

SEPARATOR SET PN 83464

THIS SEPARATOR SET CONTAINS 19  
TABS TOTAL IN THE FOLLOWING  
ORDER:

MAINTENANCE MANUAL

1. INTRODUCTION
2. OPERATION
3. INSTALLATION
4. STORAGE TEK INTERFACE
5. INDUSTRY INTERFACE
6. SCSI INTERFACE
7. VS INTERFACE
8. FUNCTIONAL DESCRIPTION
9. MAINTENANCE
10. REMOVAL/REPLACEMENT
11. DIAGNOSTICS

APPENDICES

IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD

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**Storage Technology Corporation**

**2920  
Tape  
Subsystem**

**Maintenance Manual**

**PN 95521**

**JANUARY 1986**

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IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD



# CHAPTER 1

## GENERAL INFORMATION

### 1.1 INTRODUCTION

This chapter is an introduction to the Storage Technology Corporation Model 292X Magnetic Tape Subsystem (MTS). This chapter includes a general description of the physical and functional layout of the MTS and includes the MTS specifications.

Two model types are available, the 2921 and the 2922. The 2921 has a tape speed of 50 inches per second (ips) (127 cm/s), start/stop. The 2922 has a tape speed of 50 ips (127 cm/s) start/stop and 100 ips (254 cm/s) streaming.

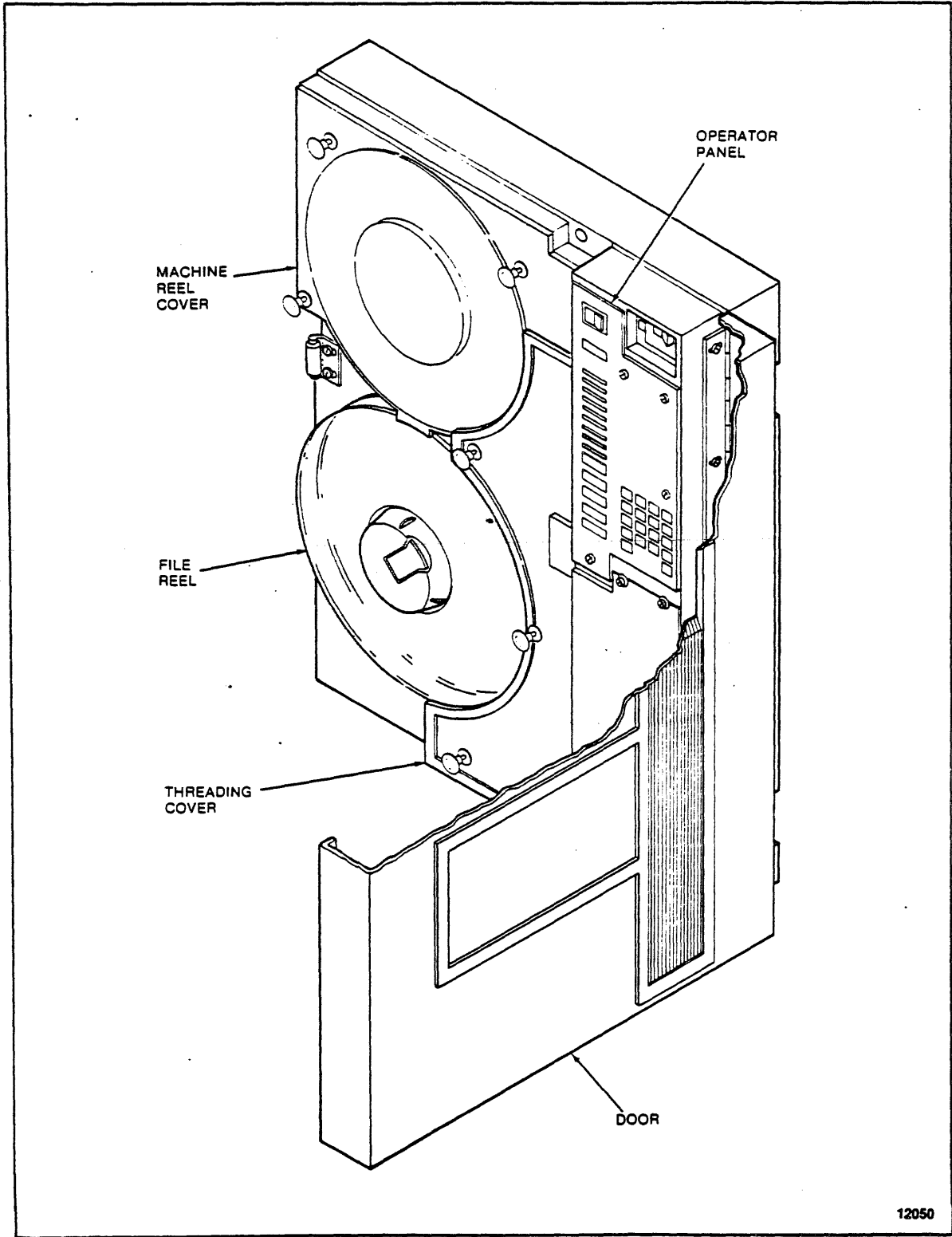
### 1.2 GENERAL DESCRIPTION

The MTS (Figures 1-1 through 1-4) is an integrated tape formatter/controller and half-inch (12.7 cm) tape drive packaged as a single self-contained unit (1x1). The MTS is a dual-density device capable of recording and reading ANSI compatible tapes in phase-encoded (PE) format at 1600 bits per inch (bpi) (63 bpm) and group-coded recording (GCR) format at 6250 bpi (246 bpm) at a tape speed of 50 (127 cm/s) or 50/100 ips (127 cm/s/254 cm/s), depending on the model.

The MTS is a low-cost, medium performance device intended for use in normal tape processing and/or disk off-loading. The device features automatic or semiautomatic tape threading/loading of open reel sizes 7, 8.5, and 10.5 inches; tension arm tape buffering; microprocessor capstan servo and microprocessor reel servo; and on-board diagnostics for functional verification and fault detection.

Data can be read when tape is moving either forward or backward but recording can be performed during forward tape motion only. Performance specifications are shown in Table 1-1.

Nominal access time from stop is shown in Table 1-2 for the models 2921 and 2922. Access time is defined as the time from assertion of Busy on receipt of a read or write command at the interface to the time the beginning of the record is read from or written to tape. This is assuming tape starts from a stopped position, no turn-around condition is required, and tape is not positioned at BOT. See Chapter 2 for a detailed description of the access time and interblock gap generation.



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Figure 1-1. Model 292X MTS Front View (Vertical Mount)

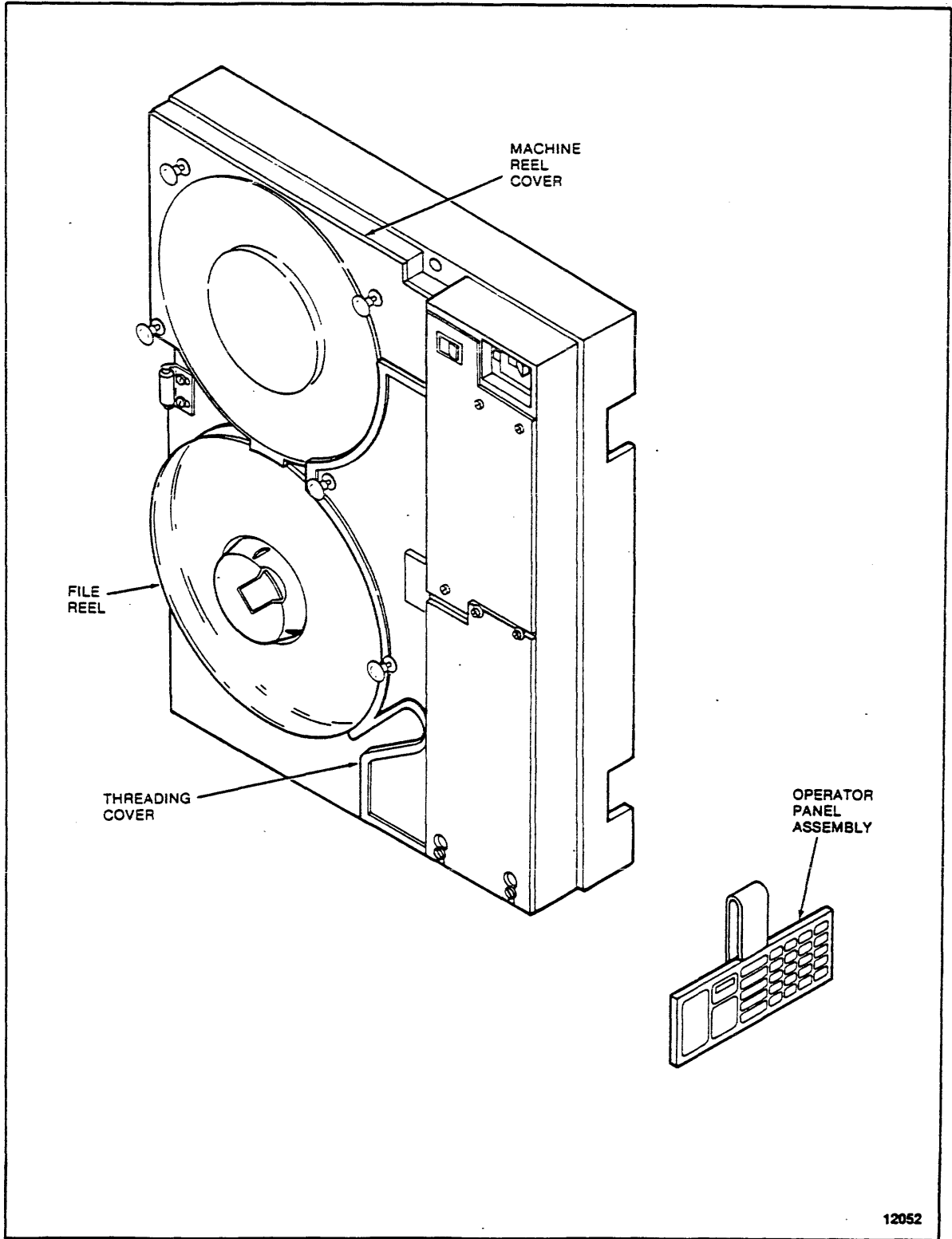


Figure 1-2. Model 292X MTS Front View (Center of Gravity Mount)

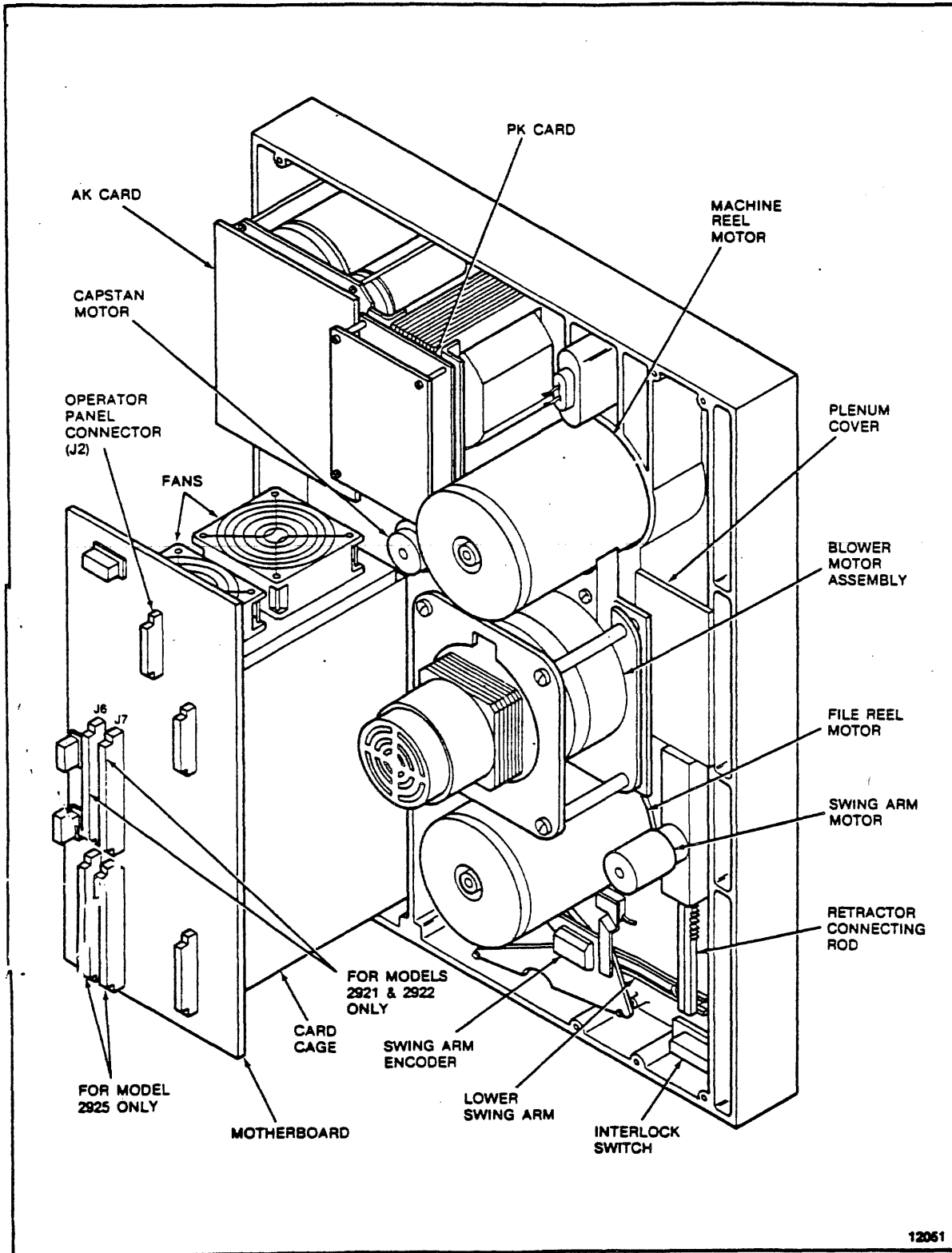


Figure 1-3. Model 292X MTS Rear View (Vertical Mount)

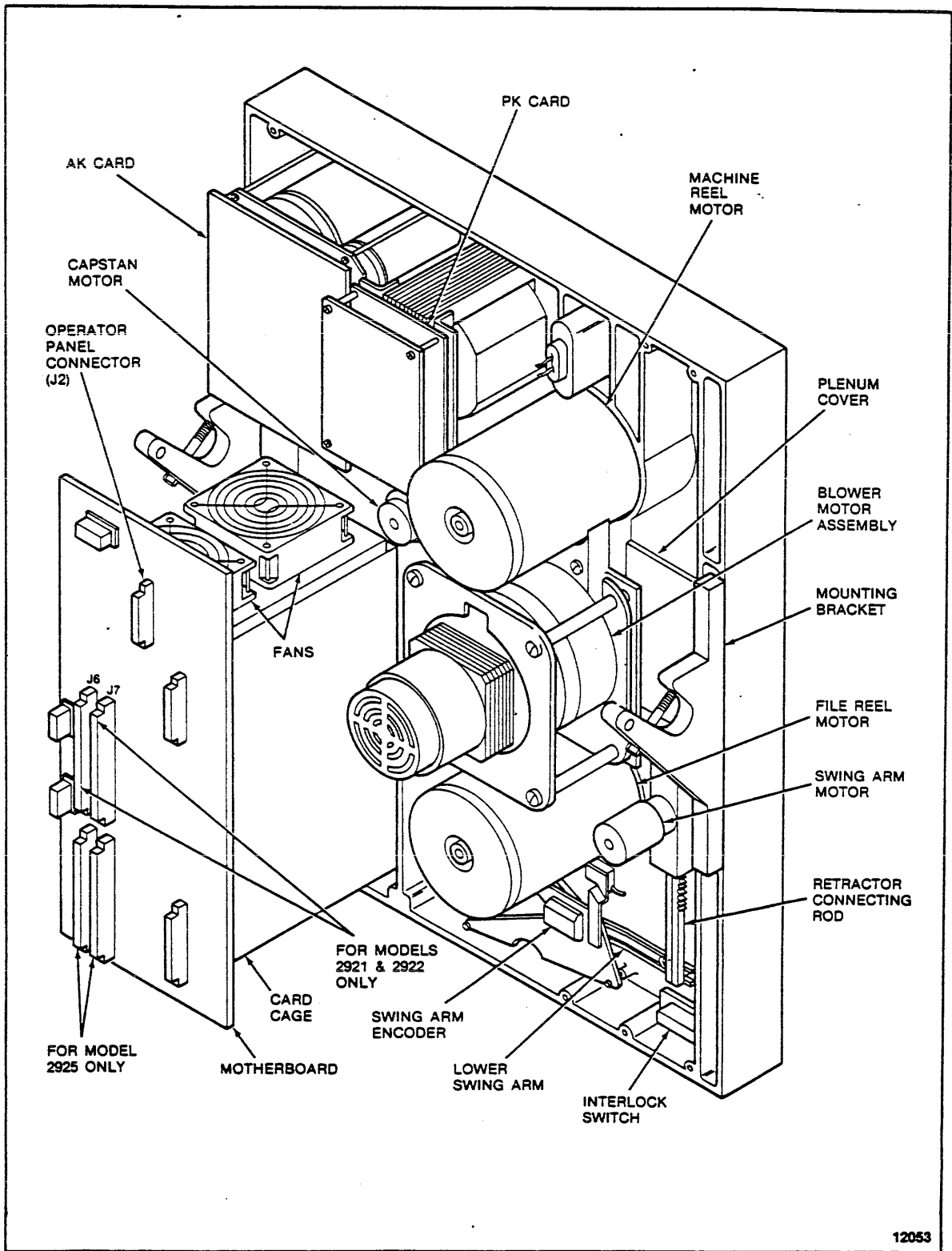


Figure 1-4. Model 292X MTS Rear View (Center of Gravity Mount)

Table 1-1. Performance Specifications

Tape Speed	50 ips/127 cm/s	100 ips/254 cm/s
Data Density GCR PE	6250 bpi(246 bpmm) 1600 bpi(63 bpmm)	6250 bpi(246 bpmm) 1600 bpi(63 bpmm)
Data Transfer Rate GCR PE	313 kB/s 80 kB/s	625 KB/s 160 KB/s
Access Time (nominal)	5.0 ms	See Table 1-2
Write Interblock Gap (nominal) GCR PE	0.45 in.(1.14 cm) 0.60 in.(1.52 cm)	See Chapter 2
Rewind Time (nominal) (2400-foot reel) (731.52 meter reel)	2.5 minutes	2.5 minutes

Table 1-2. Nominal Access Time From Stop (milliseconds) -  
2921/2922

MODE	IBG	READ	WRITE
Start/Stop 6250 bpi 246 bpmm	0.28 in./0.71 cm	5.6 ms	--
	0.30 in./0.76 cm	6.0 ms	--
	0.45 in./1.14 cm	9.0 ms	6.0 ms
Start/Stop 1600 bpi 63 bpmm	0.50 in./1.27 cm	5.6 ms	--
	0.60 in./1.52 cm	7.6 ms	6.0 ms
Streaming 6250 bpi 246 bpmm	0.28 - 1.2 in./ 0.71 - 3.05 cm	12.0 ms	--
	0.30 in./0.76 cm	--	12.5 ms
Streaming 1600 bpi 63 bpmm	0.5 - 1.2 in./ 1.27 - 3.05 cm	12.0 ms	--
	0.60 in./1.52 cm	--	12.5 ms

## 1.2.1 Power Features

Models 2921 and 2922 operate from either a 120 Vac, 60 Hz power source or a 220 Vac, 50 Hz power source. Chapter 8 provides a description of the power supply.

## 1.2.2 Interface Features

Both models can be provided with either the StorageTek Standard Interface or the Industry Standard Interface (Pertec). The STK Standard Interface is described in Chapter 4 and the Industry Standard Interface is described in Chapter 5.

## 1.2.3 Mounting Options

Both models are available with either vertical or center of gravity (horizontal) mounting options. Chapter 3 describes each installation.

## 1.2.4 Diagnostic Features

The internal diagnostics programs are capable of detecting fault conditions in the tape subsystem and isolating failures within a specific number of field replaceable units (FRUs). A unique package is required for machines using the Industry Standard Interface. Optional programs are available on floppy diskettes to provide 292X interface verification and limited online exercising. See Chapter 11 for details.

## 1.2.5 Electronics

The electronics of the MTS are located on five plug-in printed circuit cards located in a card cage below the operator panel. The Industry Standard Interface requires two additional cards: PA and PB adaptor cards. These cards are identified in Figures 1-5 and 1-6. In addition, there is an operator panel circuit card (KK) and three power supply circuit cards: the AK and NK regulator cards and the PK power circuit damage protection card. Chapter 8 describes the functions of each card.

