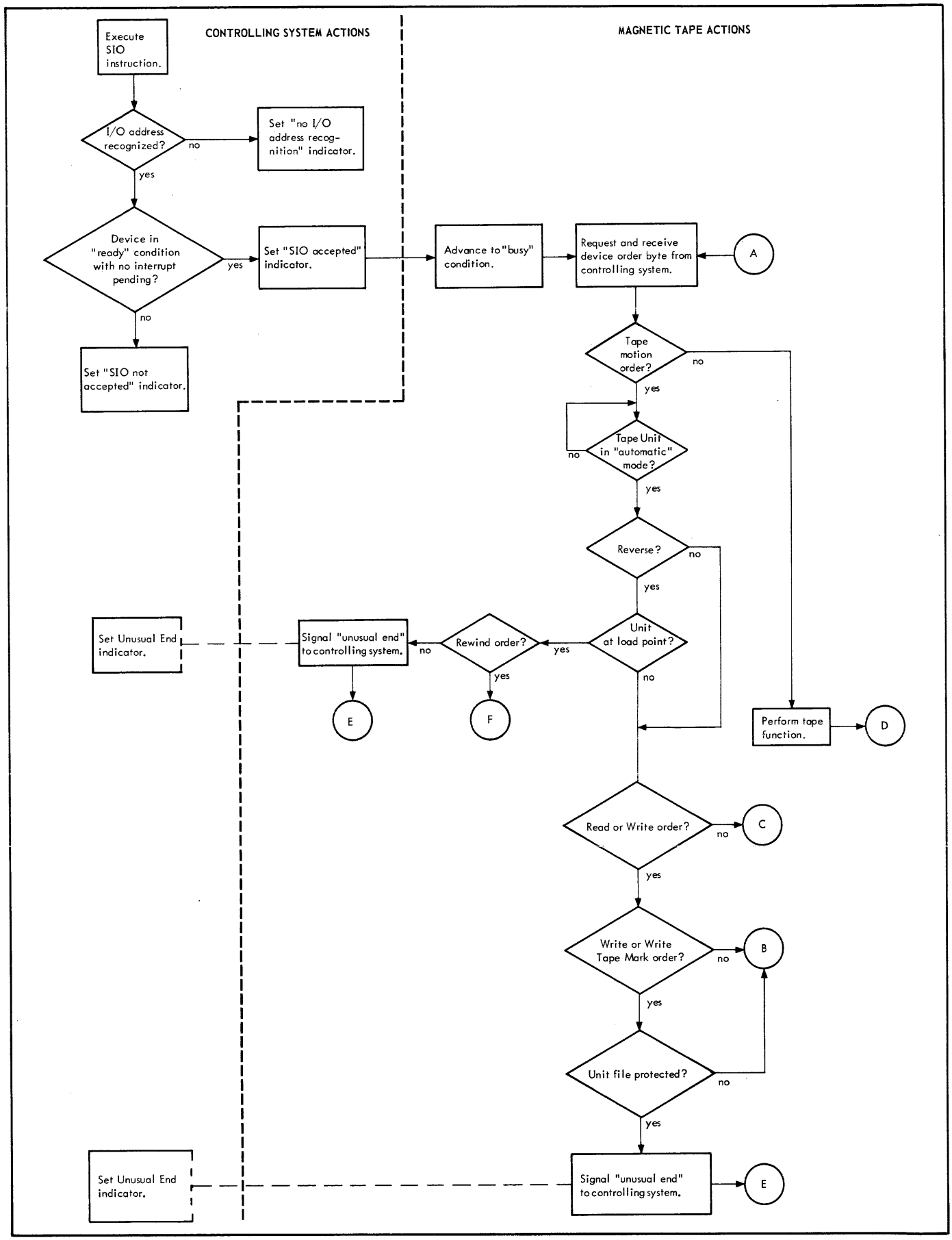


Figure 5. Controlling System/Magnetic Tape Actions

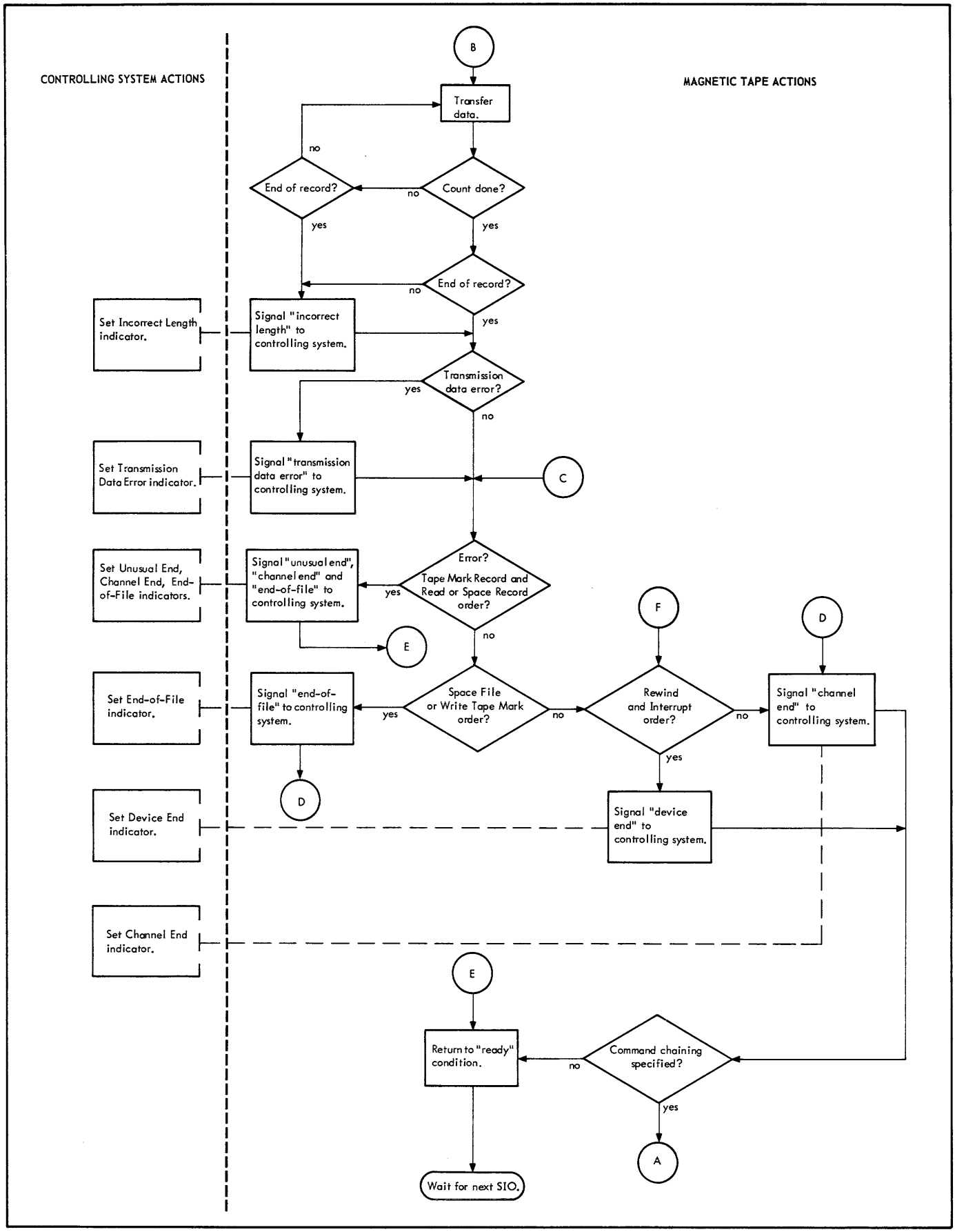


Figure 5. Controlling System/Magnetic Tape Actions (continued)

4. OPERATIONS

OPERATOR CONTROLS

The operator control panel (see Figure 6) 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.

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.

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 should light.

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.