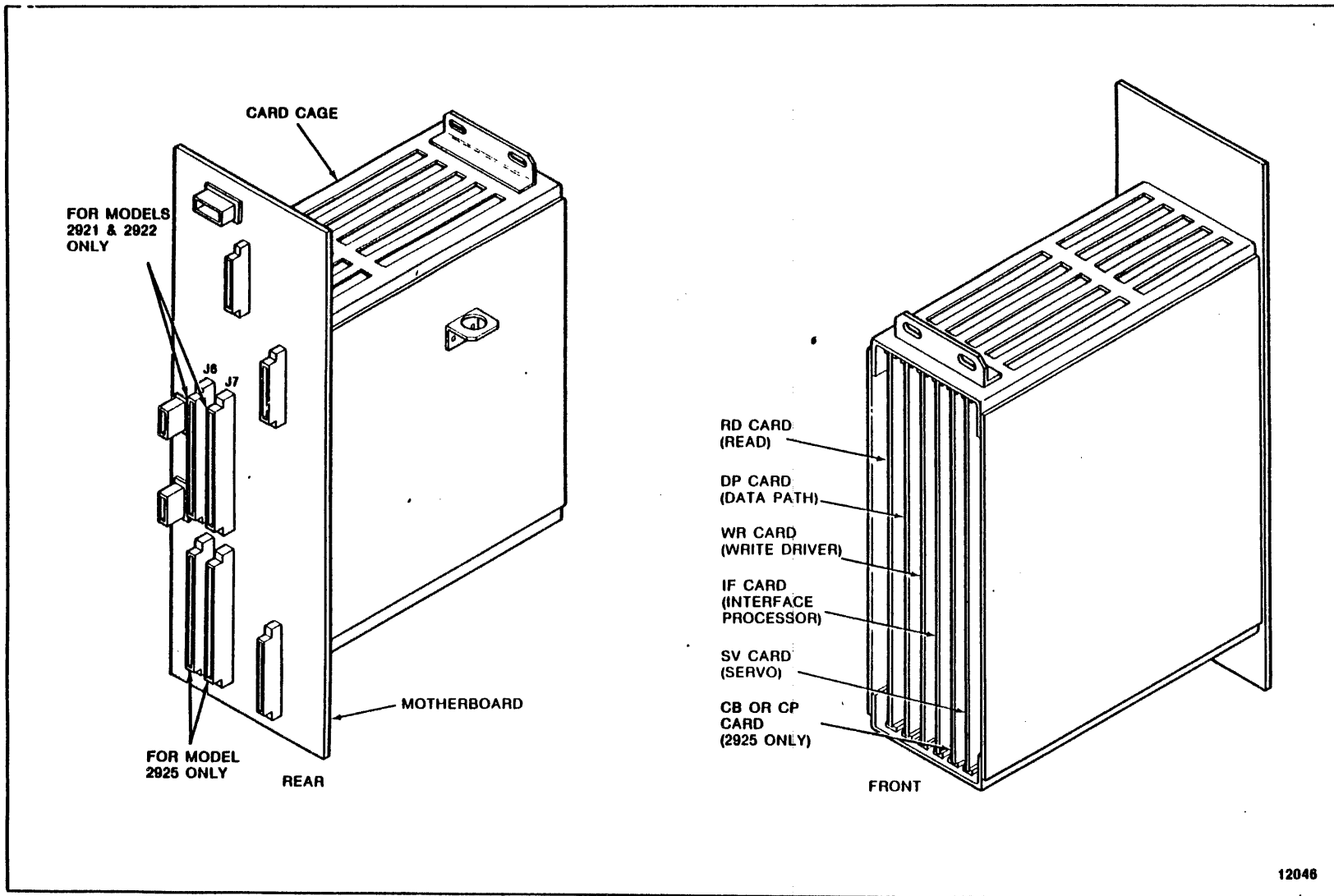
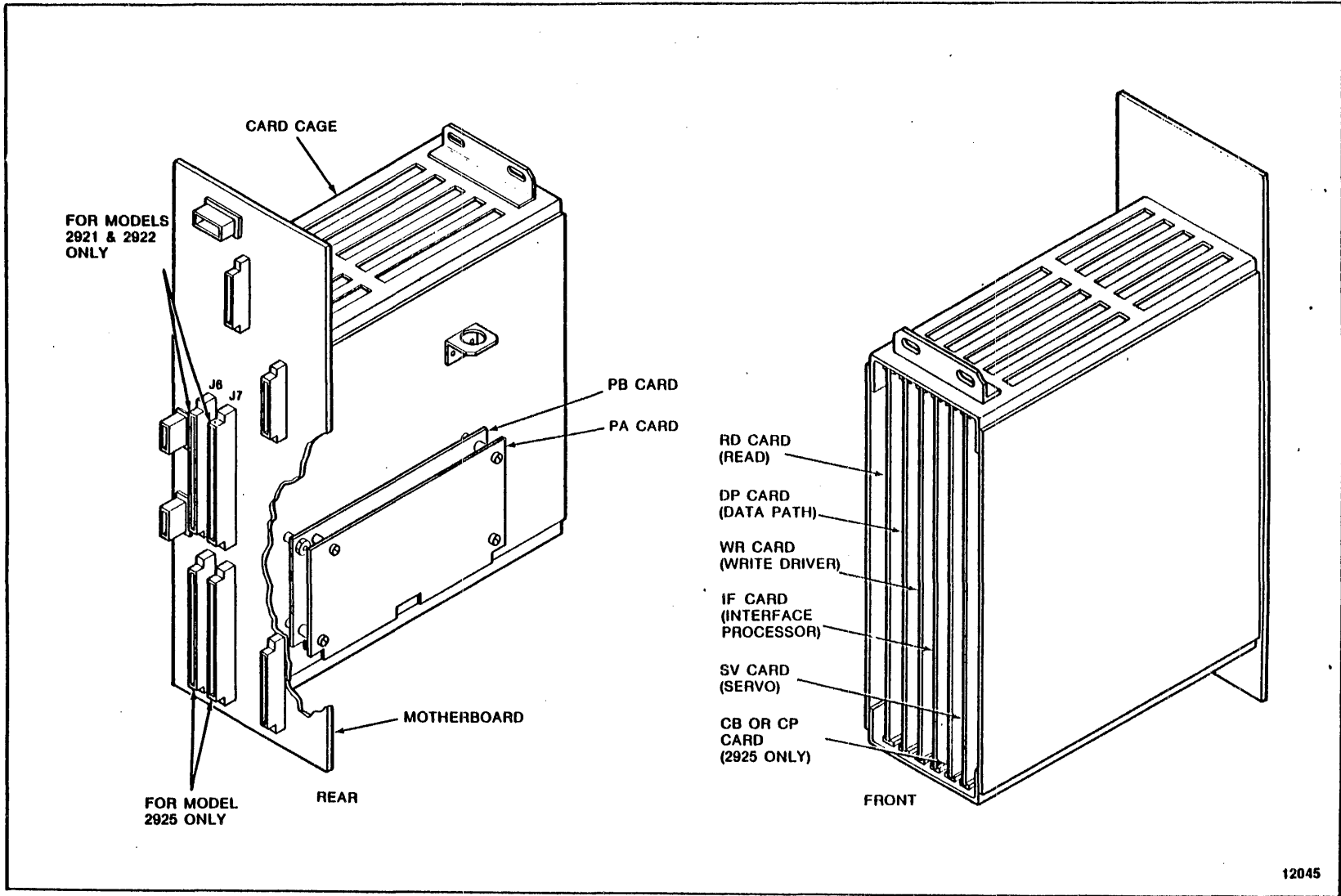


Figure 1-5. Model 292X MTS STORAGE TEK Standard Card Cage





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Figure 1-6. Model 292X MTS Industry Standard Card Cage

## 1.3 SPECIFICATIONS

Physical, environmental and power requirements for the MTS are as follows:

### 1.3.1 Physical Dimensions

The nominal outside dimensions of the MTS are:

Height	24.5 inches (62.2 cm)	
Width	19.0 inches (48.3 cm)	
Depth	16.0 inches (40.6 cm)	
Projection	4.8 inches (12.2 cm)	from RETMA mounting surface
Weight	125 pounds (57 kg)	

### 1.3.2 Environmental Requirements

Temperature (Ambient Room Air):

Optimum	+16°C to +22°C (+60°F to +72°F)
Operating	+16°C to +31°C (+60°F to +90°F)
Non-Operating	-40°C to +70°C (-40°F to +158°F)

Relative Humidity:

Optimum	37% to 42%, noncondensing
Operating	20% to 80%, noncondensing
Storage	10% to 90%, noncondensing
Shipping	Any, noncondensing

The storage environment must not exist outside the limits of the operating environment for a period longer than six months.

The MTS must not be subjected to a temperature change greater than 8°C (15°F) per hour.

Altitude:

Operating	Up to 1830 meters (6,000 feet) standard Up to 3050 meters (10,000 feet) with manual-assisted thread
Non-Operating	Up to 15,240 meters (50,000 feet)

### 1.3.3 Power Requirements

The MTS is designed to operate on any one of the following single-phase power sources (refer to Table 1-3) :

Table 1-3. Power Requirements

Nominal Voltage	Voltage Range	Frequency	Maximum Current
100 Vac	85-110	60 ( $\pm 1$ ) Hz	4 amps
120 Vac	102-132	60 ( $\pm 1$ ) Hz	4 amps
100 Vac	85-110	50 ( $\pm 1$ ) Hz	4 amps
200 Vac	170-220	50 ( $\pm 1$ ) Hz	2 amps
220 Vac	187-242	50 ( $\pm 1$ ) Hz	2 amps
240 Vac	204-264	50 ( $\pm 1$ ) Hz	2 amps

The MTS is assembled and shipped to operate from either a 120 Vac, 60 Hz power source or a 220 Vac, 50 Hz power source. Conversion to other power sources requires changes to the primary side wiring of the MTS input power transformer (refer to chapter 3).

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# CHAPTER 2

## OPERATION

### 2.1 INTRODUCTION

This chapter describes the operator panel functions and status indicators, the common MTS operating procedures, and the required operator maintenance.

### 2.2 POWER ON/OFF SWITCH

The Power On/Off switch is used to power up or power down the MTS. When powered up, the MTS initializes and invokes a series of power-up diagnostics.

### 2.3 DISPLAY

The operator panel contains a four-character display. When the MTS is in Online Status, the display is blank. During machine check conditions, the display contains a three-digit fault code. When the MTS is offline and at idle, the display contains four dashes indicating that the MTS is ready to accept diagnostic commands. When a key is depressed, all segments of the display are lit to indicate that the key has been recognized and accepted. When pressure is removed from the key, the display returns to its previous state.

Throughout this manual, display conditions are shown enclosed within parentheses. To summarize the display conditions and their meanings:

( )	Online
(----)	Offline, panel idle, test successfully completed
(@n )	Executing maintenance routine
(@nn )	Executing diagnostic routine
( nn)	Displaying data (flashing if from probe)
(nnnn)	Displaying address
( ??)	Request for data or test ID input
(????)	Request for address input
( nnn)	Fault code (refer to Fault Code Dictionary PN 97712 or 87004)

### 2.4 OPERATOR FUNCTIONS AREA

The operator functions area of the operator panel (Figures 2-1 and 2-2) provides status indicators and a keypad for operator control of the normal functions of the MTS.

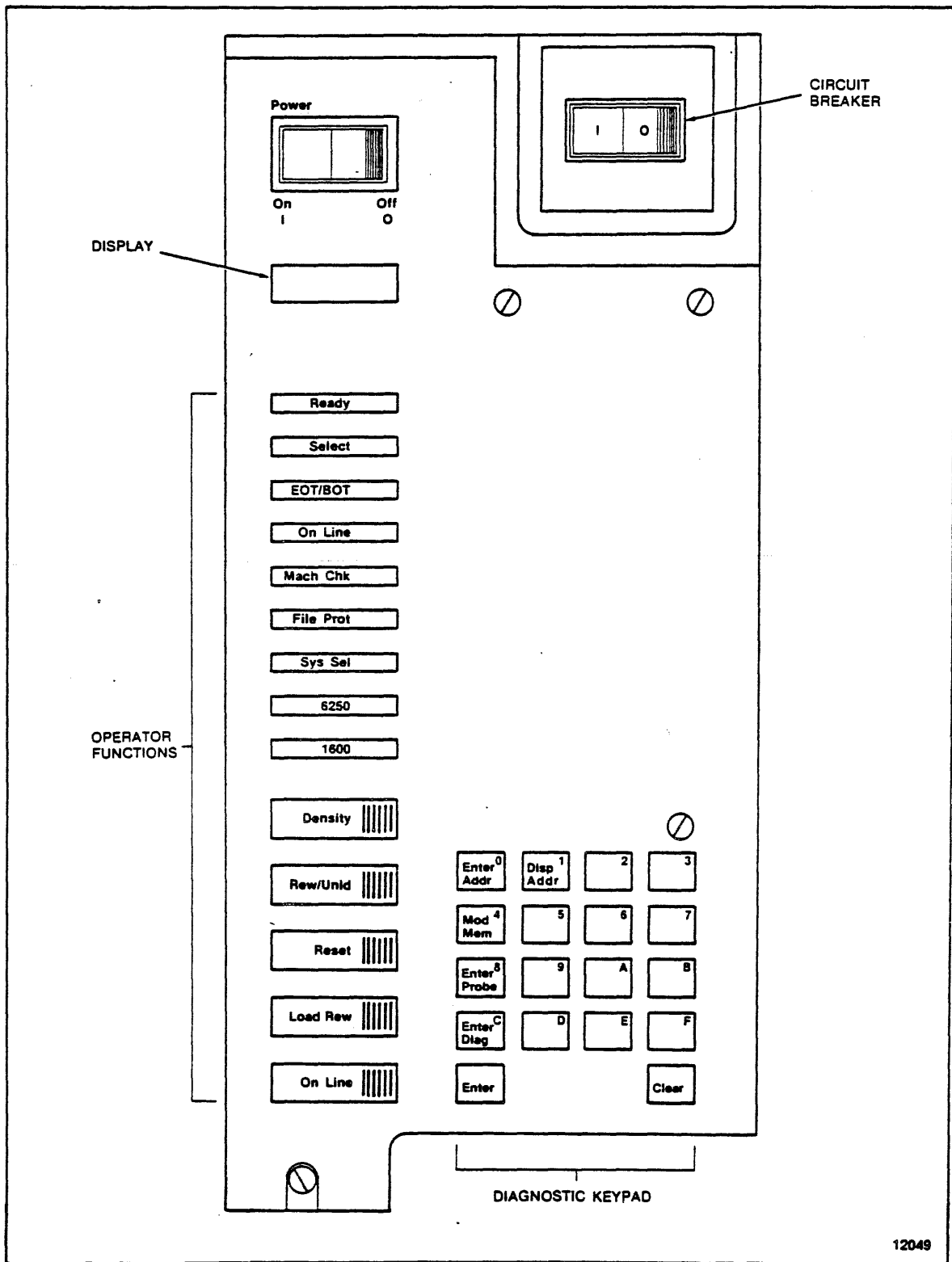


Figure 2-1. Operator Panel, Vertical Mount

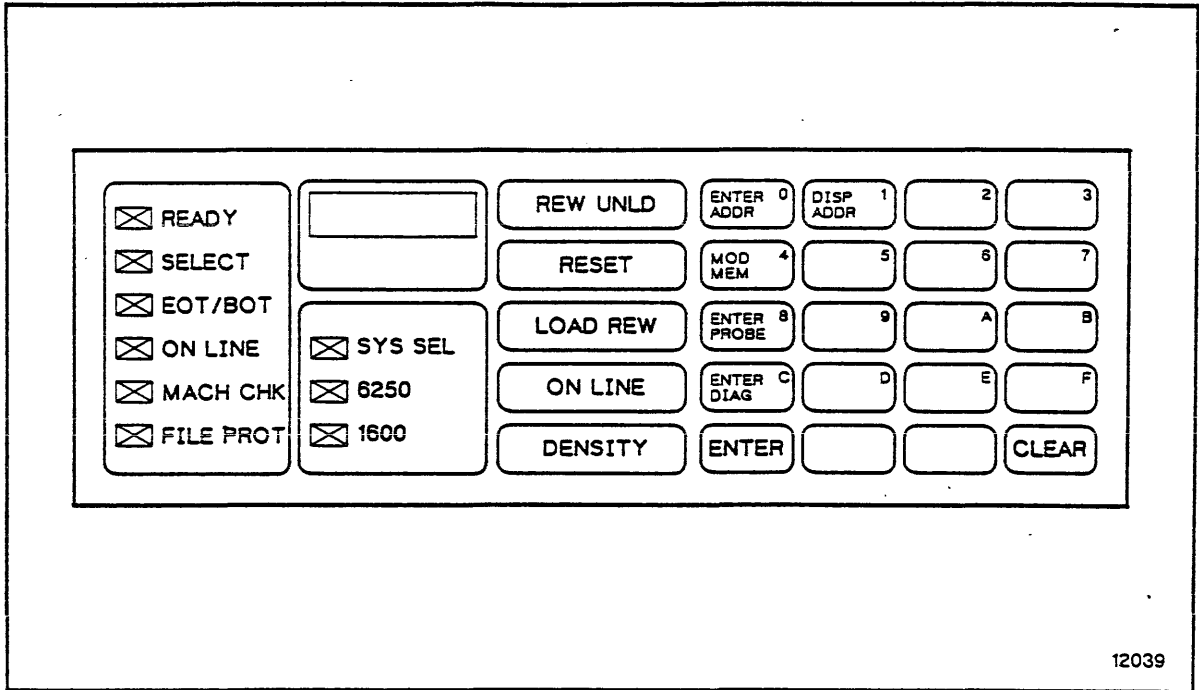


Figure 2-2. Operator Panel, Center of Gravity Mount

### 2.4.1 Ready Indicator (Green)

The Ready indicator is illuminated when the MTS is fully loaded and not performing a rewind operation. The indicator is active whether or not the MTS is in Online Status. In the model 2925 this indicator flashes along with the Machine Check Indicator to signify the inability to write a record in cache mode when other write records are in the buffer.

### 2.4.2 Select Indicator (Yellow)

The Select indicator is illuminated when the MTS is in Online Status and has been selected for use by the USER (that is, the MTS Address lines match the address of the MTS).

### 2.4.3 EOT/BOT Indicator (Green)

The EOT/BOT indicator is illuminated when EOT or BOT Status is set in the MTS; that is, when the BOT marker is detected by the BOT sensor or when the EOT marker has been detected by or is past the EOT sensor. When the indicator is lit at EOT, it remains illuminated until a rewind or backward read operation moves the EOT marker back past the EOT sensor.



#### 2.4.4 On Line Indicator (Green)

The On Line indicator is illuminated when Online Status is set in the MTS; that is, when the MTS is available to the user.

#### 2.4.5 Machine Check Indicator (Red)

The Machine Check (MACH CHK) indicator flashes to signal either a load check, which may be operator correctable, or to signal a malfunction of the MTS that requires service. A fault code of three characters is posted in the display. In model 2925 this indicator flashes along with the Ready Indicator to signify the inability to write a record while in cache mode when other write records are in the buffer.

#### 2.4.6 File Protect Indicator (Red)

The File Protect (FILE PROT) indicator is illuminated when tape is loaded and a write enable ring is not in place on the file reel. Write operations can not be performed when this indicator is illuminated.

#### 2.4.7 System Select/1600/6250 Indicators (Yellow)

The System Select (SYS SEL), 1600, and 6250 indicators are used to show the current operating density of the MTS. The operator may select a density mode using the Density Select Key when the MTS is either not loaded or loaded and positioned at BOT. The selected mode determines the density in which a tape is to be written.

Illumination of the 1600 indicator alone indicates that the tape will be written in 1600 bpi density (PE format). Illumination of the 6250 indicator alone indicates that the tape will be written in 6250 bpi density (GCR format). Illumination of the System Select indicator in combination with illumination of the 1600 indicator indicates that the recording density is to be selected by the CPU. On power up, the MTS will indicate System Select and 1600.

A read operation will be in the correct density regardless of the initial setting of the indicators. When the density of the tape being read has been determined, the corresponding indicator (1600 or 6250) is illuminated.

#### 2.4.8 Density Select Key

The Density Select (DENSITY) Key is used to select a recording density when the drive is unloaded or tape is loaded and at BOT.

Successive actuations of the key causes the MTS to cycle through the possible density modes. Upon power up, the MTS will be set to SYS SEL/1600 mode. Pressing DENSITY causes the MTS to go to 1600 bpi density. A second press causes the MTS to go to 6250 bpi density. Entering DENSITY a third time returns the MTS to SYS SEL/1600 mode.

Execution of a diagnostic routine may cause the density status of the MTS to change. A tape load operation will reinitialize the MTS to SYS SEL/1600 mode.

#### 2.4.9 Rewind/Unload Key

The Rewind/Unload (REW/UNLD) Key is used to unload tape. If tape is not at BOT when the key is pressed, a high speed rewind to BOT is initiated, the swing arms are retracted, and tape is unloaded from the tape path. Select and Ready Status are reset by this key. This key is not accepted if the MTS is in Online Status.

#### 2.4.10 Reset Key

The Reset key is used to generate a subsystem reset. Pressing this key resets Select, puts the MTS in Offline Status, terminates any operation and tape motion that is in progress, clears any machine check condition, and returns the display to idle (----).

#### 2.4.11 Load/Rewind Key

The Load/Rewind (LOAD/REW) key serves a dual purpose. If tape is not loaded, this key is used to load tape and position tape at BOT. If tape is loaded, this key causes tape to be rewound and positioned at BOT. This key is disabled if the MTS is in Online Status.

#### 2.4.12 On Line Key

The On Line key is used to set the MTS to Online Status. Setting the MTS to online status will cause all presently on-going MTS operations to cease. Online status disables the Rewind/Unload and Load/Rewind keys. The online condition is reset by the reset key.

### 2.5 DIAGNOSTIC KEYPAD

Commands entered on the diagnostic keypad (Figures 2-1 and 2-2) allow access to various functions. These include maintenance programs execution, internal diagnostics execution, memory examination and modification, and a continuous readout of a

memory space location (probe). The operations available are dependent upon the status of the MTS and the current display contents. The keypad will not respond when the MTS is in Online Status or if a machine check is present ( nnn). While idle (----) or error ( nnn) is present, all panel functions are available. During the execution of a maintenance program or diagnostic routine (@n ) or (@nn ), only memory read functions are available (Enter Address, Enter Probe, and Display Address). The Reset Key serves to return the panel to an idle condition (----).

The main function of each key on the keypad is marked on the key. Some keys have alternate control functions. The protocol for using the diagnostic keypad consists of entering a control function and then entering data characters as required. The display contains input and output symbols appropriate to the function in process.

The diagnostic Keypad is also used to enter data characters. The data character associated with a given key appears in its upper right corner.

### 2.5.1 Enter Address Key

The Enter Address Key is used to select an address from which data display is desired. Pressing the Enter Address <ENTER ADDR> key allows the entry of a hexadecimal number representing a location within the memory of the MTS controller. The display prompts for the entry with four question marks (????) until the first entry is made. The first entry then appears right-justified in the display with subsequent entries producing a shift left on the display. Any number of entries may be made. If the target address desired is the same as that most recently referenced, a press of the Enter key directly following the prompt display is sufficient.

When the desired address appears on the display, the Enter key terminates address entry and causes the byte at that address to be displayed as two hexadecimal digits, right-justified. At this time each actuation of the Enter key displays the contents of the next memory location.

### 2.5.2 Display Address Key

When using the Enter key to display a long series of memory locations, it may be necessary to determine the location currently being displayed. The Display Address Key is used to display the MTS current address. Pressing the Display Address <DISP ADDR> key causes the current address to be displayed as four hexadecimal digits. Press the Enter key to display the contents of this address as in a normal enter address sequence.

The address last displayed is stored so that normal machine operation will not destroy it. The Display Address key may then be used at any time (for instance, following a diagnostic routine) and the Enter key may be pressed to recall a frequent memory location.

If the Display Address key is pressed following subsystem power up and before the Enter Address function is used, memory location 0000 is displayed.

### 2.5.3 Modify Memory Key

The Modify Memory <MOD MEM> key is used to modify a writeable memory location within the MTS controller. This key is recognized only while data from the target location (from an <ENTER ADDR> or <DISP ADDR> key sequence) is being displayed. No memory modification is allowed while a diagnostic routine is executing. If this key is pressed at any other time, there will be no response.

#### CAUTION

If the memory is modified, MTS operation is not guaranteed.

Following the actuation of the Modify Memory key, the display prompts for a byte value input (two hexadecimal entries) by displaying two question marks ( ??). The operator may now use as many keystrokes as necessary to produce the required data in the display. Each entry results in a shift left of the two digits on the right (the two digits on the left remain blank).

When the data desired to be written is being displayed, pressing the Enter key causes the data to be stored in the current memory location. (If the location being written is a read-only address, there will be no effect on that location.)

### 2.5.4 Enter Probe Key

The Enter Probe <ENTER PROBE> key is used to cause a constantly updated display of a particular controller memory space location. The updating is indicated by a rapidly flashing byte on the display.

Following the actuation of the Enter Probe key, the display prompts for address input by displaying four question marks (????). Input of the address is as described in Section 2.5.1. Following the delimiting Enter key actuation, the contents of that address is displayed in the two digits on the right. The

display flashes the byte continuously at about ten times per second. The system may be brought back to idle by using either the Clear or Reset key.

## 2.5.5 Enter Diagnostic Key

The Enter Diagnostic <ENTER DIAG> key is used to initiate the entry of subsystem self-contained diagnostic routine numbers. After pressing the Enter Diagnostic key, the display prompts for the entry of a two-digit hexadecimal routine identification by displaying two question marks ( ??). The operator may now use as many keystrokes as necessary to produce the required ID in the display. Each entry results in a shift left of the two digits on the right (the two digits on the left remain blank).

When the desired routine number appears in the display, pressing the Enter key results in the attempted execution of that routine. The ID is displayed while the routine is being executed. If the routine is not successful, fault codes are displayed as three hexadecimal digits. If the routine is successful, completion is indicated by the idle display (----).

A routine in progress may be terminated by pressing the Reset key.

## 2.5.6 Enter Key

The Enter <ENTER> key is specific in nature and is described in the sections above for all sequences. For most cases this key serves to delimit address and data entries and initiates the performance of a requested function.

## 2.5.7 Clear Key

The Clear <CLEAR> key is used to clear the last data and/or address entry in the display and return to the prompt mode (question marks in the display) of the last function attempted. If the MTS is currently in a prompt mode (no entry has been made), the MTS returns to an idle state and awaits a function request. If a diagnostic routine is being executed, its ID is again displayed.

## 2.6 TAPE THREADING OPERATIONS

MTS operations are provided by the operator functions keypad on the operator panel. Machines with vertical mount can have tape loaded automatically, semiautomatically, or manually. Machines with center of gravity mount can have tape loaded semiautomatically or manually. Procedures are described below.

## 2.6.1 Automatic Thread/Load--Vertical Mount

The automatic thread/load is the normal procedure for vertically mounted machines.

1. Power up the MTS, if necessary; the swing arms automatically extend and then retract. Ensure the machine reel cover and the thread cover are closed.
2. Unlatch the file hub locking lever. Place the reel of tape on the file reel hub, then relatch the lever. Make certain that the reel is secure.
3. Press LOAD/REWIND. The vacuum blower motor turns on, the sensors are enabled, and power for the reel motors is turned on.

The MTS initially assumes that the tape leader is positioned at the entrance of the tape threading path and rotates clockwise to slip the tape leader into the path. If tape is not sensed at the EOT/BOT sensor within a given amount of time, the file reel reverses and attempts to position the tape leader using the leader sensor. If the leader cannot be sensed, it is assumed that the leader is stuck to the tape reel with static and the file reel is rotated rapidly to try to break the static. When the leader is sensed, it is positioned at the entrance of the tape threading path.

Vacuum created by the blower motor pulls the tape up the tape threading path. The tape is sensed at the EOT/BOT sensor as Tape Present. When the tape has wrapped the machine reel hub, it is sensed as Tape Attached and the blower motor turns off. If any of these steps fails to occur in the prescribed time, a mark is counted against the load. If three marks are counted, the load has been unsuccessful and a fault code is posted in the display.

When Tape Attached is sensed, the tape is moved forward until the beginning-of-tape (BOT) marker is found. Tape continues to move forward a few feet and stops. The swing arms are lowered into their normal operating area.

Tape is rewound to BOT. When BOT is sensed and tape is stopped, the file reel is moved such that the MTS logic can determine file reel size. Tape then moves forward past BOT and a series of start/stop operations is run forward and then repeated backward. These start/stops allow the adaptive features of the capstan control algorithms to initialize for the current tape.

Tape is then brought back to BOT and stopped. The Ready indicator is illuminated and the MTS is ready for operation.

4. Pressing ON LINE after the Ready indicator is lit enables the MTS to accept commands from the user.

## 2.6.2 Semiautomatic Thread/Load--Vertical Mount

If the tape does not load successfully during automatic thread/load, the semiautomatic thread/load procedure can be used.

1. Power up the MTS and load the file reel onto the hub.
2. Press the Load/Rewind button twice, with a four second interval between presses.
3. Manually and slowly rotate the file reel clockwise to allow the tape leader to drop into the tape path until the file motor moves on its own.

## 2.6.3 Semiautomatic Thread/Load--Center of Gravity Mount

The semiautomatic thread/load is the normal procedure for center of gravity mounted machines.

1. Power up the MTS and load the file reel onto the hub.
2. Press the Load/Rewind button once.
3. Manually and slowly rotate the file reel clockwise and pull the tape leader into the tape path cavity.
4. Continue to rotate the file reel until enough tape leader is released into the tape path for the file motor to move on its own.

## 2.6.4 Manual Thread/Load--Vertical or Center of Gravity Mount

If the blower motor is not operating, tape must be loaded manually. Refer to 2-3

1. Power up the MTS and load the file reel onto the hub.
2. Open the thread cover and remove the machine reel cover.
3. Pull the tape leader under the lower swing arm roller, through the tape path, over the capstan wheel, under the upper swing arm roller and over the machine reel.
4. Manually wind the upper reel clockwise, using a finger to hold the tape leader against the machine reel hub, until the tape is secured to the reel.

5. Press the Load/Rewind button.

## 2.6.5 Midtape Load, EOT Area

If a load is required when the tape is in the EOT area (after POWER DOWN or LOOP OUT), a load problem may occur. A forward search for BOT will be initiated and may cause tape to be pulled off the file reel. To avoid this, use the following procedure:

1. Power up the machine if necessary (allow diagnostics to complete).
2. Press 'UNLOAD'.
3. Allow the tape to rewind onto the file reel for about 10 seconds.
4. Press 'RESET' to halt the unload.
5. Press 'LOAD' for a midtape load.

## 2.6.6 Rewind

1. If the MTS is in Online Status, press RESET.
2. Press LOAD/REWIND. Tape rewinds at high speed, passes BOT, stops, moves forward to the BOT marker, and stops in Ready Status.

## 2.6.7 Unload

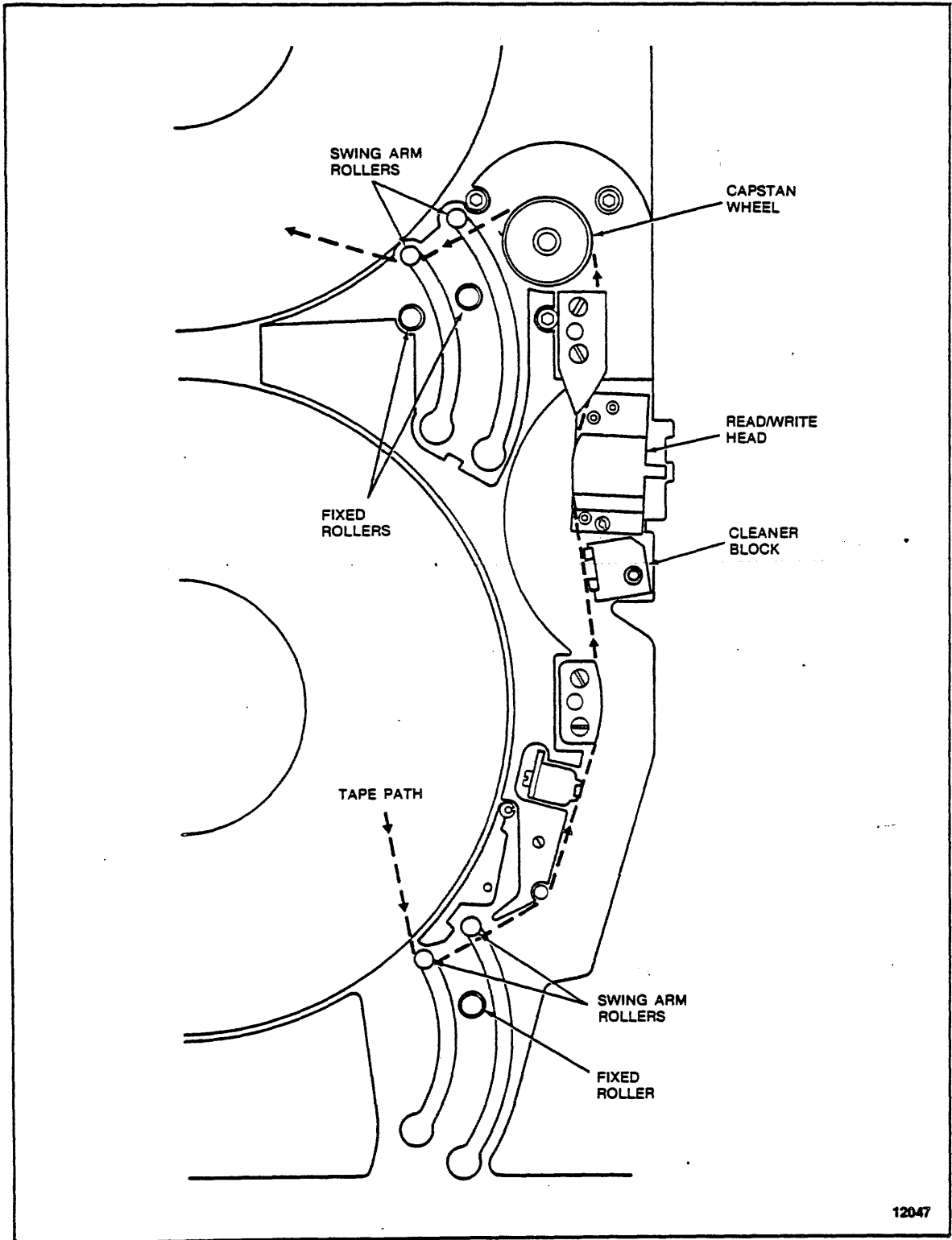
1. If the MTS is in Online Status, press RESET.
2. Press REWIND/UNLOAD. If tape is positioned off BOT, it will rewind at high speed, pass BOT, stop, and move forward to the BOT marker. With tape at BOT, the swing arms retract, tape is unloaded onto the file reel, and power for the reel motors is turned off.

## 2.7 OPERATOR MAINTENANCE

Because cleanliness is crucial to successful magnetic tape operations, there are several operator cleaning procedures which should be performed daily or after each eight-hour shift under normal operating conditions.

These procedures are for cleaning components of the tape path (Figure 2-4). Cleaning should be done using only Storage Technology Hub and Transport Cleaner Fluid to moisten a lint-free





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Figure 2-3. Tape Thread Path

cloth or foam-tipped swab. Refer to Appendix B for the part number of the cleaning supplies. After applying cleaner, allow a few minutes for excess fluid to evaporate before mounting a tape.

### 2.7.1 Read/Write Head and Tape Cleaner Block

**WARNING**

The tape cleaner blade is sharp. Use extreme care when handling the tape cleaner block.

Clean the read/write head and the tape cleaner block using a lint-free cloth moistened with Hub and Transport Cleaner Fluid. Make certain the head and cleaner block are free of oxide deposits. Use foam-tipped swabs to clean the cleaner block.

### 2.7.2 EOT/BOT and Leader Sensors

Clean the EOT/BOT and leader sensor windows using a foam-tipped swab moistened with Hub and Transport Cleaner Fluid. Allow time for complete drying and remove any residue with a dry swab.

### 2.7.3 Tape Guides, Rollers, and Swing Arms

Clean the two tape guides, the three fixed rollers, and the four swing arm rollers using a lint-free cloth moistened with Hub and Transport Cleaner Fluid. To reach otherwise inaccessible areas, foam-tipped swabs may be used. If necessary, the edge of a data processing card may be used to clean the flange corners of the guides.

### 2.7.4 Capstan

Clean the capstan using a lint-free cloth wrapped around the index finger and moistened with Hub and Transport Cleaner Fluid.

**CAUTION**

Do not touch the outer, tape-contacting surface of the capstan with the bare hand as the surface is sensitive to contamination. Always use a cloth when handling the capstan and grip only the hub of the capstan.

With the free hand, slowly rotate the capstan hub while wiping the capstan surface with the moistened cloth. Two or three

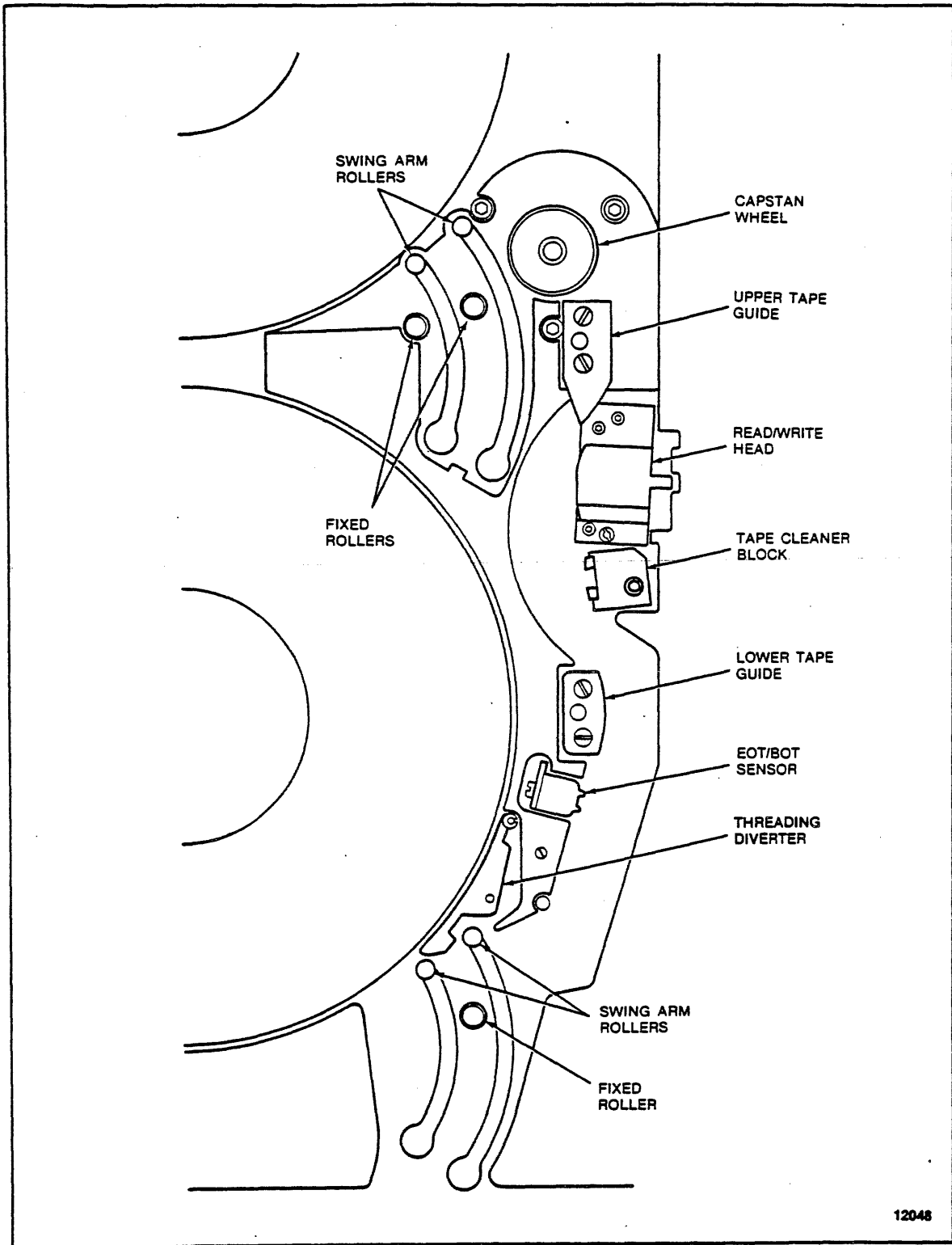


Figure 2-4. Tape Path Components--Tape Not Loaded

revolutions is sufficient. Wipe the capstan with a dry, lint-free cloth to remove excess cleaner fluid.

## 2.7.5 File Reel Hub

Clean the expansion surface of the file reel hub using a lint-free cloth moistened with Hub and Transport Cleaner Fluid.

## 2.8 TAPE MOTION CHARACTERISTICS

The 2921 operates at a nominal tape velocity of 50 inches per second (ips) in the start/stop mode.

The 2922 operates at a nominal tape velocity of 50 ips in the start/stop mode and 100 ips in the streaming mode.

The 2925 with Cache Buffer operates at a nominal tape velocity of 100 ips in the streaming mode. Although the 2925 is capable of 50 ips operation, the 50 ips mode is generally not used.

### NOTE

The MTS defaults to the velocity switch setting at power on.

The effects of velocity profiles and gap sizes in tape 2925 are generally masked from the host interface as a result of the cache buffer. The buffered MTS includes both the start/stop mode and streaming mode as described in the following paragraphs. The start/stop and streaming modes are apparent to the host interface when the MTS is operated in the long-record (non-buffered) mode.

### 2.8.1 Start/Stop Mode

In start/stop mode the tape travels a certain distance after the read head reaches the end of a record before the tape begins to decelerate. This "holdover" travel can be useful at 1600 bits per inch (bpi) density because it gives the maximum "reinstruct window" during which time the MTS can be given a new command and continue traveling at full speed. The nominal holdover distances at 1600 bpi are 0.25 inch for a read and 0.19 inch for a write, which translates into reinstruct windows of 4.0 milliseconds and 2.8 milliseconds, respectively.

If the MTS is reinstructed during the deceleration ramp in either density, tape need not come to a complete stop as shown in Figure 2-5. Refer to Section 2.9 for further information on IBGs. In GCR (6250 bpi) mode, if a write reinstruct is issued within the first half of the deceleration period (that is, within 2.5 milliseconds), a 0.37 inch gap results. The gap after a complete stop is 0.43 inch. This is illustrated in Figure 2-5. Refer to

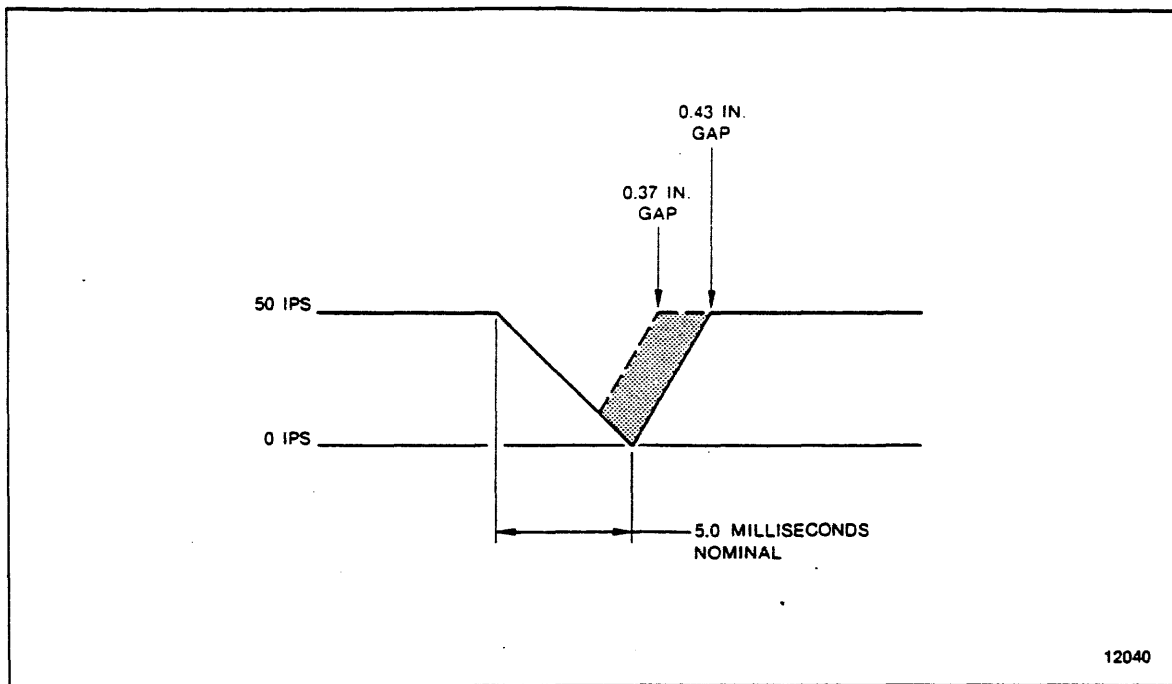


Figure 2-5. Start/Stop Mode Velocity Profile

Section 2.9 for further information on IBGs.

The nominal start or stop time at 50 ips is 5.0 milliseconds. The dotted area in Figure 2-5 shows, however, that the tape need not come to a complete stop if it is restructured early enough. The start and stop times are then less than 5.0 milliseconds. If the tape does come to a complete stop, it can be restarted without further delays.

## 2.8.2 Streaming Mode

In the 100 ips streaming mode without cache buffer, the tape does not stop at all if restructured promptly enough. However, if the end of the interblock gap is reached and a new command has not been received, a repositioning cycle is performed. Repositioning is accomplished relatively quickly by using the capstan to stop the tape and back it up to the point where it is ready for the next instruction. Meanwhile, the machine and file reels are decelerated more slowly with the difference in the tape being taken up by the tension arm buffer (Figure 2-6).

At point A in Figure 2-6, the tape has traversed the gap without a restruct. The capstan decelerates to a stop at point B, then ramps up to backward velocity at point C. The amount of time that the tape moves at full backward velocity between points C and D, is a function of the interblock gap length; the longer the

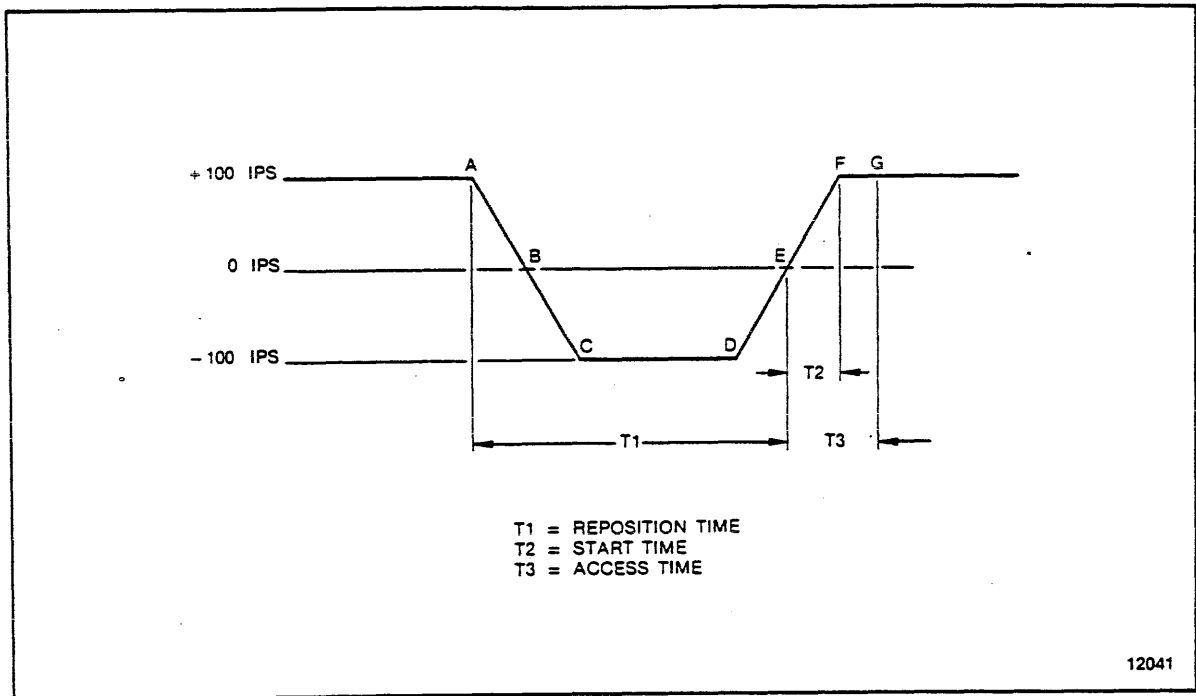


Figure 2-6. Capstan Velocity Profile

gap selected, the longer it takes to back up. The tape then decelerates and stops at point E. The tape remains at point E until a new command is received. The nominal streaming mode start time between points E and F is 10.0 milliseconds. Point G denotes the beginning of the next record on the tape.