RESET

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

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. Model 7371 controller can have eight tape units connected to it. Model 7361 controller can have a maximum of two tape units connected to it (each unit may be switched to any one of the 8 switch positions). No two units connected to a controller may have the same switch setting (except OFF).

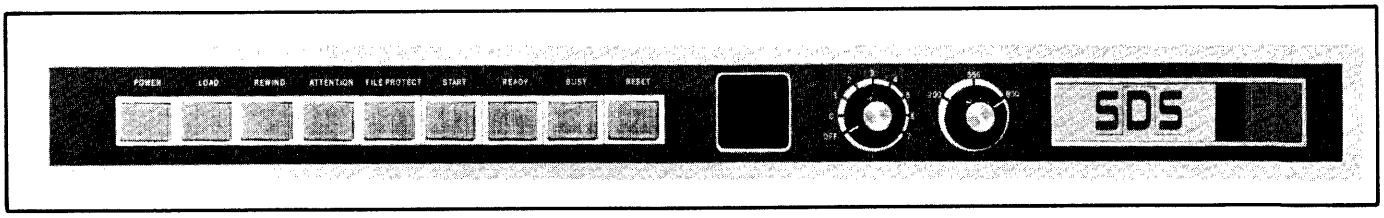


Figure 6. Operator Control Panel (Model 7372)

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.

DENSITY SELECT

This switch permits the selection of one of three operating densities: 200, 556, or 800 bits per inch for Models 7371/7372. Models 7361/7362 record at 556 bits per inch only.

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 it in both hands.

AUXILIARY (MAINTENANCE) CONTROL PANEL

This panel (see Figure 7) 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 7372 unit is 75 inches per second, and 37.5 inches per second for a Model 7362. When a direction switch is used in conjunction with the FAST switch, the speed is 250 inches per second on the 7372, and 150 inches per second on the 7362.

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 opened 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 8):

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 opened position (which releases the reel motor brakes).

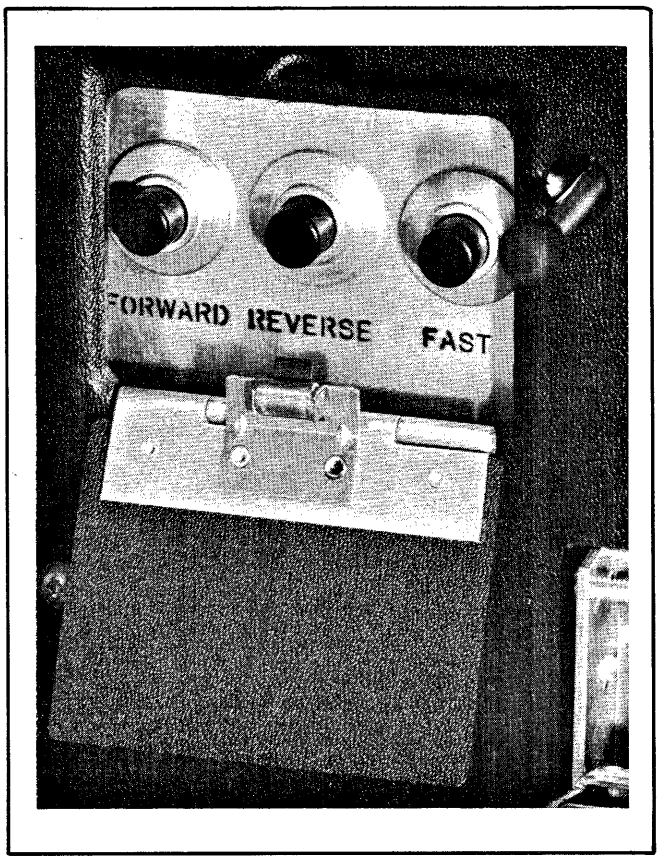


Figure 7. Auxiliary Control Panel

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 8. 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, feeding 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.