With the cache buffer model, the effects of reposition and access times are generally masked from the host interface. The MTS will act to keep tape streaming with a minimum number of repositions between records.

## 2.9 INTERBLOCK GAP (IBG)

Interblock gaps are generated by the MTS as shown in Table 2-1. An interface command sequence can be used to select the gap settings; or, defaults can be selected by way of the switches on the IF card.

For Model 2922 in the 50 ips start/stop mode, the nominal GCR IBGs vary as a function of restruct time. In this mode, the tape decelerates but does not stop if restructured early enough, causing the shorter 0.37 inch nominal gap to be generated.

For Model 2922 in the 100 ips streaming mode, variable gaps may be generated. The gap size is then a function of how quickly the MTS is restructured, up to the maximum gap length selected. For example, if a 0.9 inch maximum gap length is selected and the MTS is restructured before the tape moves that far, then a shorter gap (between 0.3 inch and 0.9 inch for 6250 characters per inch) is generated. If not restructured in time, then a repositioning cycle is necessary and the next gap generated is the short gap length, listed under "fixed" in Table 2-1. For example, after repositioning in 6250 bpi, a 0.30 inch gap is generated. The maximum gap lengths that may be selected are shown in Table 2-2.

Table 2-1. Generated Interblock Gap Lengths (Inches)

DENSITY	50 IPS START/STOP		100 IPS STREAMING	
	NOMINAL	MAX	FIXED	VARIABLE
6250 BPI	0.37 to 0.43	0.50	0.30	0.30 to "Select"
1600 BPI	0.60	0.65	0.60	0.60 to "Select"

Note: Minimum IBGs are 0.28 inch for GCR and 0.50 inch for PE per ANSI.

Table 2-2. Selectable Interblock Gaps

DENSITY	GAP SIZE
6250 BPI	0.3, 0.6, or 0.9 in. 0.76, 1.52, or 2.29 cm
1600 BPI	0.6, 0.9, or 1.2 inches 1.52, 2.29, or 3.05 cm

For Model 2925 cache buffer in the 100 ips streaming mode, fixed IBGs of 0.3 inch at 6250 bpi, or 0.6 inch at 1600 bpi are generated.

A reposition cycle occurs when reading in the 100 ips streaming mode (either 6250 bpi or 1600 bpi), if a gap of 1.2 inches is traversed without a reinstruct command, or no reinstruct is received before the next block is encountered. This is independent of the gap size selected. The minimum read gap that is supported in both 50 ips start/stop mode and 100 ips streaming mode is 0.28 inch for 6250 bpi and 0.50 inch for 1600 bpi. During 100 ips streaming mode, if the next block is encountered before the MTS is reinstructed, the tape is repositioned relative to the start of this next block, rather than to the beginning of the IBG, to achieve minimum access time.

Reposition cycles while reading are generally masked from the host when operating with the cache buffer model.

## 2.10 REPOSITION TIMING

Reposition time is the time between point A and point E shown in Figure 2-6. It is a function of the maximum interblock gap length selected. Table 2-2 shows the reposition times for each gap length listed in Table 2-3.

Table 2-3. Reposition Times (Milliseconds)

DENSITY	INTERBLOCK GAP	REPOSITION TIMES
6250 BPI	0.3 in.	50.0 ms
	0.6 in.	53.0 ms
	0.9 in.	66.0 ms
1600 BPI	0.6 in.	50.0 ms
	0.9 in.	53.0 ms
	1.2 in.	66.0 ms

## 2.11 REINSTRUCT TIMES

Reinstruct time without cache buffer, is defined for streaming mode as the time from the resetting of the interface output signal BUSY at the completion of a command, to the time when the tape moves to the latest point in the interblock gap beyond which a reposition cycle is required. These times are a function of gap size, density, and read/write operations. Table 2-4 shows the times for the longest gaps and Table 2-5 for the shortest gaps.



With the cache buffer model, a delay on the host interface between commands does not directly relate to the crossing of an interblock gap on tape. A shorter delay, however, generally results in better system throughput.

Table 2-4. Nominal Reconstruct Times (Maximum Gap)

DENSITY	MAXIMUM INTERBLOCK GAP	REINSTRUCT TIME (MILLISECONDS)	
		READ	WRITE
6250 BPI	0.9 in.	8.0 ms	6.5 ms
1600 BPI	1.2 in.	11.0 ms	9.5 ms

Table 2-5. Nominal Reconstruct Times (Minimum Gap)

DENSITY	MINIMUM INTERBLOCK GAP	REINSTRUCT TIME (MILLISECONDS)	
		READ	WRITE
6250 BPI	0.3 in.	2.0 ms	0.5 ms
1600 BPI	0.6 in.	5.0 ms	3.5 ms

## 2.12 SPEED CHANGE

An interface command sequence is used to change speeds between 50 ips and 100 ips. The user can change speeds at various times (for example, at the beginning of the tape or after reading some data) provided execution of the previous command is complete. This causes the repositioning of the loaded tape and the movement of the tension arms to a new position. The amount of time required to accomplish this change is:

100 ips to 50 ips: approximately 300 milliseconds

50 ips to 100 ips: approximately 300 milliseconds

## 2.13 TURNAROUND

Turnaround delays are encountered between certain command sequences. For example, when a write command follows a read forward or read backward command, the erase head must be properly repositioned. When any backward-type command follows a write command, a gap is erased in the forward direction before the backward-type command is executed.

Turnaround delays include not only any time necessary for tape repositioning but also time for the swing arms to approach their normal stopped positions. At 50 ips the arms may take as long as 100.0 milliseconds to stabilize. However, if sufficient time has elapsed since the previous command ended, the arms may have already stopped so that no extra time for arm motion is required.

In the 100 ips mode a change in direction necessitates a delay even if the swing arms are stable. Since the stop position forward is different from the stop position backward, a change in direction means the swing arms must first move toward their new stop position before any motion can take place. This change of stop positions takes approximately 160.0 milliseconds.

## 2.14 DUTY CYCLE

In the 100 ips streaming mode, the Model 2922 enters a duty cycle limit mode if more than 6000 tape starts are encountered within 5 minutes. The Model 2925 enters duty cycle limit mode if more than 3000 tape starts occur within 5 minutes. Once in duty cycle limit mode the MTS stays in this mode for a fixed time period and then automatically exits duty cycle limit mode when the time period is completed. While in duty cycle limit mode the MTS does not allow a tape start (after a deceleration and stop) until the tape has been idle for a specified time. Thus, the access time for the command issued could be increased if the MTS is in duty cycle limit mode, and if the host misses the reinstruct window needed to ensure streaming.

If the drive is kept streaming, many commands can be processed for one tape start and the chance of entering duty cycle limit is greatly reduced, and usually avoided altogether.

There is no duty cycle limit for the 50 ips start/stop mode.

With the Model 2925 operating at 100 ips, the MTS minimizes the number of tape starts so that the duty cycle limit is generally avoided.

## 2.15 CACHE BUFFER

The 2925 contains a cache buffer located on a printed circuit card in the card cage. This card also includes the host interface logic and the microprocessor control for the buffer. The cache has two modes of operation. The first is buffered mode where multiple read or write records are generally contained in the cache. The second is long-record mode where, at most, one record is allowed in the cache. Long-record mode is required for records that are longer than 256K bytes.

### 2.15.1 Buffered Mode Operation

In buffered mode, data can be transferred between the host and the cache at a faster or slower rate than the normal tape data rate. Buffered mode is a switch selectable option. Up to 255 read or write records may be contained in the buffer memory.

If a series of write records are received from the host at a fast enough rate, there will be multiple records in the cache. These records are then written to tape. If an error is encountered when writing to tape, the cache control automatically tries an error recovery process. This is accomplished by doing an Erase Gap over the bad record and then rewriting the record from the buffer memory. A switch-selectable option allows this process to be repeated 5, 10, or 15 times. At the time the host writes the record into the buffer memory, the status to the host may indicate no errors. Later when that record is written to tape, errors may occur that require retries. If the retries are successful, no error status is sent to the host, although the errors are summarized in the Sense or Status Bytes. If a retry is not successful, Reject or Hard Error is sent to the host on the next available command.

A switch-selectable option determines if single-track corrections written at 6250 bpi are left on tape or rewritten. In either case the status presented to the host at the time the record is written into the buffer memory will not indicate the single-track correction. All errors are summarized in the Sense or Status Bytes. The switch is ignored in long-record mode.

During read operations a series of read records are read ahead from tape, and held in the cache for later transfer to the host. If an uncorrectable error is encountered when reading from tape, the cache control attempts an error recovery process by backspacing and re-reading the record. A switch-selectable option allows this process to be repeated 0, 5, 10, or 15 times. If the record is successfully read during a retry, then, when it is later transferred to the host, the status with that record will indicate good data. Errors encountered during the retries will be summarized in the Sense or Status Bytes. If a correctable error is encountered when reading from tape, then,

when that record is later sent to the host, the status with that record will indicate the correction and all errors will be summarized in the Sense or Status Bytes. It may occur that a record cannot be read from tape, even after all retries. When the host later requests that record, data will be transferred and Data Check or Hard Error status asserted at that time.

A command to write a tape mark following a series of Write commands may or may not (depending on the switch setting), cause all data in the buffer memory to be written out to tape, before accepting any other commands. A switch-selectable option allows either one Write Tape Mark command or two Write Tape Mark commands in a row to be received before draining all memory data out onto tape and thus synchronizing physical tape with the logical host interface.

A series of read commands causes records to be read ahead into cache. If any command other than a read (except a NOP for machines with the StorageTek Standard Interface) occurs while there are records remaining in cache, those records are ignored and physical tape is positioned to align with the logical host interface. The Read Forward and Write commands are the only commands that can cause multiple records to be in cache memory. All other commands cause physical tape to become aligned with the logical host interface.

## 2.15.2 Long-Record Mode Operation

In long-record mode, the cache acts as a conduit between the host interface and physical tape. This mode does not store multiple records in cache, but rather causes a single record to pass through, between the host interface and the tape. When dealing with records larger than cache memory, this mode of operation must be selected. The host interface must be able to transfer data at a rate equal to or faster than the tape data rate in this mode.

## 2.15.3 Cache-Specific Commands

Several commands are used specifically with the cache buffer. These include both functional and diagnostic commands. When writing data in functional mode, a failure may result where several records that cannot be written to tape, are left in cache memory. On the next available command, the MTS will signal Reject or Hard Error for this command and all subsequent commands, except for the Sense command. The Sense command reports status, including how many records are remaining in cache memory that could not be written to tape. The mode set command may then be used to set the MTS to the cache data mode where host data is written to or read from the cache memory without involving physical tape. The host can now read back the records

left in cache memory in an attempt to recover the data. Care must be exercised to determine if the data on tape is usable.

If the host does not issue a Sense command following the Reject, then all subsequent commands continue to be Rejected. Also for machines with the StorageTek Standard Interface, if the Sense command does not request 59 or more sense bytes from the MTS, all subsequent commands will continue to be rejected. For machines with the Industry Standard interface, a Read Controller Sense Command must be executed. After the required number of sense bytes have been received by the host a Reset command will free the MTS to again accept all commands.

If performing diagnostics, the mode set (StorageTek Interface) or Write Extended (Industry Standard Interface) command can be used to enter cache data mode, where the host can write to and read back from the cache memory itself; data is not passed through to tape. The mode set command can also be used to select buffered or long-record mode. Power-on default to either buffered or long-record mode is a switch-selectable option.

The CLR command (StorageTek Interface) can be used following a series of buffered writes to "synchronize" the tape by causing any remaining data blocks in cache memory to be written to tape before accepting further commands from the host.

#### 2.15.4 Early EOT

When writing records in buffered mode the MTS determines how much tape is left before reaching the EOT marker. Starting a short distance before the EOT marker, the amount of write data allowed in the buffer memory is reduced to either one or four records, depending on an option switch setting.

#### 2.15.5 Maximum Block Size

For optimum performance, the cache buffer microprocessor should know the maximum read or write block size to be expected. It can then manage the remaining buffer memory space most efficiently. Switch-selectable options are: 8, 16, 24, or 32K byte. If records longer than the switch setting are encountered, system performance may be degraded.

SEPARATOR SET PN 83464

THIS SEPARATOR SET CONTAINS 19  
TABS TOTAL IN THE FOLLOWING  
ORDER:

MAINTENANCE MANUAL

1. INTRODUCTION
2. OPERATION
3. INSTALLATION
4. STORAGETEK INTERFACE
5. INDUSTRY INTERFACE
6. SCSI INTERFACE
7. VS INTERFACE
8. FUNCTIONAL DESCRIPTION
9. MAINTENANCE
10. REMOVAL/REPLACEMENT
11. DIAGNOSTICS

APPENDICES

IPC

PN COMPATIBILITY

MML

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD

# CHAPTER 3

## INSTALLATION

### 3.1 INTRODUCTION

This chapter provides instructions for inspection, power set up, preliminary checkout, and cabinet mounting of the MTS.

Each MTS is shipped on a foam cushion shipping pallet assembly with a corrugated overcarton. The container provides stability and protection for the MTS and should not be removed until the unit is ready to be mounted into an equipment rack. Provision has been made for an operational checkout of the MTS while on the shipping pallet.

### 3.2 INSPECTION

1. Position the packaged MTS upright at the operational checkout station.

#### WARNING

The MTS and its shipping carton weigh approximately 150 pounds (68 kg). Use appropriate mechanical aids and sufficient personnel when moving the unit to prevent personnel injury or equipment damage.

2. Remove the unpacking instructions and any other documents from the exterior of the shipping carton.
3. Visually inspect the exterior of the shipping carton for evidence of physical damage that may have occurred in transit. Verify that a shock watch is located on the carton and inspect the bubble. A red bubble indicates that damage has occurred. If any damage is found or if no shock watch is located on the carton, promptly report the condition to a company representative.
4. Remove only the top of the shipping container (corrugated carton, corrugated inner tray, and top foam cushion). The MTS should be sitting upright, supported by the bottom of the cushion pallet assembly. Do not lay the MTS on its side.
5. Remove the front cushion foam from the lower front area of the cushion pallet. This permits access to the front of the MTS.

6. Open the taped end of the antistatic polybag. Pull the bag completely down around the sides of the MTS. Cut the polybag as necessary to permit free opening of the front door of the MTS. Do not attempt to remove the polybag from under the MTS until ready to mount the unit in a rack.
7. Check all items against the shipping list to verify container contents. Verify that the serial number of the unit corresponds to that on the shipping invoice. Contact a company representative in case of a packing shortage or incorrect serial number.
8. Visually inspect the MTS for evidence of physical damage that may have occurred during handling or in transit. If any damage is found, promptly report the condition to a company representative.
9. Open the front door of the MTS and remove any cellophane and tape.
10. Remove all packing materials from cables and connectors. Check for bent or misaligned pins and straighten as necessary.
11. Verify that all cable connections are tight. (Refer to Figure 3-1.)
12. Check for loose hardware throughout the MTS and tighten as necessary. Ensure that all DIP packages on the circuit cards in the card cage are secure in their sockets.

### 3.3 POWER CONNECTION

The input frequency rating for the unit is determined by the frequency option installed at the time of manufacture.

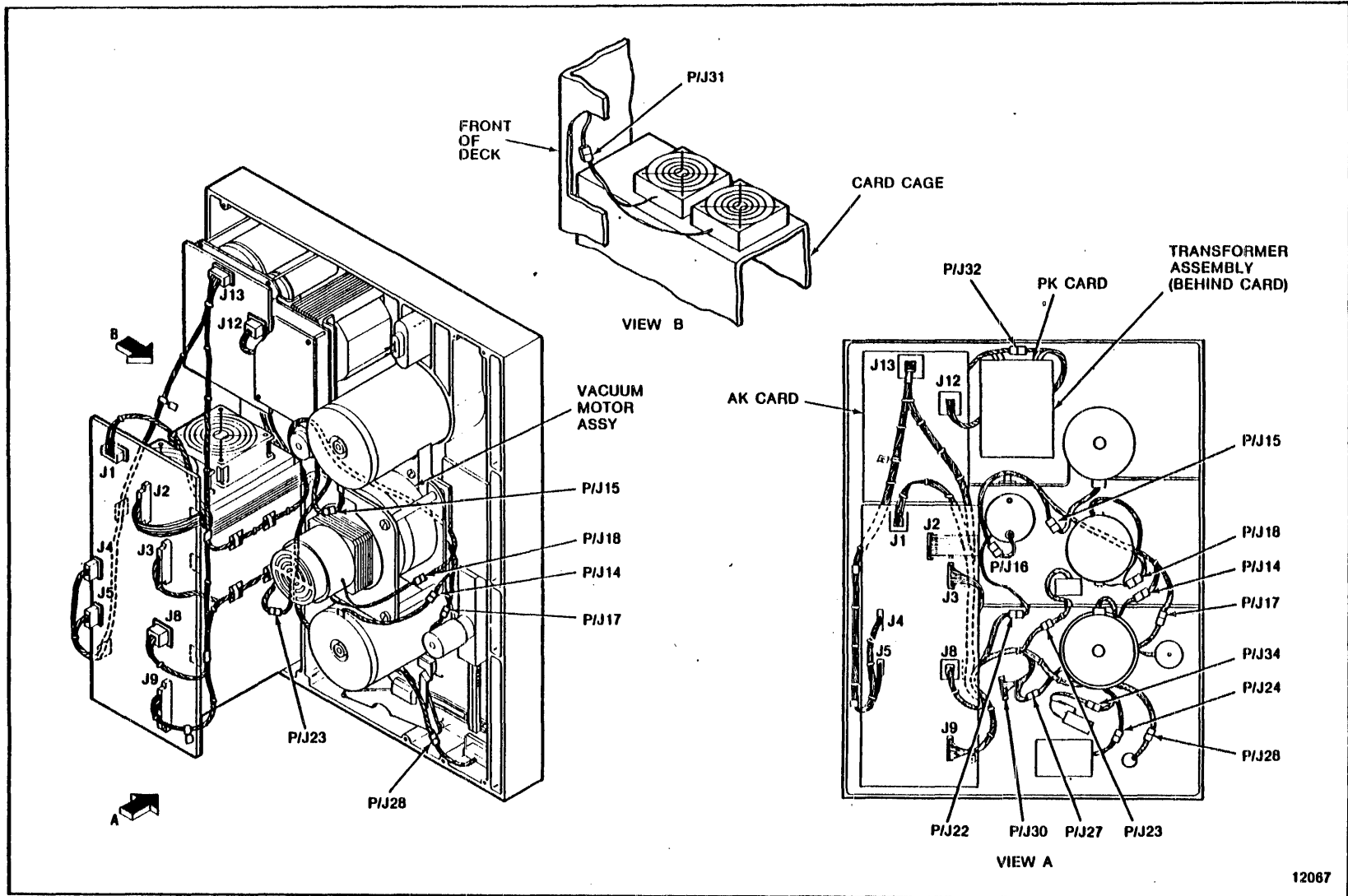
Verify that the facility AC power frequency and voltage matches that indicated on the CAUTION - HIGH VOLTAGE label on the MTS before connecting the unit to the facility power.

If the facility AC power does not match the machine configuration, move the X or PKX wire to the appropriate terminal on top of the PK board as shown in Table 3-1.

If this wire is moved in order to change the input voltage rating of the unit, ensure that the indication on the CAUTION - HIGH VOLTAGE label accurately reflects the new configuration.

The MTS is equipped with a three-conductor power cable. The card cage and the deck casting are connected to the safety ground of the power cord. The center pin of the power plug is the ground connection.





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Figure 3-1. Cables and Connectors

Table 3-1. PK Board Wiring for Input Power

Input VAC	Input Freq.	Connect X or PKX Wire
100	60 Hz	To PK Board Terminal 6
120	60 Hz	To PK Board Terminal 4
200	50 Hz	To PK Board Terminal 6
220	50 Hz	To PK Board Terminal 4
240	50 Hz	To PK Board Terminal 2

### 3.4 PRELIMINARY CHECKOUT

The preliminary checkout tests the major electrical functions of the MTS offline before it is installed in an equipment rack. Test the MTS on the cushion pallet assembly and without connections to the CPU.

1. Ensure the Power On/Off switch is off, then plug the power cord into the facility power.

**WARNING**

Do not touch any part inside the MTS when the MTS is powered up to prevent electrical shock or damage to the machine.

2. Set the circuit breaker to ON.
3. Press on the operator panel Power On/Off switch. The cooling fans in the top of the electronics cage should turn on and MTS power-on diagnostics will be initiated.
4. Without a tape on the file reel hub, press LOAD/REWIND. The threading vacuum blower will come on and the machine reel will rotate as if in a tape threading sequence. Since the presence of tape will not be detected, the operation will halt and the Machine Check indicator will flash, indicating a load failure. Press RESET to enable the MTS again.

## NOTE

Center of gravity (horizontal) mounting requires the semiautomatic thread procedure on every tape load. Enabling the Center of Gravity Option causes the load sequence to automatically pause for manual positioning of the tape leader. To enable this option, set the appropriate DIP switch on the IF card to the OFF position. Refer to Figures 3-2 and 3-3.

5. Mount a write enable ring onto a reel of scratch tape.
6. For vertically mounted units, use the following procedure:
  - a) Mount the reel of scratch tape onto the file hub with the tape leader end positioned at the threading channel.
  - b) Ensure that the threading door is closed with all catches firmly engaged.
  - c) Press the Load/Rewind button; tape will load automatically.
7. For center of gravity (horizontally) mounted units, use the following procedure:
  - a) Mount the reel of scratch tape onto the file hub.
  - b) Press the Load/Rewind button.
  - c) Manually and slowly rotate the file reel clockwise and pull the tape leader into the tape path cavity.
  - d) Continue to rotate the file reel until enough tape leader is released into the tape path for the file motor to move on its own.
8. Successful tape thread and load causes the EOT/BOT indicator to be illuminated and the File Protect indicator to be off.
9. Remove the write enable ring from the scratch tape, mount the reel of scratch tape onto the file hub, and load the tape as in step 6 or 7 above. Both the EOT/BOT indicator and the File Protect indicator should be illuminated.
10. Check reel motion by completing the following steps. Terminate each step by pressing RESET.
  - a) Initiate steady state forward motion by entering the following at the diagnostic keypad: <ENTER DIAG>, <0>, <ENTER>.

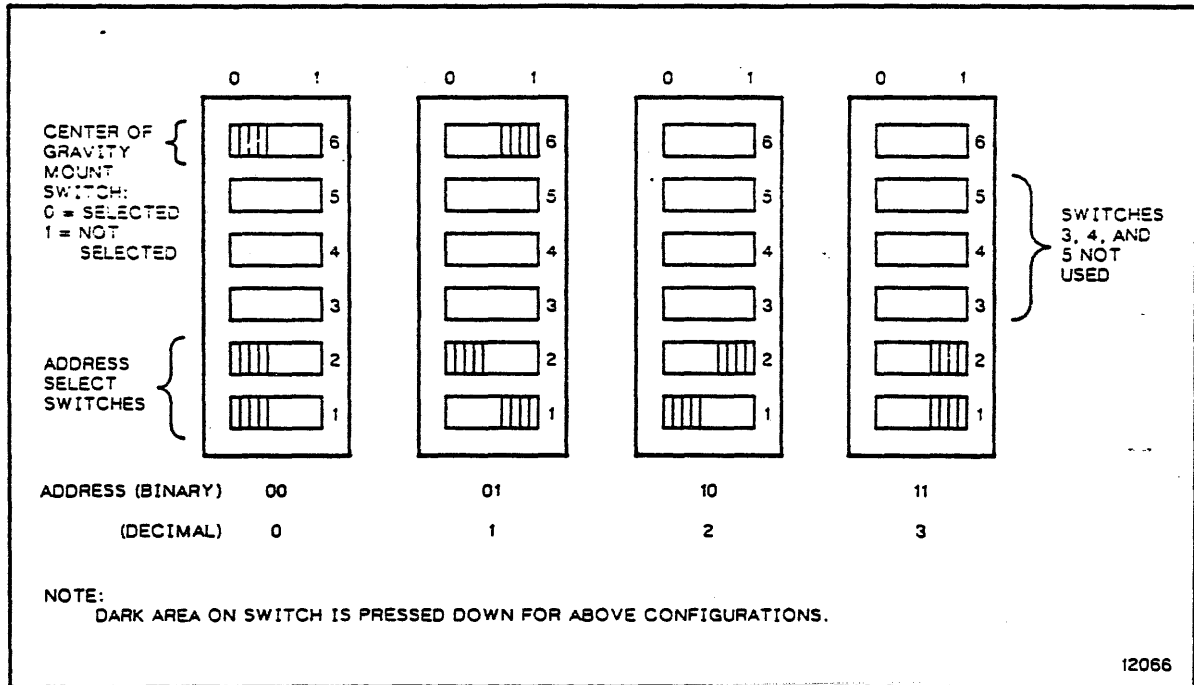


Figure 3-2. Interface Card Address, Center of Gravity Configuration

- b) Initiate steady state backward motion by entering: <ENTER DIAG>, <1>, <ENTER>.
  - c) Initiate shoeshine motion by entering: <ENTER DIAG>, <2>, <ENTER>. Change shoeshine motion speed by continuing to press <ENTER>.
  - d) Initiate start/stop motion (backward and forward) by entering: <ENTER DIAG>, <3>, <ENTER>. Change speed and direction by continuing to press <ENTER>.
11. Press REWIND/UNLOAD and ensure that the MTS rewinds to BOT and successfully unloads the reel of tape. Remove the reel of tape.
  12. If the MTS is not to be rack mounted at this time, reinstall all packaging material previously removed to assure safe storage.

### 3.5 VERTICAL CABINET MOUNTING

The MTS is designed to be mounted in a standard 19-inch RETMA rack or universal cabinet with a minimum panel space of 29.8 inches (75.8 cm).

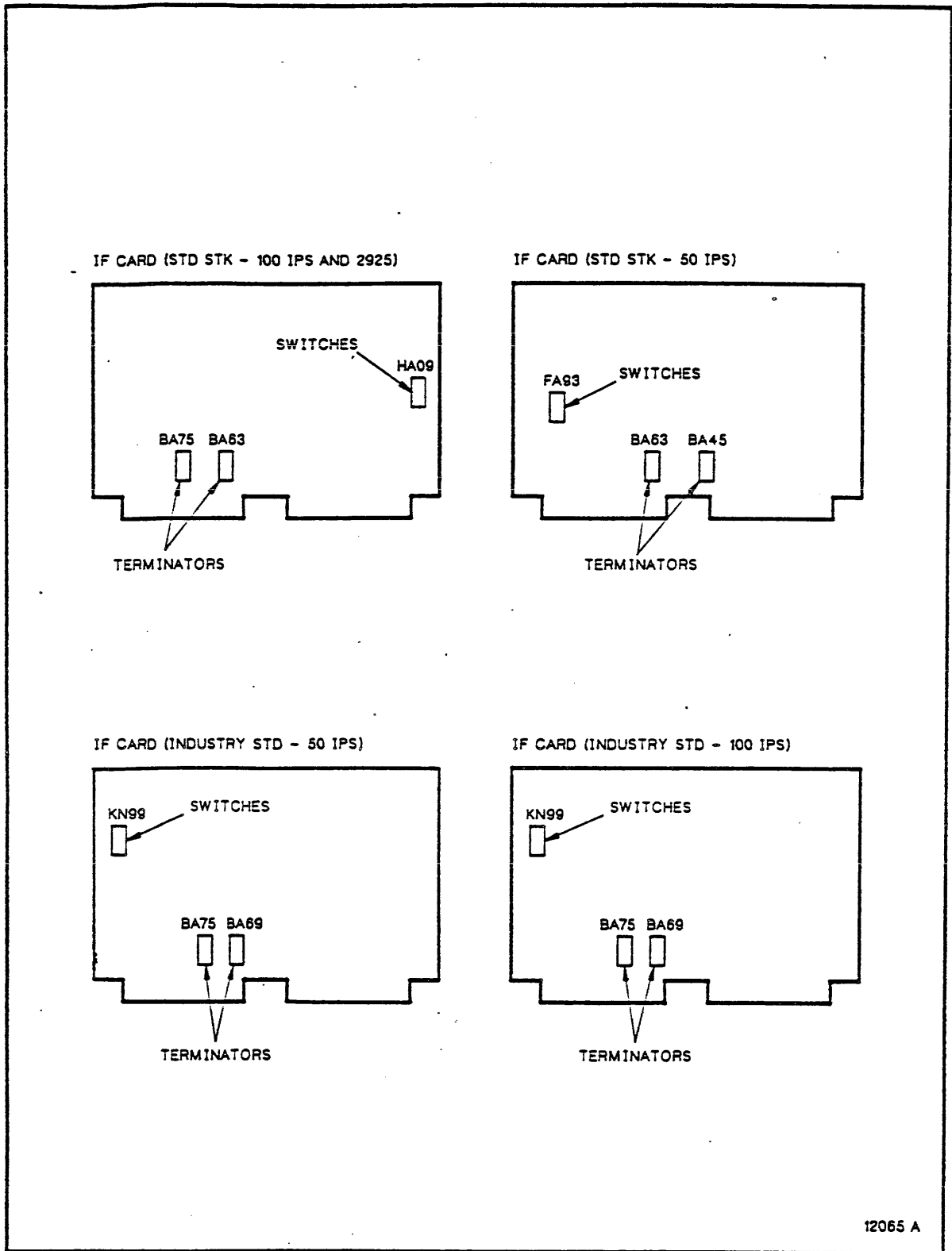


Figure 3-3. IF Card Terminator and Address Switch Locations

## NOTE

The hinges, screws, and Keeper required for mounting the MTS onto a vertical rack are supplied in a package shipped with the MTS.

### CAUTION

Instability of the vertical rack may occur when the deck casting is open. To prevent tipping, a 90 pound (40 kg) ballast (refer to Figure 3-4) may be secured to the bottom of the rack at the back. Any suitable alternative may be used if the possibility of the rack tipping is precluded.

1. Install the two half hinges on the mounting rails of the rack as shown in Figure 3-5 using two 10-32 x 0.750-inch screws with flat and lockwashers (supplied). Note that the half hinge with the longer hinge pin is the bottom hinge.

### WARNING

The MTS weighs approximately 125 pounds (57 kg). Use appropriate mechanical aids and sufficient personnel when moving the unit to avoid personnel injury or equipment damage. A suggested lifting method is shown in Figure 3-6.

2. Lift the MTS from the cushion pallet assembly. Ensure that the antistatic polybag does not hang or pull on the MTS components causing damage.
3. Position the MTS near the hinges and start the unit onto the lower hinge pin, then onto the upper hinge pin (refer to Figure 3-5).
4. Loosen the bottom screw of the upper half hinge on the MTS casting, slide the Keeper into place, then refasten the screw. Refer to Figure 3-5.
5. Connect the MTS chassis ground strap by placing the ground strap lug over the top screw of the top hinge on the back side of the mounting rail and securing with a 10-32 nut and lockwasher.

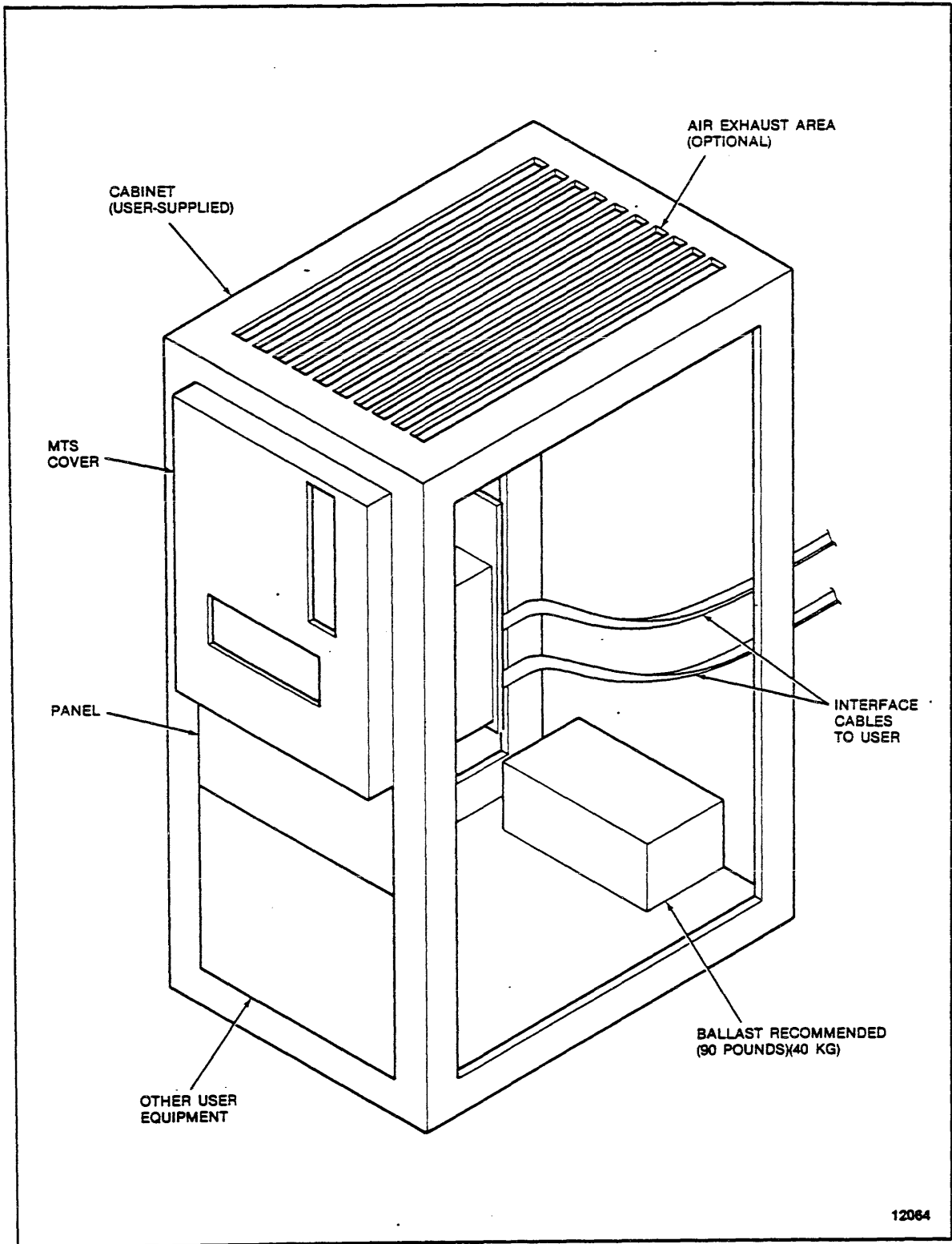


Figure 3-4. Vertical Mounting Installation

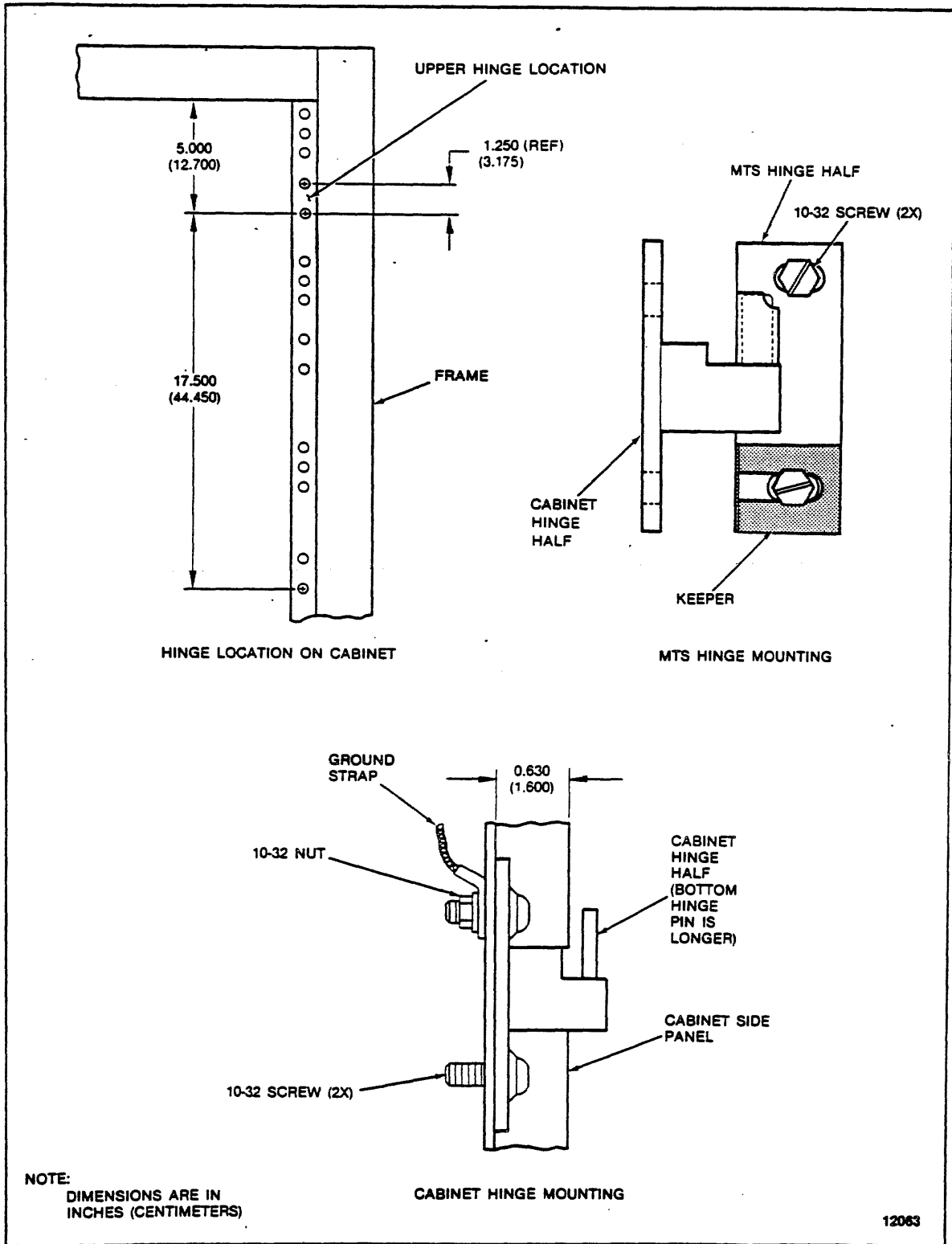


Figure 3-5. Vertical Mounting Dimensions



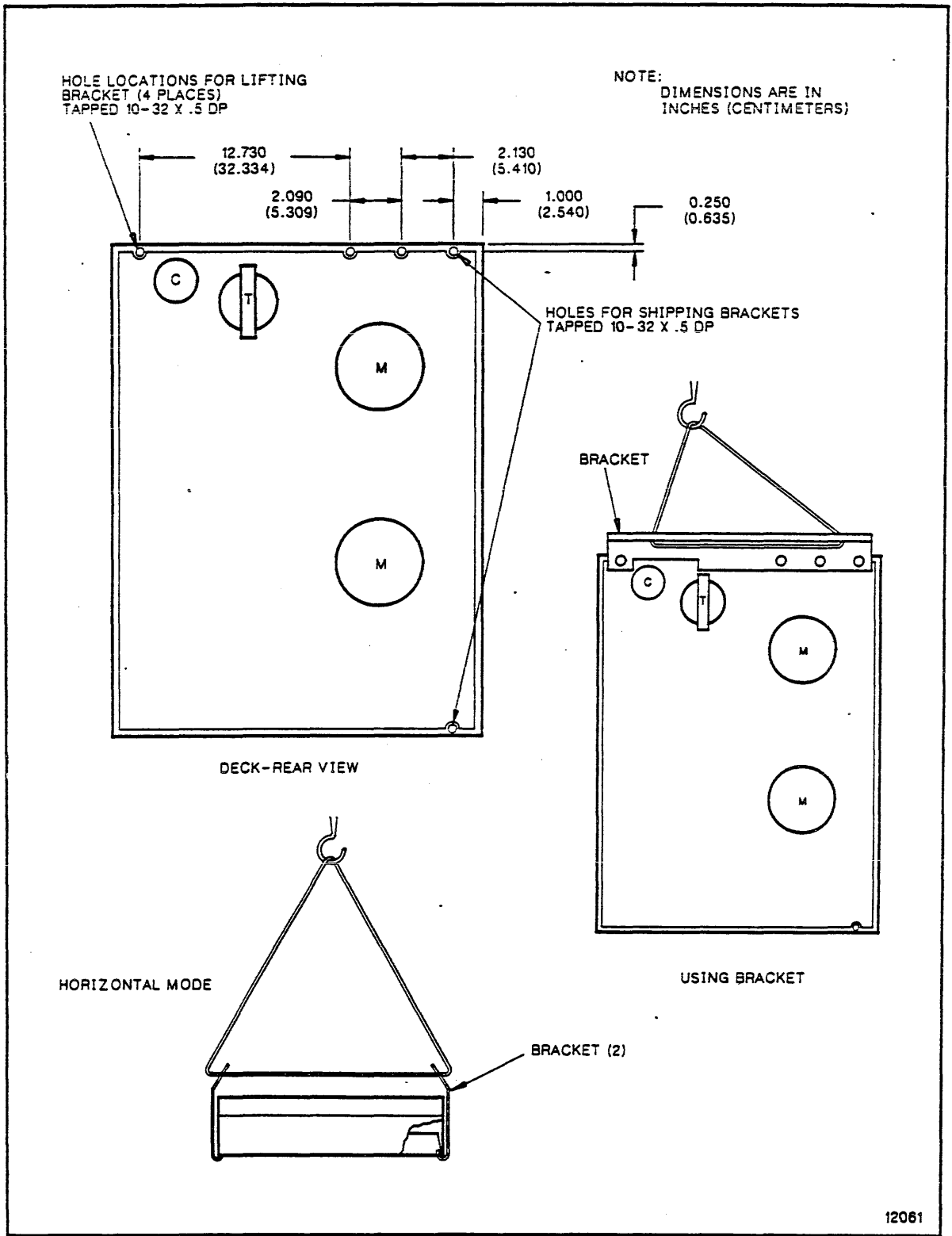


Figure 3-6. Suggested Lifting Methods

### 3.6 CENTER OF GRAVITY (HORIZONTAL) CABINET MOUNT

#### NOTE

A mounting kit is shipped with each center of gravity mount MTS. Detailed instructions are included in the kit. Follow these instructions when mounting the MTS.

#### WARNING

The MTS weighs approximately 125 pounds (57 kg). Use appropriate mechanical aids and sufficient personnel when moving the unit to avoid personnel injury or equipment damage. A suggested lifting method is shown in Figure 3-6.

Cabinet Dimension requirements and casting pivot locations and dimensions are shown in Figure 3-7.

### 3.7 STORAGETEK STANDARD INTERFACE CABLING

Interface cables are not supplied with the MTS. For electromagnetic compatibility (EMC) purposes, shielded I/O cables are recommended (Spectra-Strip 152-2831-060 or equivalent, plus Spectra-Strip 802-060 60-pin connectors). Two cables are required. The maximum cable length from the USER CPU to the last MTS in the string is 40 feet (12.19 meters). Refer to Figures 3-9 and 3-10. Terminators are required on the IF card slot A3 (the KCB or CP card slot A2 if a 2925 is in use) of the last MTS in the string and must be removed from any other MTS units in the string. Refer to Figure 3-3 for the locations of the terminators on the IF card. Refer to Figure 3-8 for the locations of the terminators on the CB and CP cards when the 2925 is used.