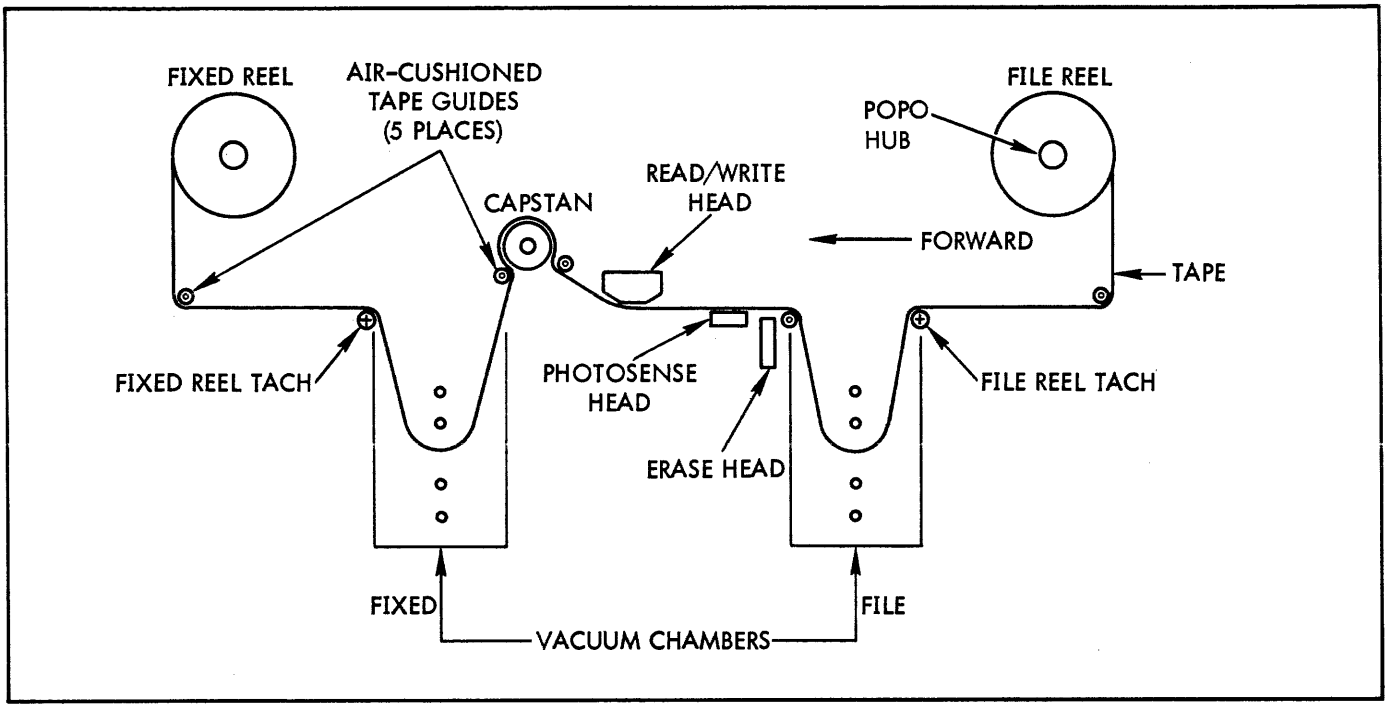


Figure 8. Magnetic Tape Transport Tape Path

APPENDIX A

SIGMA BCD – EBCDIC CONVERSION CHART

EBCDIC Character	EBCDIC Code Hexadecimal	BCD Code Octal	BCD Character	EBCDIC Character	EBCDIC Code Hexadecimal	BCD Code Octal	BCD Character
A	C1	61	A	6	F6	06	6
B	C2	62	B	7	F7	07	7
C	C3	63	C	8	F8	10	8
D	C4	64	D	9	F9	11	9
E	C5	65	E				
F	C6	66	F	blank	40	20	blank
G	C7	67	G	¢	4A	72	? or backspace
H	C8	70	H	.	4B	73	.
I	C9	71	I	<	4C	74	) or ¤
J	D1	41	J	(	4D	75	[
K	D2	42	K	+	4E	76	<
L	D3	43	L	|	4F	77	≠
M	D4	44	M	&	50	60	+ or &
N	D5	45	N	!	5A	52	! or Carr. Ret.
O	D6	46	O	$	5B	53	$
P	D7	47	P	*	5C	54	*
Q	D8	50	Q	)	5D	55	]
R	D9	51	R	;	5E	56	;
S	E2	22	S	¬	5F	57	△
T	E3	23	T	-	60	40	- (dash or minus)
U	E4	24	U	/	61	21	/
V	E5	25	V	none assigned	6A	32	‡ or tab
W	E6	26	W	,	6B	33	,
X	E7	27	X	%	6C	34	(or %
Y	E8	30	Y	-	6D	35	~
Z	E9	31	Z	>	6E	36	\
				?	6F	37	#
0	F0	12	0[†]	:	7A	12	0[†]
1	F1	01	1	#	7B	13	# or =
2	F2	02	2	@	7C	14	@ or '
3	F3	03	3	'	7D	15	:
4	F4	04	4	=	7E	16	>
5	F5	05	5	"	7F	17	√[††]