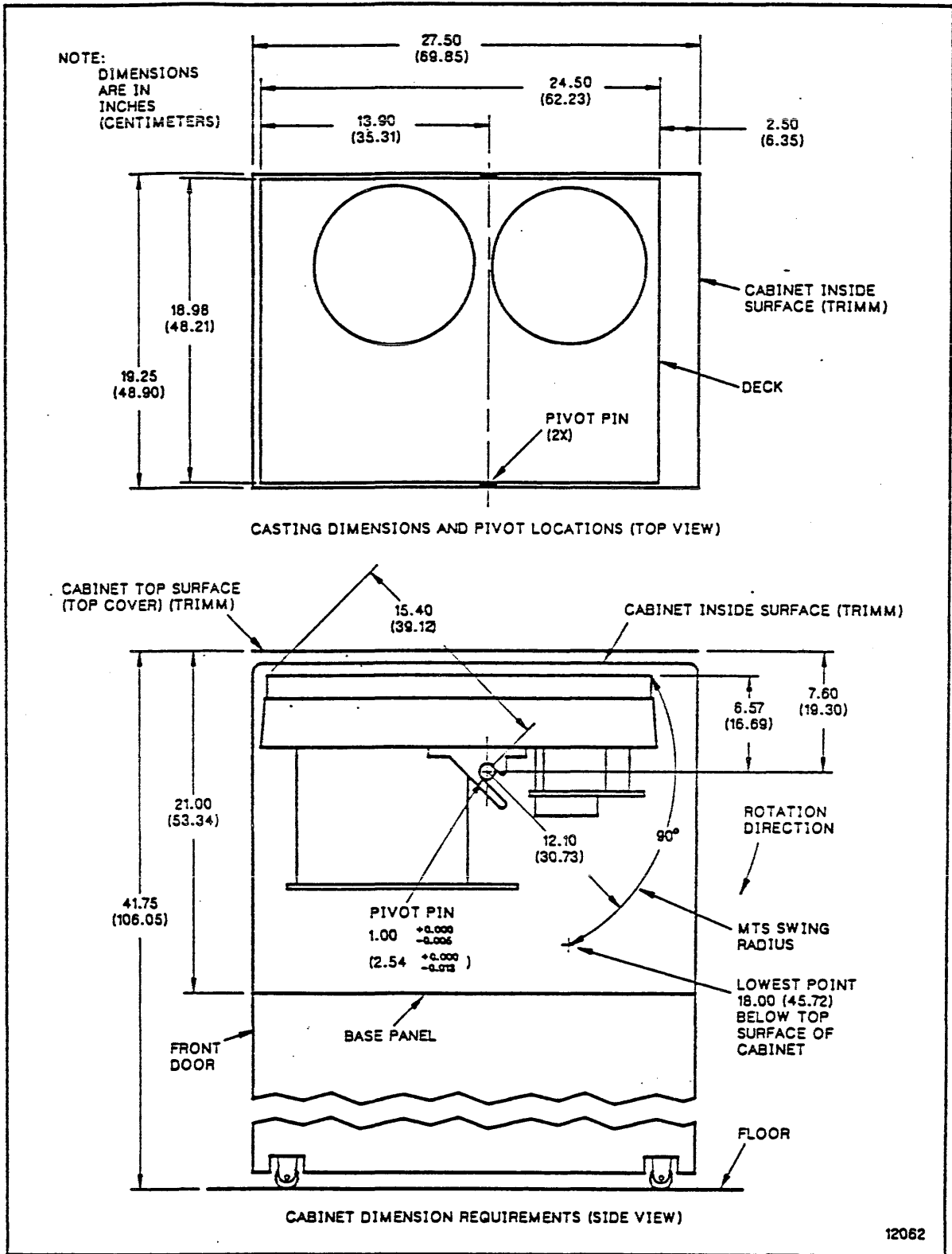


Figure 3-7. Center of Gravity Mounting Dimensions

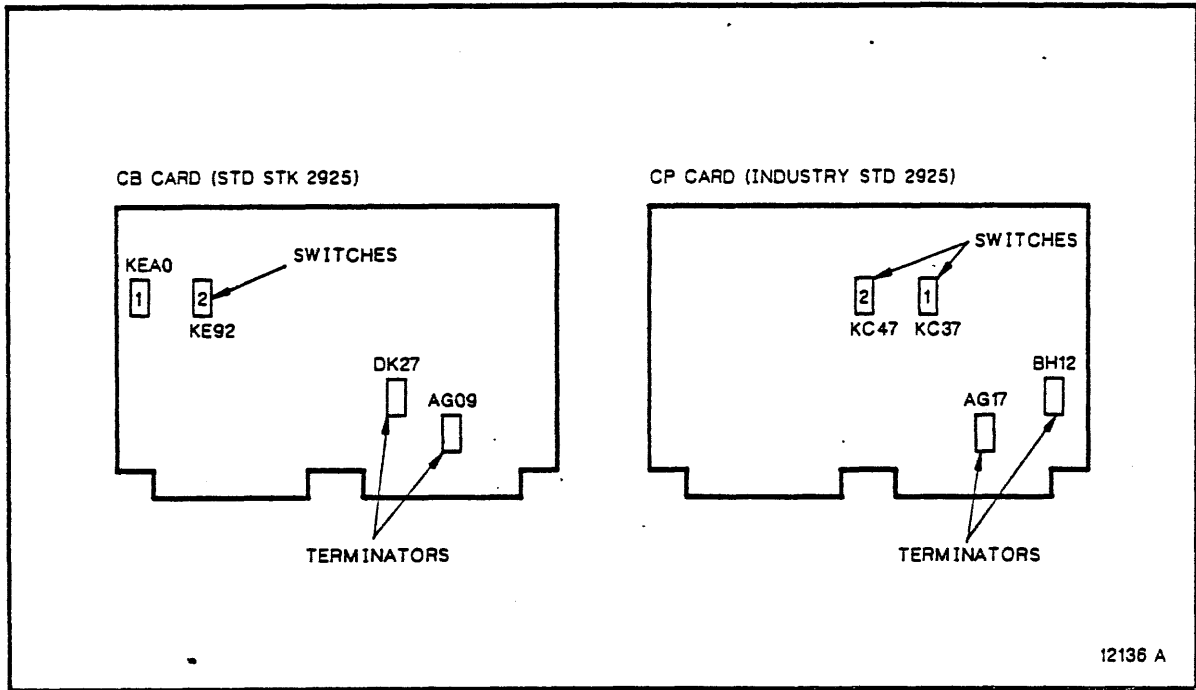


Figure 3-8. CB and CP Card Terminator and Address Switch Locations (2925 Only)

### 3.8 INDUSTRY STANDARD INTERFACE CABLING

Interface cables are not supplied with the MTS. Two 50-conductor twisted-pair cables are required, with card edge connector AMP 88373-1 or equivalent and keying plug AMP 88113-1 or equivalent. For electromagnetic compatibility (EMC) purposes, shielded I/O cables are recommended (Spectra-Strip 152-2831-050 or equivalent, plus Spectra-Strip 802-050 50-pin connectors).

The keys between tabs are located as follows:

Connectors:	J6A	J6B	J7A	J7B
Key Between Tabs:	5, 7	5, 7	11, 13	11, 13

The maximum cable length from the USER CPU to the last MTS in the string is 40 feet (12.19 meters). Refer to Figure 3-11.

Terminators are required only on the IF card of the last MTS in the string and must be removed from any other MTS units in the string. Refer to Figure 3-3 for the locations of the terminators. When the 2925 is in use, the terminators are located on the CB or

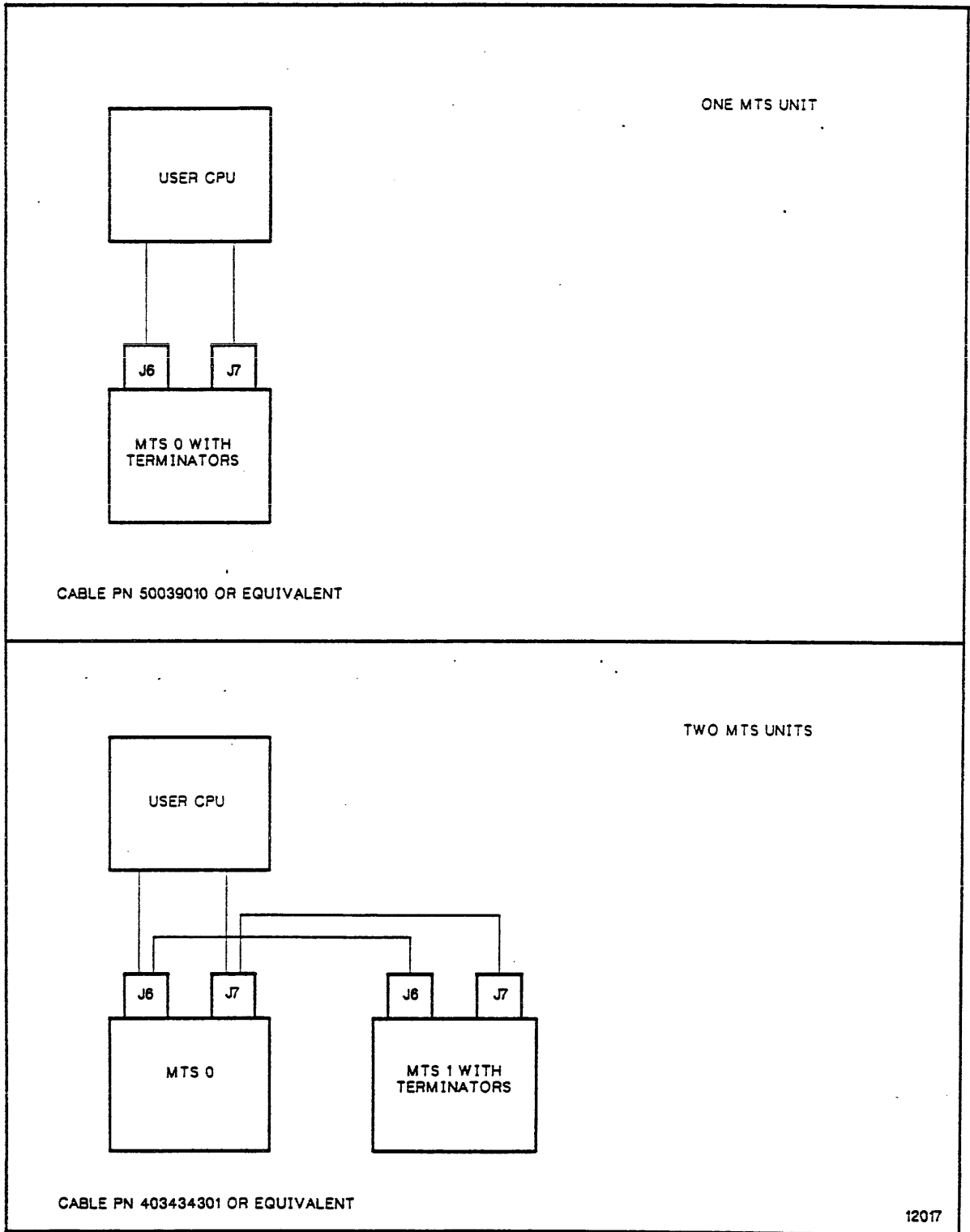
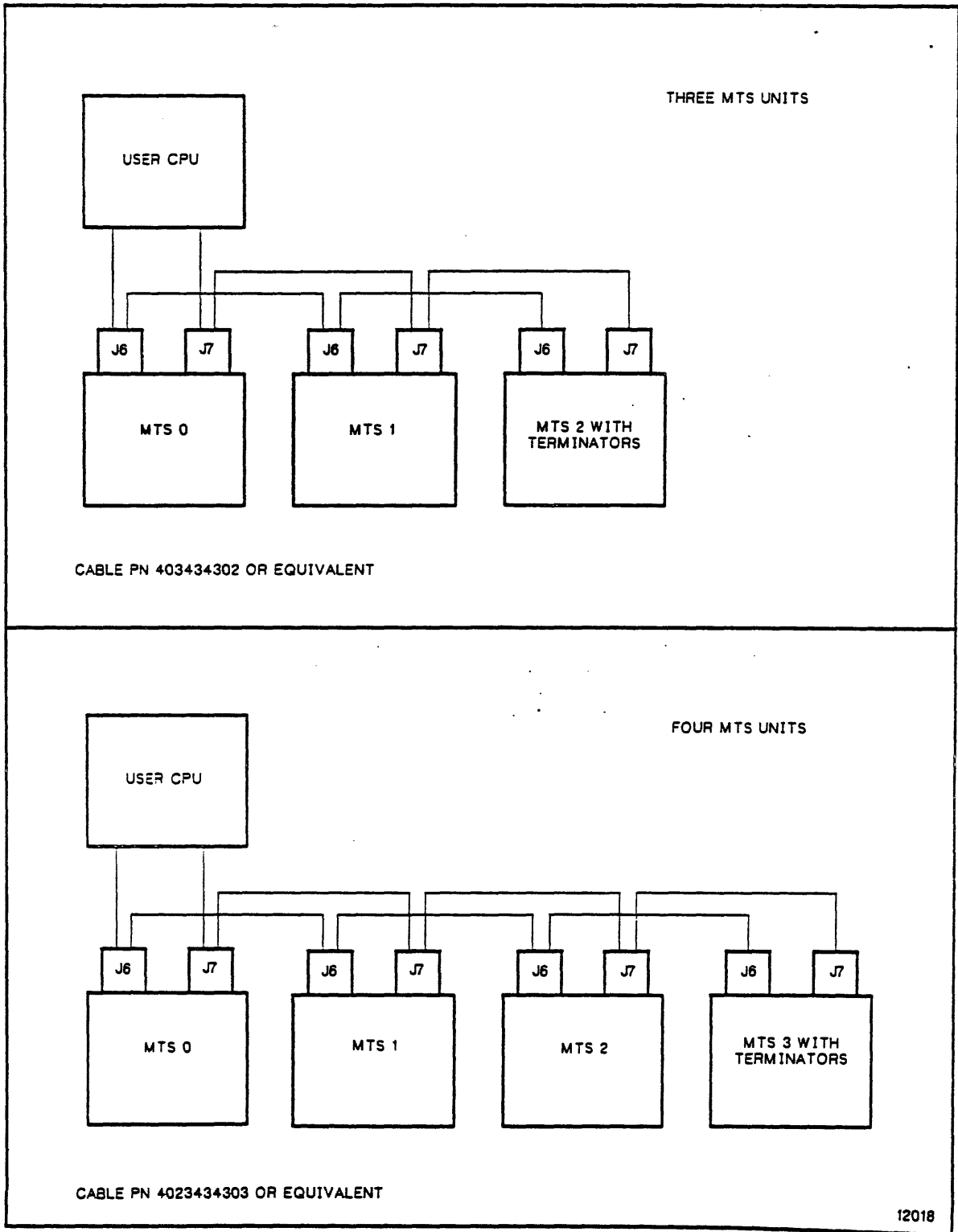


Figure 3-9. Storagetek Standard Interface Cabling Block Diagram (Sheet 1 of 2)



**Figure 3-9. Storagetek Standard Interface Cabling  
Block Diagram (Sheet 2 of 2)**

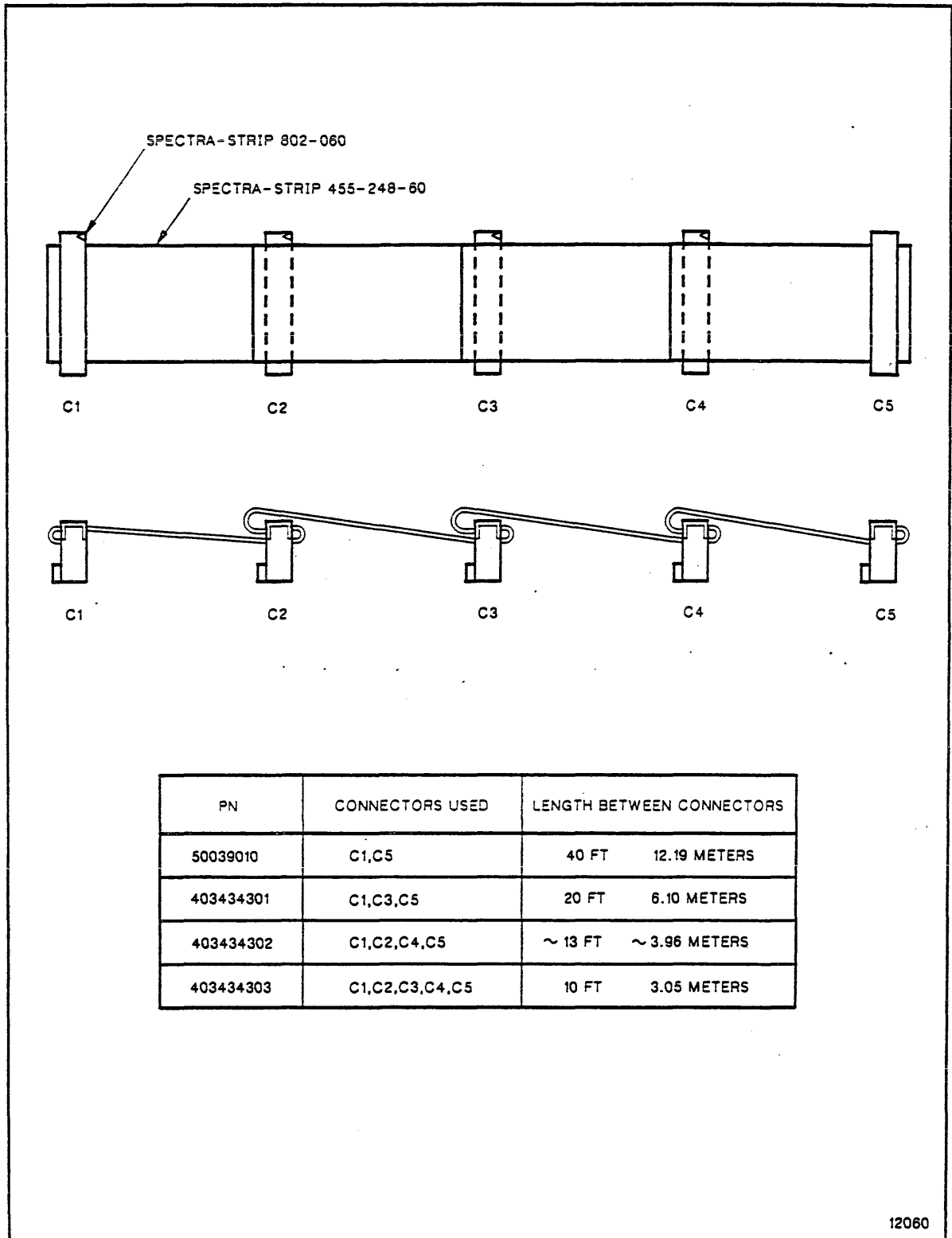


Figure 3-10. StorageTek Standard Interface Cable Configuration

CP card. Refer to Figure 3-8 for the location of the CB/CP card terminators.

#### NOTE

For I/O cables exiting the cabinet, clamps (3M 3504-2 or equivalent) should be mounted at the point of exit and adequate ground contact made to the cable shield.

### 3.9 ADDRESS SELECTION

The address of the MTS is selected by setting the appropriate DIP switches on the IF card. Refer to Figures 3-2 and 3-3. When using the 2925, the address switches located on the IF card must be on. The address of the MTS is selected by setting the appropriate DIP switches on the CB or CP cards. (Refer to Figure 3-12)

#### 3.9.1 Option Switches on the 292X IF and IFP Cards

There are six (6) option switches on each of the various types of 2920 IF cards (50 ips StorageTek, 100 ips StorageTek, 50 ips Industry Standard and the 100 ips Industry Standard Interface). These switches are contained in a six-switch package and are numbered from 1 to 6. The switches may be ON (CLOSED, LEFT, LOGIC 0, DISABLED) or they may be OFF (OPEN, RIGHT, LOGIC 1, ENABLED).

In the tables that follow, the Machine Address is the MTS Address as presented on the interface to select a particular drive, The Horizontal/Vertical switch selects the autoload (vertical) or the manual assist load algorithm (horizontal); The default speed/gap selection switches select the speed/gap combination to which the drive will be set each time a tape is loaded. Any time after the tape is loaded an interface command or Diagnostic 4 may be used to change the speed/gap setting. In 50 ips only the nominal gap is used. In 100 ips streaming mode there are three selections: 100/1 (nominal gap maximum); 100/2 (nominal + .3" gap maximum) and 100/3 (nominal + .6" gap maximum). In the Industry Standard 100 ips Interface the HISP (High Speed Select) and the LGAP (Write Extended Gap) lines may be ignored. This is for the benefit of those couplers which have not implemented these lines or have used them for other purposes. The IF and IFP card switch definitions are shown in Table 3-2 thru Table 3-5.



Table 3-2. StorageTek Interface 50 ips IF Card Switch Definitions

Machine Address Selection:				
Address	0	1	2	3
Switch 1	ON	OFF	ON	OFF
Switch 2	ON	ON	OFF	OFF
Unused:				
Switch 3 is reserved.				
Switch 4 is reserved.				
Switch 5 is reserved.				
Vertical or Horizontal Load Selection				
Orientation	Vertical		Horizontal	
Switch 6	ON		OFF	

**Table 3-3. StorageTek Interface 100 ips IF Card Switch Definitions**

Machine Address Selection:				
Address	0	1	2	3
Switch 1 <sup>1</sup>	ON	OFF	ON	OFF
Switch 2 <sup>1</sup>	ON	ON	OFF	OFF
Speed/ Gap	50	100/ 1	100/ 2	100/ 3
Switch 3	ON	OFF	ON	OFF
Switch 4	ON	ON	OFF	OFF
Switch 5 is reserved.				
Vertical or Horizontal Load Selection				
Orientation	Vertical		Horizontal	
Switch 6	ON		OFF	
<sup>1</sup> These two switches always ON when 2925 is being used.				

Table 3-4. Industry Interface 50 ips IFP Card Switch Definitions

Machine Address Selection:				
Drive Address	0	1	2	3
Switch 1	ON	OFF	ON	OFF
Switch 2	ON	ON	OFF	OFF
Formatter Address			0	1
Switch 3			ON	OFF
Unused				
Switch 4 is reserved.				
Switch 5 is reserved.				
Vertical or Horizontal Load Selection				
Orientation	Vertical		Horizontal	
Switch 6	ON		OFF	

**Table 3-5. Industry Interface 100 ips IFP Card Switch Definitions**

Machine Address Selection:				
Drive Address	0	1	2	3
Switch 1	ON	OFF	ON	OFF
Switch 2	ON	ON	OFF	OFF
Formatter Address			0	1
Switch 3			ON	OFF
HISP <sup>1</sup> /LGAP <sup>2</sup> Status			Obey	Ignore
Switch 4			ON	OFF
Speed/Gap			50	100/3
Switch 5			ON	OFF
Vertical or Horizontal Load Selection				
Orientation	Vertical		Horizontal	
Switch 6	ON		OFF	
<sup>1</sup> High Speed Select <sup>2</sup> Write Extended Gap				

### 3.9.2 Option Switches on the 2925 CB and CP Cards

There are ten option switches on each of the various types of 2925 CB or CP cards. These switches are contained in a ten-switch package and are numbered from 1 to 10. The switches may be ON (Closed, Left, Logic 0, Disabled) or they may be OFF (Open, Right, Logic 1, Enabled).

The CB CP card switch definitions are shown in Table 3-6, Table 3-7 and Figure 3-12.

#### 3.9.2.1 LOCATION KEA0(CB) OR KC39(CP)

The ten switches located at KEA0(CB) or KC39(CP) are defined in this paragraph. Use the definitions in conjunction with Figure 3-12 and table 3-6.

### 3.9.2.1.1 Switches 1, 2 and 7 at KEA0(CB) or KC39(CP)

These three switches determine the data rate for the 2925 using the Industry Standard Interface.

The switches are defined as follows:

- Switch 1 = Data Rate 0
- Switch 2 = Data Rate 1
- Switch 7 = Data Rate 2

When set in the following configurations, the data rates are shown:

<u>Rate 2</u>	<u>Rate 1</u>	<u>Rate 0</u>	<u>Resulting Data Rate</u>
0	0	0	1000 Kb/s
0	0	1	833 Kb/s
0	1	0	714 Kb/s
0	1	1	625 Kb/s
1	0	0	500 Kb/s
1	0	1	313 Kb/s
1	1	0	200 Kb/s
1	1	1	76 Kb/s

#### NOTE

These switches are spares when using a StorageTek Interface.

### 3.9.2.1.2 Switches 3 and 4 at Location KEA0(CB) or KC39(CP)

These two switches set the interface ramp as follows:

NTF RAMP 1		Interface Ramp bit 1, IND STD
NTF RAMP 0		Interface Ramp bit 0, IND STD
RAMP 1	RAMP 0	
0	0	Interface Ramp = 1ms to 2ms
0	1	Interface Ramp = 4ms to 6ms
1	0	Interface Ramp = 8ms to 12ms
1	1	Interface Ramp = 12 ms to 18ms

The interface ramp refers to the time from busy falling to the time the first strobe (FRDST or FWDST for IND STD) is sent to the Host.

### 3.9.2.1.3 Switches 5 and 6 at Location KEA0(CB) or KC39(CP)

Switches 5 and 6 define the maximum block size as shown:

AX BLK SIZE 1	Maximum Block Size bit 1
---------------	--------------------------

AX BLK SIZE 0		Maximum Block Size bit 0
SIZE 1	SIZE 0	
0	0	Maximum Block Size = 8K
0	1	Maximum Block Size = 16K
1	0	Maximum Block Size = 24K
1	1	Maximum Block Size = 32K

The maximum block size is used for reading ahead and for accepting the next buffered write. If there is not the Maximum Block Size left as free space in the buffer, the microprocessor quits reading ahead or on a write holds off ending status to the Host until there is enough room.

#### 3.9.2.1.4 Switch 8 at Location KEA0(CB) or KC39(CP)

Switch 8 defines the GCR Write Correction as follows:

0 GCR ONE TRACK No GCR One Track; When enabled, the subsystem will retry single track GCR write errors. When disabled, the subsystem will not retry single track GCR write errors.

#### 3.9.2.1.5 Switches 9 and 10 at Location KEA0(CB) or KC39(CP)

Switches 9 and 10 define the Cache Address as follows:

CACHE ADDRESS 1		
CACHE ADDRESS 0		
ADDR 1	ADDR 0	
0	0	Cache Address = 0
0	1	Cache Address = 1
1	0	Cache Address = 2
1	1	Cache Address = 3

Table 3-6. CB(STK) KEA0 and CP (IND STD) KC39 Definitions

Machine Address Selection									
Address	0	1	2	3					
Switch 10	ON	ON	OFF	OFF					
Switch 9	ON	OFF	ON	OFF					
Switch 8 ON = no correction during GCR WRT OFF = correct 1 track GCR WRT									
Switch 7 see description for ;1, 2, and 7 (IND STD only)									
Max Block Size in Buffer									
Size	8K	16K	24K	32K					
Switch 6	ON	ON	OFF	OFF					
Switch 5	ON	OFF	ON	OFF					
IND STD Data Rate (IND STD only)									
RATE(Kb/s)	1meg	833	714	6254	500	312	200	75	
Switch 7	ON	ON	ON	ON	OFF	OFF	OFF	OFF	
Switch 2	ON	ON	OFF	OFF	ON	ON	OFF	OFF	
Switch 1	ON	OFF	ON	OFF	ON	OFF	ON	OFF	

### 3.9.2.2 LOCATION KE92(CB) OR KC47(CP)

The ten switches located at KE92(CB) or KC47(CP) are defined in the following paragraphs. Use the definitions in conjunction with Figure 3-12 and Table 3-7.

#### 3.9.2.2.1 Switches 1 and 2 at Location KE92(CB) or KC47(CP)

These two switches define the Write Retry Count as follows:

WR RETRY CNT1	Write Retry Count Bit 1
WR RETRY CNT0	Write Retry Count Bit 0
CNT1	CNT0
0	0
0	1
	Write Retry Count = 5
	Write Retry Count = 5

1	0	Write Retry Count = 10
1	1	Write Retry Count = 15

### 3.9.2.2.2 Switches 3 and 4 at Location KE92(CB) or KC47(CP)

These two switches define the Read Retry Count as follows:

RD RETRY CNT1		Read Retry Count Bit 1
RD RETRY CNT0		Read Retry Count Bit 0
CNT1	CNT0	
0	0	Read Retry Count = 0
0	1	Read Retry Count = 5
1	0	Read Retry Count = 10
1	1	Read Retry Count = 15

### 3.9.2.2.3 Switch 5 at Location KE92(CB) or KC47(CP)

This switch is the Tape Mark Sync. When enabled, the buffer is synchronized after two Tape Marks in a row are read from tape or written from Host. When disabled, the buffer is synchronized after one Tape Mark is read from tape or written from Host.

### 3.9.2.2.4 Switch 6 at Location KE92(CB) or KC47(CP)

This switch is the Early EOT switch. When enabled, the subsystem will allow only one write record in the buffer at a time when the Early EOT indication is valid. Also, dummy status is not presented to the Host, i.e., the record just received from the Host will be written to tape and errors checked before status is presented for that record.

When disabled, the subsystem will allow at most 4 write records in the buffer when the Early EOT indication is valid. If there are more than 4 records in the Buffer when Early EOT is indicated, the cache processor reduces the number of records in the Buffer to 4 or less.

Once the actual EOT status is sent from the Tape Drive, the subsystem will behave as if the switch is enabled (i.e., as described in the previous paragraph).

#### NOTE

Switch 7 at location KE92 or KC47 is a spare.

### 3.9.2.2.5 Switch 8 at Location KE92(CB) or KC47(CP)

Switch 8 is the Long Record Mode switch. When enabled, the subsystem defaults to Long Record Mode at power up and front



panel reset. When disabled, the subsystem defaults to Buffered mode at power up and front panel reset.

### 3.9.2.2.6 Switch 9 at Location KE92(CB) or KC47(CP)

Switch 9 is the Formatter Address switch and is defined as follows:

FORMATTER ADDRESS	
ADDRESS	
0	Formatter address = 0
1	Formatter address = 1

#### NOTE

Switch 9 is a spare when a StorageTek Interface is in use.

Switch 10 is a spare with both interfaces.

Table 3-7. CB (STK) KE92 and CP (IND STD) KC47 Definitions

Unused:				
Switch 10 is reserved				
Industry Standard formatter address				
Address	0	1		
Switch 9	ON	OFF		
Long Record Mode				
Mode	Buffered	Sync (Long Record Mode)		
Switch 8	ON	OFF		
Switch 7 is reserved				
Early EOT: Switch 6 ON = early EOT 4 records in buffer OFF = one record in buffer				
Tape Mark Sync: Switch 5 ON = sync buffer after 1 tape mark OFF = sync buffer after 2 tape marks				
Number of Read Retries:				
Retries	0	5	10	15
Switch 4	ON	ON	OFF	OFF
Switch 3	ON	OFF	ON	OFF
Number of Write Retries				
Retries	0	5	10	15
Switch 2	ON	ON	OFF	OFF
Switch 1	ON	OFF	ON	OFF

### 3.10 RESHIPING

If the MTS requires reshipping, Field Bill 68390 supplies the necessary parts and Field Instruction 68369 contains detailed instructions to ensure that the MTS is shipped without damage.



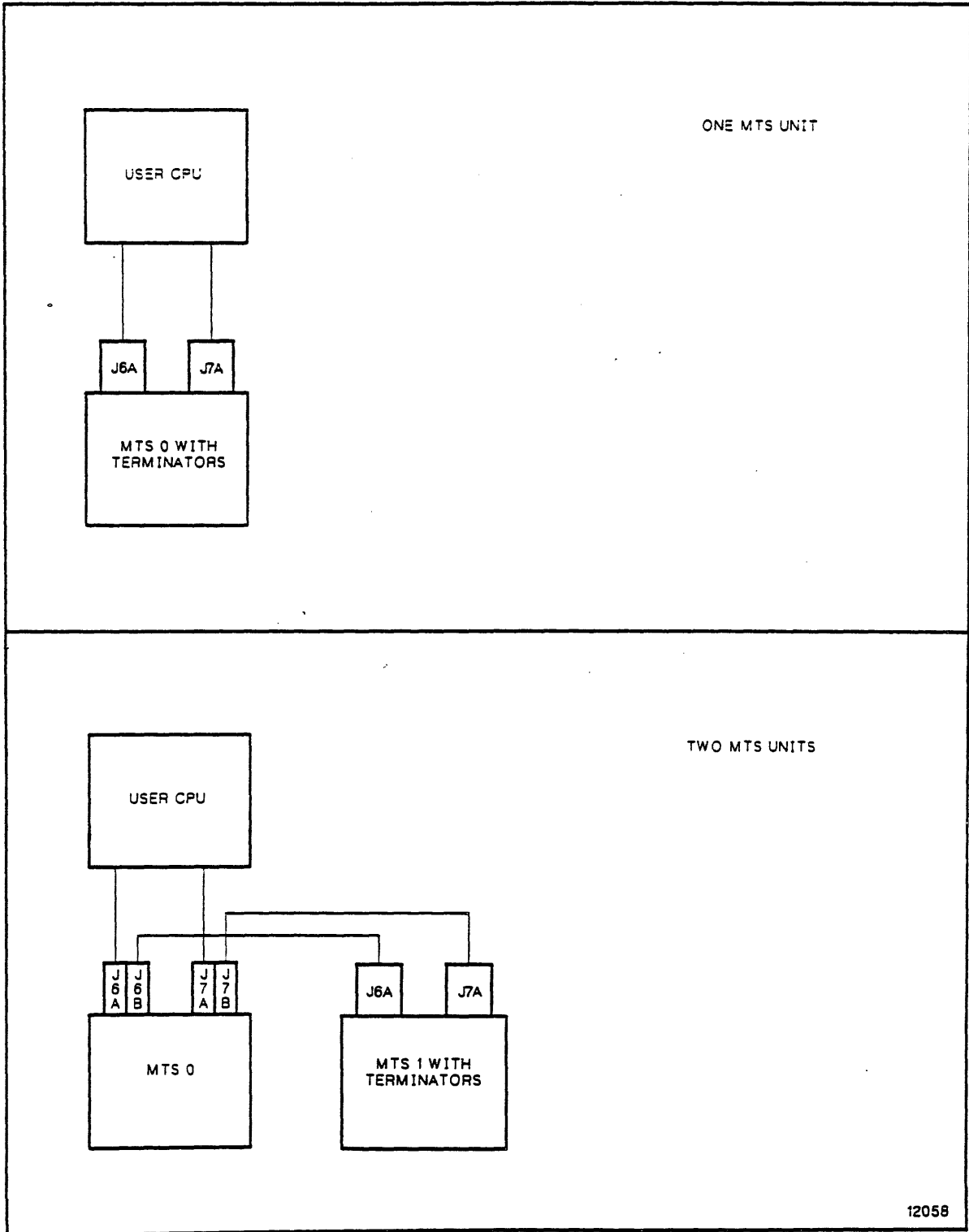
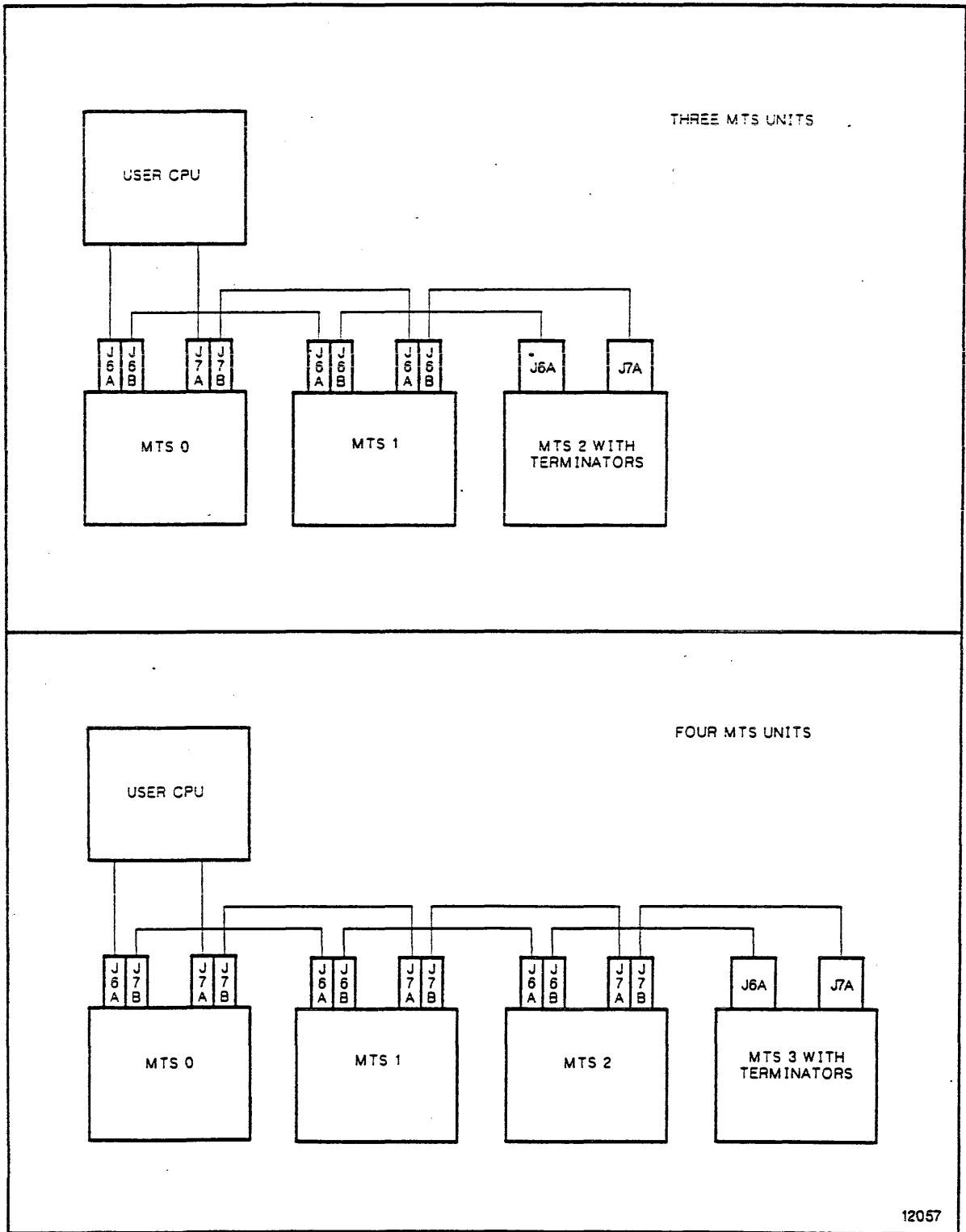
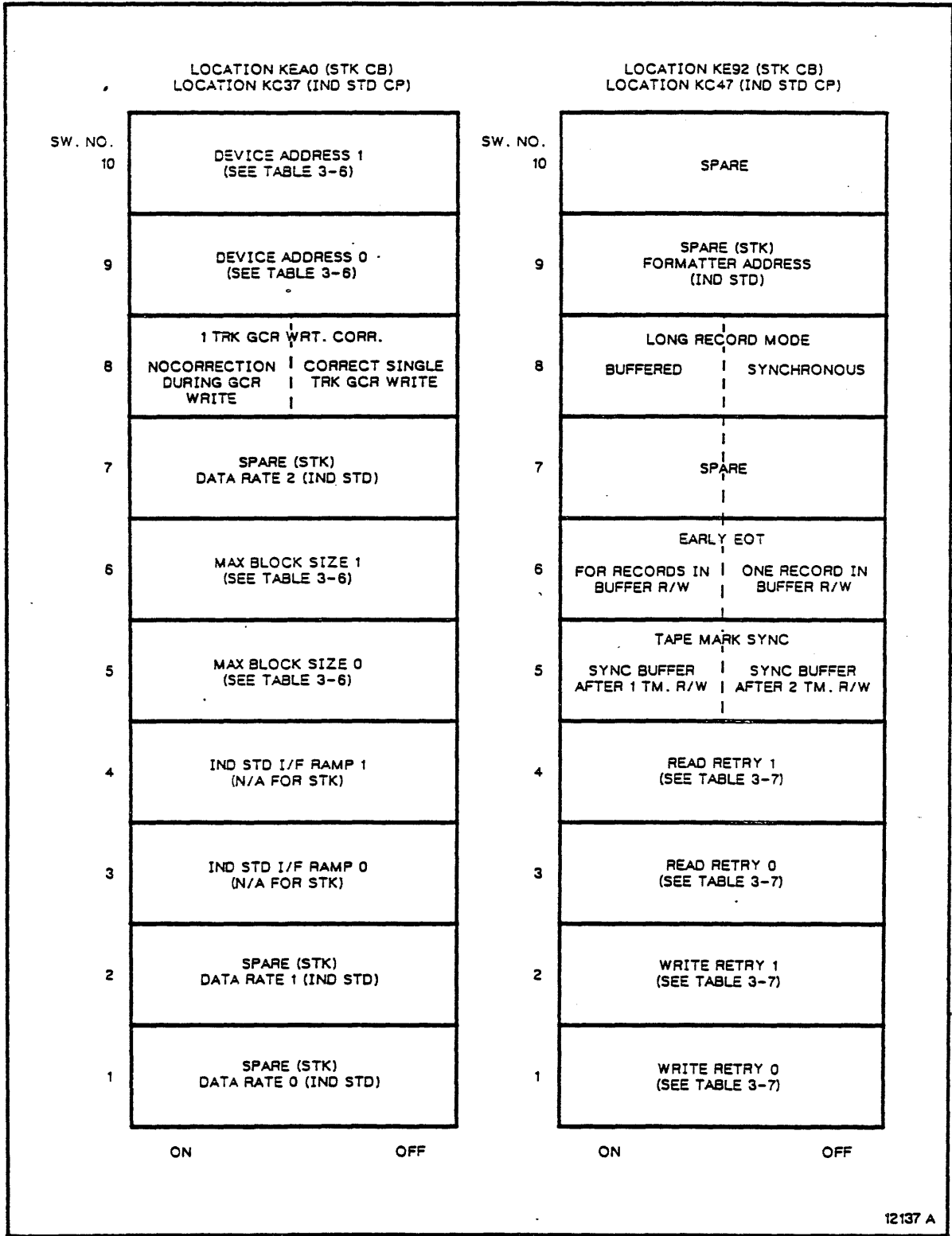


Figure 3-11. Industry Standard Interface Cabling Block Diagram  
(Sheet 2 of 3)



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Figure 3-11. Industry Standard Interface Cabling Block Diagram  
(Sheet 3 of 3)



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Figure 3-12. CB and CP Card Switch Definitions

SEPARATOR SET PN 83464

THIS SEPARATOR SET CONTAINS 19  
TABS TOTAL IN THE FOLLOWING  
ORDER:

MAINTENANCE MANUAL

1. INTRODUCTION
  2. OPERATION
  3. INSTALLATION
  4. STORAGETEK INTERFACE
  5. INDUSTRY INTERFACE
  6. SCSI INTERFACE
  7. VS INTERFACE
  8. FUNCTIONAL DESCRIPTION
  9. MAINTENANCE
  10. REMOVAL/REPLACEMENT
  11. DIAGNOSTICS
- APPENDICES

IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD

## CHAPTER 4

# STORAGE TECHNOLOGY STANDARD INTERFACE

### 4.1 INTRODUCTION

This chapter provides a description of the MTS-user interface circuits, defines the MTS-user interface signals, and describes the user commands to the MTS for the Storage Technology Standard Interface.

The MTS and user interface connections are shown in Tables 4-1 and 4-2. The MTS and user interface circuits are shown in Figure 4-1. The maximum allowable cable length from the user system to the last MTS in a chain is 40 feet (12.19 meters). Refer to Figures 4-2 and 4-3 for cabling and cables.

The interface signal levels are:

Unasserted (Reset) = +3.4 ( $\pm 0.3$ ) Vdc = nonselected line  
Asserted (Set) = 0 (<0.7) Vdc = selected line

The interface resistive termination for each signal is 390 ohms to ground and 180 ohms to +5 Vdc. The termination for each signal line is provided in the MTS or required of the user interface or both. The termination includes a ground wire, connected in both the MTS and the user interfaces. Only the last MTS in a chain contains terminators.

### 4.2 STORAGETEK STANDARD INTERFACE INPUT SIGNAL DEFINITIONS

The input line definitions given in this section are for functional mode only. The timing specifications given refer to measurements made at the Standard Interface connector.

#### 4.2.1 MTS Address (AD0, AD1)

The two MTS Address lines are decoded to select one of the four possible MTSS, as shown in Table 4-3.

If the MTS is not busy (the BUSY line is not asserted), the Address lines may be changed at will to select a different MTS and thus view a different set of MTS status lines. The delay time between the selection of a new MTS and stabilization of the MTS status lines is 150 nanoseconds maximum.

For command operations, the MTS Address lines must be stable 90 nanoseconds prior to the assertion of START, remain stable until



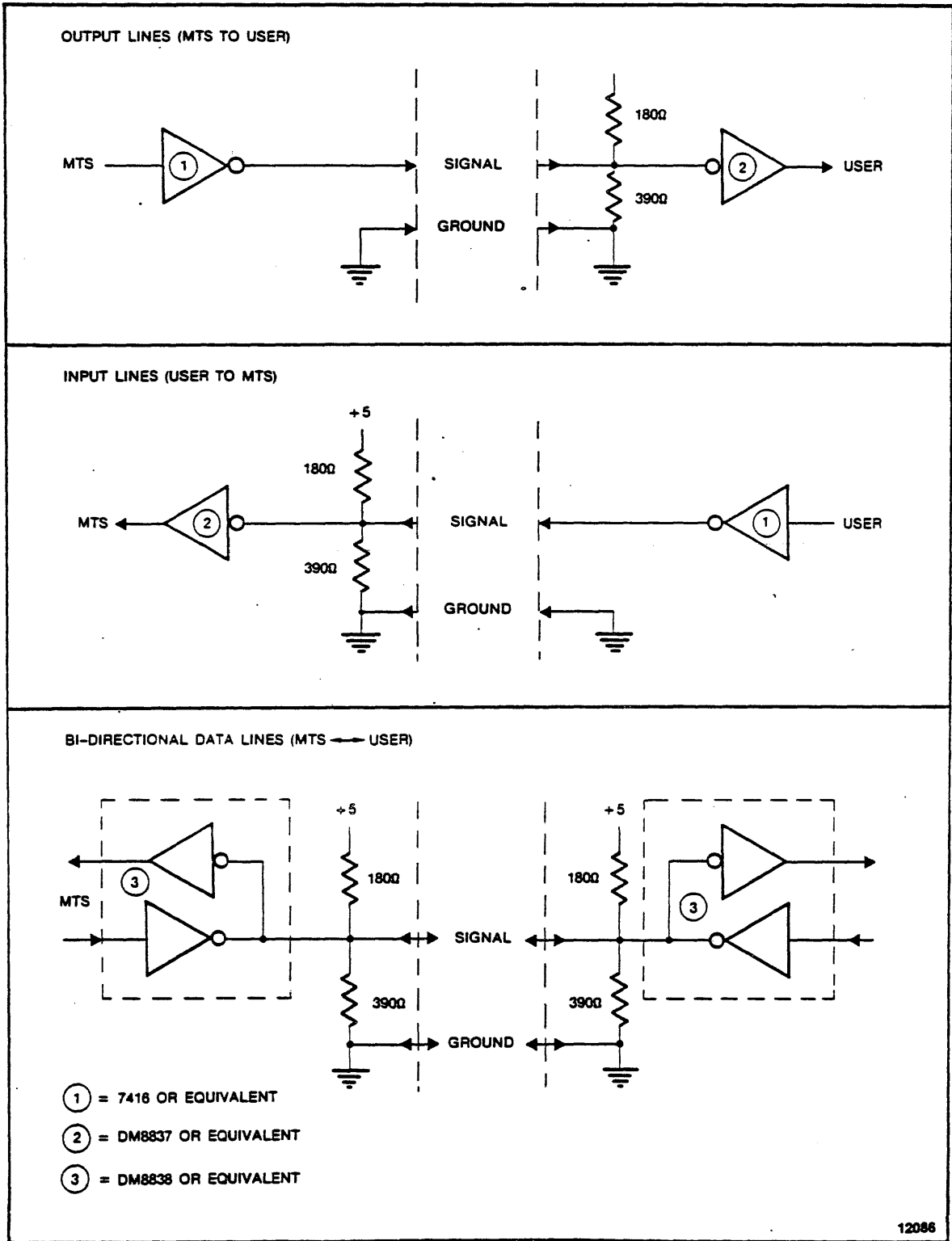


Figure 4-1. MTS-User Interface Circuits

Table 4-1. Input Lines for the Storage Technology Standard Interface

DESCRIPTION	MNEMONIC	MTS CONNECTOR			TERMINATION RESISTANCE LOCATION
		NO.	SIGNAL PIN	GROUND PIN	
MTS Address 0	AD0	J7	A01	B01	MTS
MTS Address 1	AD1	J7	A02	B02	MTS
Command Select 0	CMD0	J7	A03	B03	MTS
Command Select 1	CMD1	J7	A04	B04	MTS
Command Select 2	CMD2	J7	A05	B05	MTS
Command Select 3	CMD3	J7	A06	B06	MTS
Density Select 0	DS0	J7	A07	B07	MTS
Initiate Command	START	J7	A08	B08	MTS
Terminate Command	STOP	J7	A09	B09	MTS
Transfer Acknowledge	TRAK	J7	A10	B10	MTS
Bi-Directional Data P	DATA-P	J7	A11	B11	Both
Bi-Directional Data 0	DATA-0	J7	A12	B12	Both
Bi-Directional Data 1	DATA-1	J7	A13	B13	Both
Bi-Directional Data 2	DATA-2	J7	A14	B14	Both
Bi-Directional Data 3	DATA-3	J7	A15	B15	Both
Bi-Directional Data 4	DATA-4	J7	A16	B16	Both
Bi-Directional Data 5	DATA-5	J7	A17	B17	Both
Bi-Directional Data 6	DATA-6	J7	A18	B18	Both
Bi-Directional Data 7	DATA-7	J7	A19	B19	Both
System Reset	RESET	J7	A20	B20	MTS
Select Multiplex 1	SLX1	J7	A21	B21	MTS
Select Multiplex 0	SLX0	J7	A22	B22	MTS
Density Select 1	DS1	J7	A23	B23	MTS
Select Multiplex 2	SLX2	J7	A24	B24	MTS