[†]During writing, both X 'F0' and '7A' are recorded as 12_8 on the tape. During reading, 12_8 is always read and translated as X 'F0'.

[††]A tape record consisting of only (√) characters is defined as a tape mark. See discussion on Tape Marks for complete information.

SIGMA BCD–EBCDIC CONVERSION CHART

Most Significant Digit	Least Significant Digit															
Hexa-decimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	ↄ Null	A	B	C	D	E HT	F	G	H EOM	I	?	.	)	[	<	ǂ
1	&	J	K	L	M	N NL	O	P	Q	R	!	$	*	]	;	△
2	- ds	/ ss	S fs	T si	U	V	W	X	Y	Z	ǂ	,	%	¬	\	ǂǂ
3	0	1	2	3	4	5	6	7	8	9	0†	#	@	:	>	√
4	ↄ blank	A	B	C	D	E	F	G	H	I	? ¢	. .	) <	[(	< +	ǂ |
5	& &	J	K	L	M	N	O	P	Q	R	! !	$ $	* *	])	; ;	△ ¬
6	- -	/ /	S	T	U	V	W	X	Y	Z	ǂ	, ,	% %	¬ -	\ >	ǂǂ ?
7	0	1	2	3	4	5	6	7	8	9	0† :	# #	@ @	: '	> =	√ "
8	ↄ	A a	B b	C c	D d	E e	F f	G g	H h	I i	?	.	)	[	<	ǂ
9	&	J j	K k	L l	M m	N n	O o	P p	Q q	R r	!	$	*	]	;	△
A	-	/	S s	T t	U u	V v	W w	X x	Y y	Z z	ǂ	,	%	¬	\	ǂǂ
B	0	1	2	3	4	5	6	7	8	9	0†	#	@	:	>	√
C	ↄ	A A	B B	C C	D D	E E	F F	G G	H H	I I	?	.	)	[	<	ǂ
D	&	J J	K K	L L	M M	N N	O O	P P	Q Q	R R	!	$	*	]	;	△
E	-	/	S S	T T	U U	V V	W W	X X	Y Y	Z Z	ǂ	,	%	¬	\	ǂǂ
F	0 0	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	0†	#	@	:	>	√ CD

NOTES:

1. The chart shows the BCD character that is recorded on tape for the EBCDIC code sent. If an EBCDIC character is assigned, it is shown below the BCD character.
2. The characters enclosed within the heavy lines are the standard SDS 62-graphic set.
3. During read, only those codes and their appropriate characters that are enclosed in the heavy lines are sent to the I/O system, regardless of the code that was sent by the computer.
4. See Appendix A in the Sigma Computer Reference Manuals for the functions of the control codes included in this chart.

†Codes X'3A', '7A', 'BA', and 'FA' are recorded and read back as BCD '0'.

APPENDIX B

SIGMA 5/7 PROGRAMMING EXAMPLE

The following coding sequence shows magnetic tape programming with an SDS Sigma 5 or Sigma 7 Computer. It is an example of a common SIO routine, entered from a program that sends a Write Binary 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
	:	:	
	LI, 1	1	In the Write routine, before branching to the common SIO routine, the starting address of the buffer is converted to a byte address and stored in the command doubleword (in the second halfword).
	LW, 9	BUFFADR	
	SCS, 9	2	
	STH, 9	ORDWB, 1	
	:	:	
	LI, 0	DA(ORDWB)	This instruction loads register 0 with the doubleword address of the command doubleword for the Write Binary 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	R2	
	CS, 2	R1	
	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 doubleword is automatically accessed upo 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 follows. 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.
ORDWB	ORD1	X'05',0	Write Binary 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 Binary order is desired, therefore, a hexadecimal 05 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 changed; the field can be loaded with a new byte count.

SIGMA 2 PROGRAMMING EXAMPLE

The following Sigma 2 magnetic tape program either writes or reads tape in the packed mode (the maximum record length is 8190 bytes). Tape may be skipped forward or backward one record, erased, or rewound. This program also allows writing a tape mark. The main program sets up locations designating the tape unit's address, the desired number of bytes, and the address of the area to be dumped on tape or to be used as a read-in area. The byte count must always be even so that data begins on a word boundary, not on a byte boundary. This routine assumes that no other I/O device is operating at the time it is entered.

The main program enters this routine via one of the following sequences:

Label	Command	Argument	Comments
	LDX B	=TAPERETN MTWRITE	Write a record.
	LDX B	=TAPERETN MTREAD	Read a record.
	LDX B	=TAPERETN MTSKPFWD	Skip a record forward.
	LDX B	=TAPERETN MTSKPREV	Skip a record backward.
	LDX B	=TAPERETN MTMRKWRT	Write a file mark.
	LDX B	=TAPERETN MTERASE	Set erase indicator.
	LDX B	=TAPERETN MTREWIND	Rewind tape.

There are five possible returns to the main program at location TAPERETN:

TAPERETN	B	SIONP	The SIO instruction could not be executed.
+1	B	ERROR	An error occurred during the operation.
+2	B	ENDOTAPE	The EOT indicator was set at the completion of the last operation and no errors.
+3	B	ENDOFILE	The EOF bit was set at the completion of the last operation and no errors.
+4	B	SUCCESS	Normal operation – proceed with main program.
MTWRITE	LDA B	MTWORDER MTEXECUT	Get Write (Packed) order. Go execute order.
MTREAD	LDA B	MTRORDER MTEXECUT	Get Read (Packed) order. Go execute order.
MTSKPFWD	LDA B	MTSKFORD MTEXECUT	Get Skip Record Forward order. Go execute order.
MTSKPREV	LDA B	MTSKRORD MTEXECUT	Get Skip Record Backward order. Go execute order.
MTMRKWRT	LDA B	MTWTMORD MTEXECUT	Get Write Tape Mark order. Go execute order.
MTERASE	LDA B	MTERSORD MTEXECUT	Get Set Erase order. Go execute order.
MTREWIND	LDA	MTREWORD	Get Rewind order.
MTEXECUT	STA	ORDER	Save order.

Label	Command	Argument	Comments
	LDA	MTADDRES	Execute a TIO to the unit to be operated on.
	TIO		
	STA	TIOSTAT	Save TIO status.
	RD	X'CO'	Get the O and C bits and save them in TIOSTAT+1.
	AND	=3	
	STA	TIOSTAT+1	
	BAZ	$+2	Is "SIO accepted"? (O and C = 0?)
	B	EXIT	No – Return to main program.
	LDA	MTADDRES	Yes – Generate the even and odd channel register addresses and save
	SCRS	3	the addresses in locations ECHANNEL and OCHANNEL
	AND	=X'E'	(E = I/O CHANNEL x 2+8, and O = I/O CHANNEL x 2+9).
	ADD	=8	
	STA	ECHANNEL	
	RCPYI	7,7	
	STA	OCHANNEL	
	LDA	MTBFRADR	Get the buffer memory address (this location is set up by the main program).
	STA	ORDER+1	Save buffer memory address.
	LDA	MTBYTCNT	Get byte count (set up by main program).
	OR	=X'2000'	Set interrupt bit.
	STA	ORDER+2	Save byte count plus interrupt bit.
	LDA	=ORDER	Set up even channel register with the address of the specified order.
	WD	*ECHANNEL	
	LDA	=X'6001'	Set up odd channel for one byte (order) and set the data chain and
	WD	*OCHANNEL	interrupt bits.
	LDA	=MTINTRPT	Set up I/O interrupt location.
	STA	X'106'	
	LDA	=X'200'	Arm and enable the I/O interrupt.
	WD	*INTARM	
	LDA	MTADDRES	Execute the specified order.
	SIO		
	STA	SIOSTAT	Save SIO status.
	RD	X'CO'	Get O and C bits.
	AND	=3	
	STA	SIOSTAT+1	Save O and C bits.
	BAZ	$+2	Was "SIO accepted"? (O and C = 0?)
	B	EXIT	No – Return to main program.
WAIT	WAIT		Yes – Wait for interrupt.
MTINTRPT	DATA	0	These two locations are to hold the program status doubleword.
	DATA	0	
	LDA	=X'200'	Disarm the I/O interrupt.
	WD	*IDISARM	
	AIO		Execute an AIO instruction and save the status plus the O and C bits.
	STA	AIOSTAT	
	RD	X'CO'	
	AND	=3	
	STA	AIOSTAT+1	
	LDA	MTADDRES	Get device address.

Label	Command	Argument	Comments
	TIO		Get device and controller status.
	AND	=X'6000'	Save device status.
	CP	=X'6000'	Test device for "busy".
	BNC	$+5	"Busy"?
	LDA	=X'200'	Yes – Arm and enable the I/O interrupt.
	WD	*INTARM	
	WD	X'D8'	
	LDX	IDISARM	
	RD	*ECHANNEL	Get operational status byte.
	AND	=X'C800'	
	STA	ERRSAVE	Save TE, IL, and UE bits.
	LDA	AIOSTAT	
	AND	=X'A000'	Save rate error and write-protect violation bits.
	OR	ERRSAVE	
	BAZ	$+2	Did an error occur?
	B	EXIT-1	Yes – Return to main program.
	LDA	MTADDRES	
	TDV		
	STA	TDVSTAT	
	SCLS	3	
	BAN	EXIT-3	Tape mark? (EOF)
	SCLS	3	No – Position EOT bit.
	BAN	EXIT-2	End Of Tape?
	RCPYI	4,4	No – Normal return to main program.
	RCPYI	4,4	End Of File return.
	RCPYI	4,4	End Of Tape return.
	RCPYI	4,4	Error return.
EXIT	RCPY	4,1	Index register to program register.
			CONSTANTS
MTWORDER	DATA	X'0001'	Write Packed order.
MTRORDER	DATA	X'0002'	Read Packed order.
MTSKFORD	DATA	X'0043'	Skip Record Forward order.
MTSKRORD	DATA	X'004B'	Skip Record Backward order.
MTWTMORD	DATA	X'0073'	Write Tape Mark order.
MTERSORD	DATA	X'0063'	Set Erase order.
MTREWORD	DATA	X'0033'	Rewind On-line order.
MTADDRES	DATA	X'0080'	Address of tape unit (set up by main program).
MTBFRADR	DATA	0	Address of tape buffer (set up by main program).
MTBYTCNT	DATA	0	Byte count (set up by main program).
ECHANNEL	DATA	X'0008'	Even channel register address.
OCHANNEL	DATA	X'0009'	Odd channel register address.
ORDER	DATA	0	This location contains the current order.
	RES	2	These locations contain buffer address and byte count.
TIOSTAT	RES	2	Reserved for TIO status storage.
SIOSTAT	RES	2	Reserved for SIO status storage.
AIOSTAT	RES	2	Reserved for AIO status storage.
TDVSTAT	RES	2	Reserved for TDV status storage.
INTARM	DATA	X'1200'	Arm and enable interrupt control word.
IDISARM	DATA	X'1100'	Disarm interrupt control word.
	DATA	WAIT	Address of wait location for interrupt.
ERRSAVE	DATA	0	Temporary storage of error bits.