Table 4-2. Output Lines for the Storage Technology Standard Interface

DESCRIPTION	MNEMONIC	MTS CONNECTOR			TERMINATION RESISTANCE LOCATION
		NO.	SIGNAL PIN	GROUND PIN	
Slave Status Change	SSC	J7	A25	B25	User
Oscillator	OSC	J7	A26	B26	User
End of Tape Status	EOTS	J7	A27	B27	User
Begin. of Tape Status	BOTS	J7	A28	B28	User
File Protect Status	FPTS	J7	A29	B29	User
Rewinding Status	REWS	J7	A30	B30	User
Error Multiplex P	ERRMX-P	J6	A1	B1	User
Error Multiplex 0	ERRMX-0	J6	A2	B2	User
Error Multiplex 1	ERRMX-1	J6	A3	B3	User
Error Multiplex 2	ERRMX-2	J6	A4	B4	User
Error Multiplex 3	ERRMX-3	J6	A5	B5	User
Error Multiplex 4	ERRMX-4	J6	A6	B6	User
Error Multiplex 5	ERRMX-5	J6	A7	B7	User
Error Multiplex 6	ERRMX-6	J6	A8	B8	User
Error Multiplex 7	ERRMX-7	J6	A9	B9	User
Busy	BUSY	J6	A10	B10	User
Transfer Request	TREQ	J6	A11	B11	User
Expecting Data	RECV	J6	A12	B12	User
Identification Burst	ID BRST	J6	A13	B13	User
Operation Incomplete	OP INC	J6	A14	B14	User
End of Data Pulse	ENDATP	J6	A15	B15	User
Tape Mark Status	TMS	J6	A16	B16	User
Command Reject	REJECT	J6	A17	B17	User
Overrun Status	OVRNS	J6	A18	B18	User
Data Check	DATA CHK	J6	A19	B19	User
EPROM Error	ROMPS	J6	A20	B20	User
Corrected Error	CRERR	J6	A21	B21	User
Block Sensed	BLOCK	J6	A22	B22	User
Reserved		J6	A23	B23	User
Data Bus Parity Error	BUPER	J6	A24	B24	User
Online Status	ONLS	J6	A25	B25	User
High Density Status	HDNS	J6	A26	B26	User
Ready Status	RDYS	J6	A27	B27	User
Write Status	WRTS	J6	A28	B28	User
Reserved		J6	A29	B29	
Reserved		J6	A30	B30	

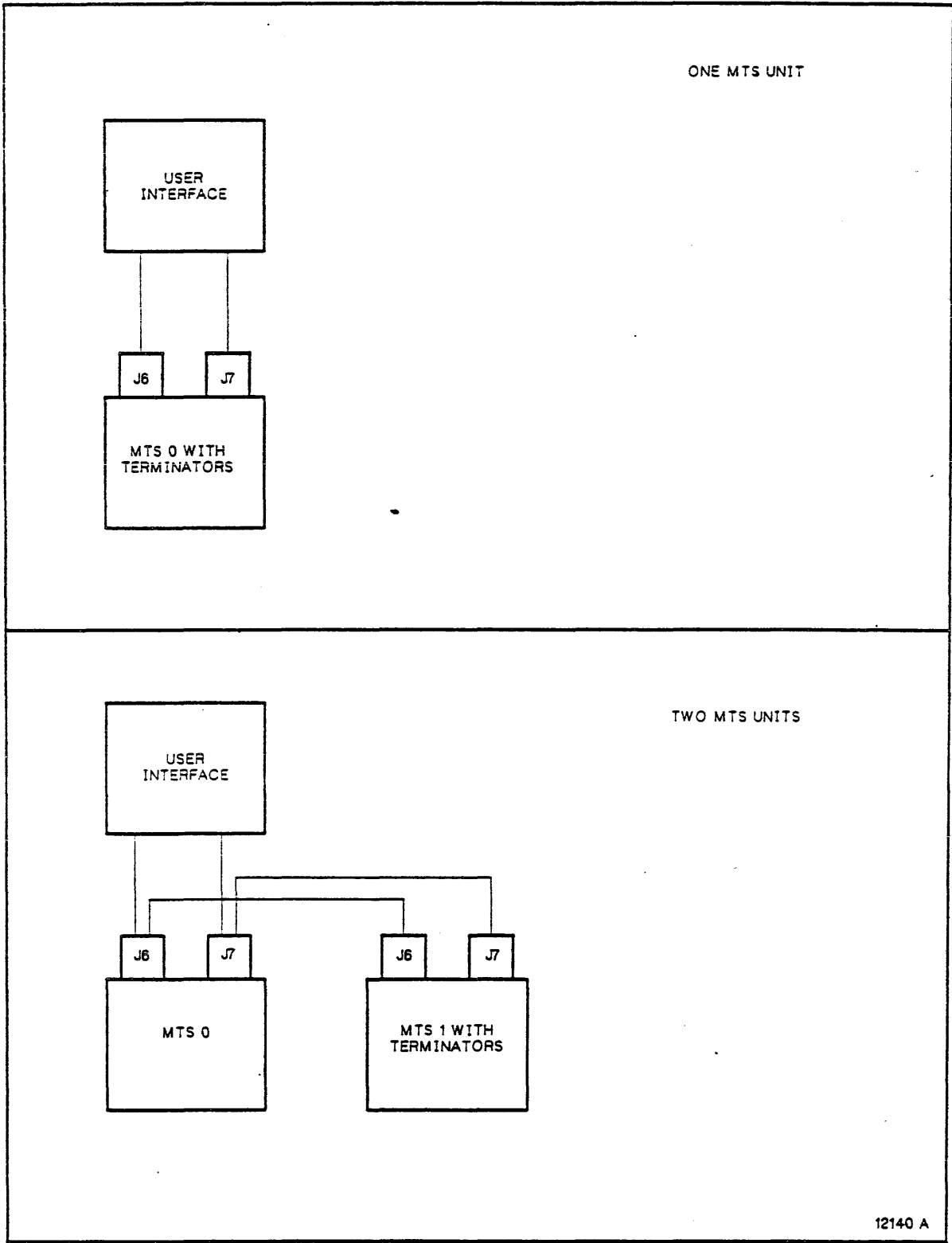


Figure 4-2. MTS Interface Cabling (Sheet 1 of 2)

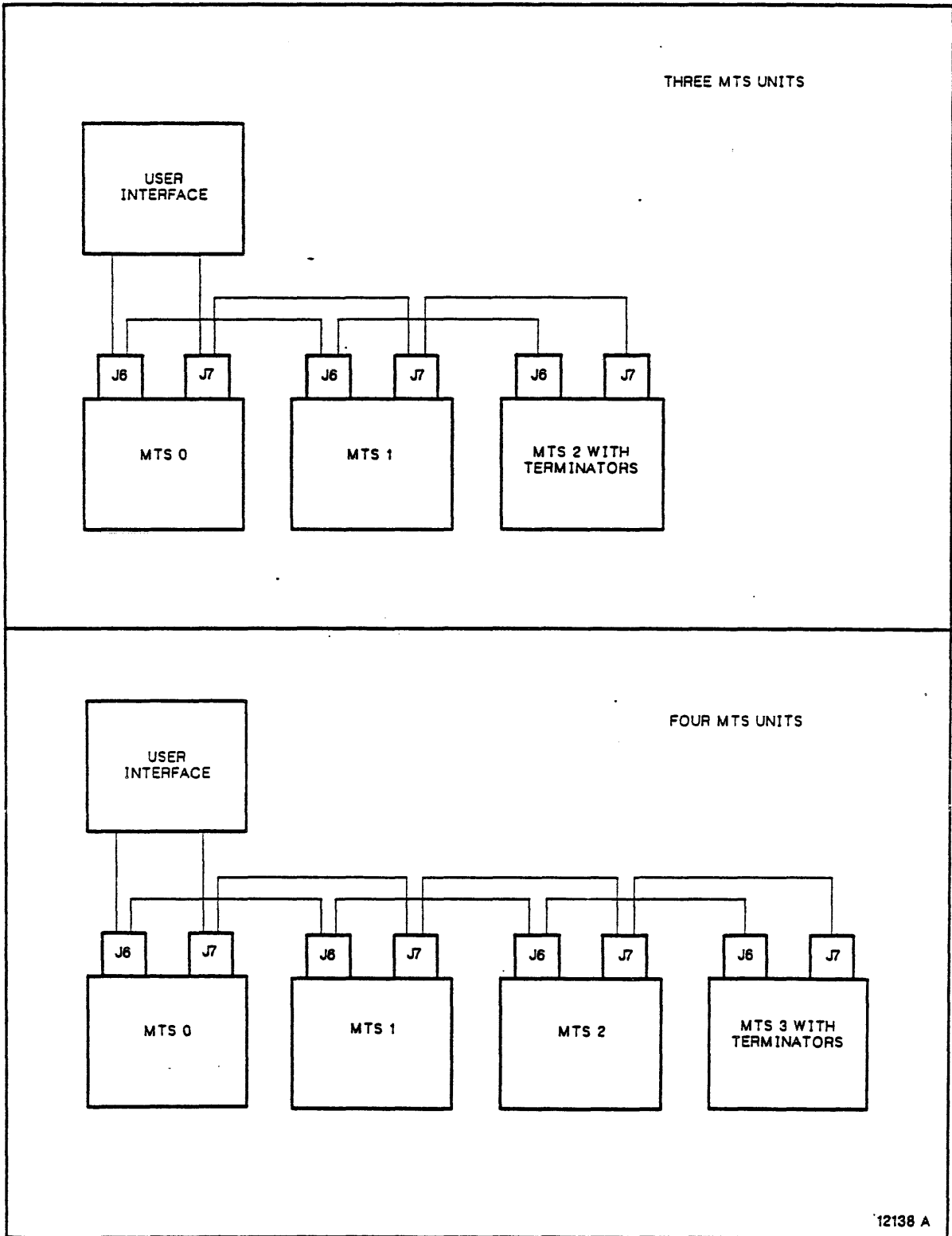


Figure 4-2. MTS Interface Cabling (Sheet 2 of 2)

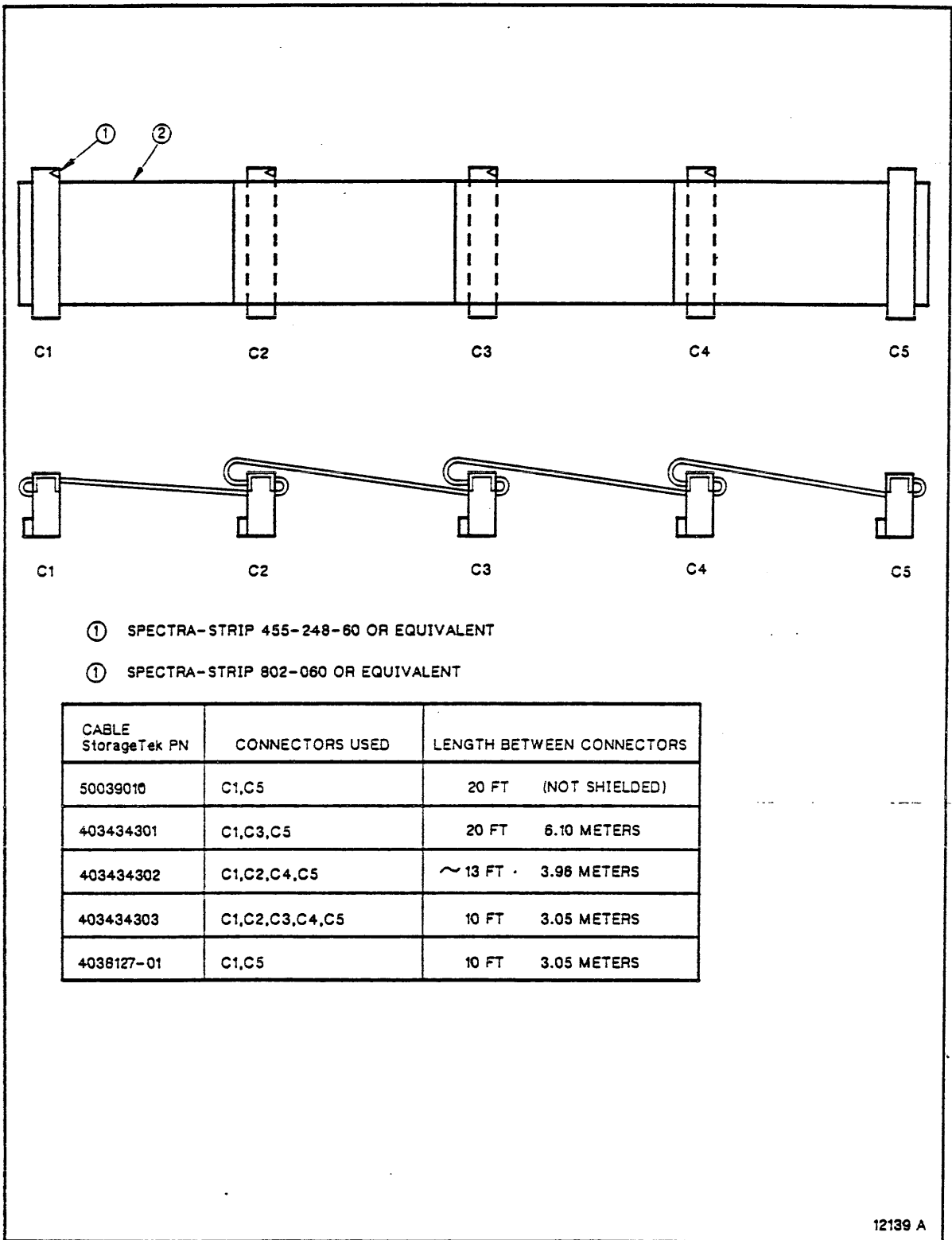


Figure 4-3. MTS Interface Cables

Table 4-3. MTS Address Line Decode

MTS ADDRESS LINES		SELECTED MTS
AD1	AD0	
0	0	0
0	1	1
1	0	2
1	1	3

the selected MTS responds by asserting BUSY, and must not change while BUSY is asserted.

#### 4.2.2 Initiate Command (START)

The assertion of the Initiate Command line causes the user Command Select and Density Select lines to be captured and the command operation to begin. START must remain asserted until the MTS responds by asserting BUSY, after which time START may be reset. START may be asserted to initiate a command whenever BUSY is not asserted. START assertions while BUSY is asserted have no effect. START must be unasserted before the MTS Address lines change.

#### 4.2.3 Command Select (CMD0, CMD1, CMD2, CMD3)

The four Command Select lines are decoded in the MTS and causes one of 16 command operations. These lines must be stable 90 nanoseconds prior to the assertion of START and must remain stable until the MTS responds by asserting BUSY. Command Select decoding is shown in Table 4-4. The detail descriptions and timing of each command operation are specified in Section 4.3.

Table 4-4. Command Select Decode

CMD0	CMD1	CMD2	CMD3	MNEMONIC	DESCRIPTION
0	0	0	0	NOP	No-Operation
0	0	0	1	CLR	Drive Clear
0	0	1	0	DMS	Diagnostic Mode Set
0	0	1	1	SNS	Sense Drive Status
0	1	0	0	RDF	Read Forward a Block
0	1	0	1	RDB	Read Backward a Block
0	1	1	0	WRT	Write a Data Block
0	1	1	1	LWR	Loop Write-to-Read
1	0	0	0	BSF	Backspace a File
1	0	0	1	BSB	Backspace a Block
1	0	1	0	FSF	Forward Space a File
1	0	1	1	FSB	Forward Space a Block
1	1	0	0	WTM	Write Tape Mark
1	1	0	1	ERG	Erase Gap
1	1	1	0	REW	Rewind Tape to BOT
1	1	1	1	RUN	Rewind and Unload Tape

#### 4.2.4 Density Select (DS0, DS1)

A switch on the MTS operator panel is used to select 1600 bpi (PE), 6250 bpi (GCR), or System Select recording density. When 1600 or 6250 bpi is selected and the tape is positioned at BOT, the MTS generates tapes written in the selected density. When System Select is selected and the tape is positioned at BOT, the MTS generates tapes written in the density selected by the Density Select lines. The Density Select lines must be stable 90 nanoseconds prior to the assertion of START and remain stable until the MTS responds by asserting BUSY. The decode of the Density Select lines is shown in Table 4-5.

Table 4-5. Density Select Line Decode

DENSITY SELECT LINES		SELECTED DENSITY
DS1	DS0	
0	0	1600 (PE)
0	1	6250 (GCR)



The MTS recording density can be altered only at the time a write command is issued and tape is positioned at BOT. At all other times the MTS reads and writes in the density indicated by the ID burst of the tape in use.

#### 4.2.5 Transfer Acknowledge (TRAK)

The assertion of the Transfer Acknowledge line by the user is in response to the assertion of Transfer Request by the MTS. The assertion of TREQ by the MTS on a WRT operation indicates that the MTS is requesting data character transfer on the Bi-Directional Data bus and the responding assertion of TRAK (or STOP) by the user indicates that the Bi-Directional Data bus contains the valid data character to be accepted.

The assertion of TREQ by the MTS on a RDF or RDB operation indicates that a data character is valid on the Bi-Directional Data bus and the responding assertion of TRAK (or STOP) by the user indicates that the data character has been transferred. The signal protocol for TREQ and TRAK is similar for either a write or a read operation. For example, once TREQ is asserted, it remains asserted until TRAK or STOP is asserted. TRAK must remain asserted until TREQ is reset, at which time TRAK must be reset.

#### 4.2.6 Terminate Command (STOP)

The Terminate Command line is asserted by the user in response to TREQ or BLOCK to indicate one of the following situations:

1. During a WRT or LWR command in response to TREQ, that the last data character to be written in the data block has been placed on the Bi-Directional Data bus.
2. On an RDF or RDB command in response to TREQ, that the MTS is to terminate the transfer of data characters on the Bi-Directional Data bus.
3. On a BSB or FSB operation in response to BLOCK, that the MTS is to terminate spacing over blocks.

For the first two situations, STOP replaces TRAK as the user response to TREQ. In response to STOP, the MTS terminates the command in progress and reset BUSY, but only after the MTS has completed the necessary tape formatting, defragmenting, and positioning according to the nature of the command in progress.

## 4.2.7 System Reset (RESET)

The assertion of System Reset by the user causes the MTS to immediately terminate any command in progress. BUSY is then asserted until completion of the reset procedure. No command is accepted while BUSY is asserted. Between the assertion of RESET and the clearing of BUSY, error status output lines are reset. The density selected remains unchanged.

During termination, the MTS discontinues formatting and deformatting, and causes tape motion to halt without regard to IBG positioning. (Note: Partially written or erased blocks during write commands may occur when a RESET is given.) If the system is in diagnostic mode, it will be set to functional mode.

The RESET pulse from the user interface must be 1 microsecond minimum.

## 4.2.8 Select Multiplex (SLX0, SLX1, SLX2)

The three Select Multiplex lines are decoded in the MTS and determine which of four 9-bit registers is multiplexed to the Error Multiplex (ERRMX) output lines. The ERRMX lines are valid only as a part of the ending status (i.e., after BUSY has been reset). The delay time between the selection of a Select Multiplex code and the stabilization of the selected MUX byte is 150 nanoseconds maximum. Table 4-6 shows the Select Multiplex decode.

Table 4-6. Select Multiplex Decode

SLX2	SLX1	SLX0	MUX BYTE	DESCRIPTION
0	0	0	0	Dead Tracks
0	0	1	1	Read/Write Errors
0	1	0	2	Diagnostic Aids
0	1	1	3	Drive Sense Byte

## 4.2.9 Bi-Directional Data (DATA 0-7,P)

The nine Bi-Directional Data lines are used to transfer the data characters between the interfaces in conjunction with the TRAK (or STOP) responses to TREQ. When a line is asserted, a ONE bit is transferred between the interfaces. When a line is reset, a ZERO bit is transferred. Odd parity must be maintained on these lines for all functional mode data transfer operations. Data bit

7 is the least significant bit; data bit 0 is the most significant.

The Data lines must be stable 90 nanoseconds prior to the assertion of TRAK (or STOP) during a write operation, or the assertion of TREQ during a read operation.

#### 4.3 STORAGETEK STANDARD INTERFACE OUTPUT SIGNAL DEFINITIONS

The output line definitions given in this section are for functional mode only.

##### 4.3.1 Transfer Request (TREQ)

The Transfer Request (TREQ) line is asserted by the MTS to request data character transfer on the Bi-Directional Data bus.

##### 4.3.2 Expecting Data (RECV)

The Expecting Data line is asserted by the MTS to indicate that the Bi-Directional Data bus is under control of the user interface and that the MTS will receive data character transfers. This line is asserted on WRT or LWR command operations only. It remains asserted until a new command is initiated.

##### 4.3.3 Block Sensed (BLOCK)

The Block Sensed line is asserted by the MTS to indicate that a data block or a tape mark block has been detected. This line is asserted during BSB and FSB commands or during any read-type command detecting a tape mark block. BLOCK is a pulse of 250 nanoseconds nominal duration for Models 2922 and 2925, and 400 nanoseconds nominal duration for the Model 2921.

##### 4.3.4 Oscillator (OSC)

The Oscillator line is derived from the internal MTS crystal oscillator. The frequency is 2.5 MHz (400 nanosecond period). The frequency is stable within 0.01% and the half-cycle periods are symmetrical within 5%.

##### 4.3.5 End of Data Pulse (ENDATP)

The End of Data Pulse line is asserted by the MTS to indicate that the last data character has been read from tape and transferred to the user. ENDATP is asserted on read command operations (RDF or RDB) only. The ENDATP pulse is 800

nanoseconds in duration.

#### 4.3.6 Busy (BUSY)

The Busy line is asserted by the MTS following the acceptance of the command initiated by START. This line remains asserted until completion of the command operation or until conditions arise which cause a REJECT. A command operation may be initiated only when BUSY is reset.

#### 4.3.7 Identification Burst (ID BRST)

The Identification Burst line is asserted by the MTS to indicate that an identification burst procedure is being performed by the MTS. It is asserted on read or write commands from BOT. ID BRST is asserted only while the identification burst procedure is being performed.

On a read command, the procedure includes the determination of the format (PE or GCR) of the burst.

If the ID burst procedure is performed satisfactorily, the MTS proceeds with the command initiated. If the procedure is not performed satisfactorily, REJECT and a reject code (Section 4.3.15) is asserted. ID BRST remains asserted. ID BRST is also asserted if a backward operation is initiated with tape positioned off BOT and tape reaches either BOT or an ARA ID burst before the end of the operation. (Under this condition, DATA CHK is also set.)

#### 4.3.8 Tape Mark Status (TMS)

The Tape Mark Status line is asserted by the MTS to indicate that a tape mark block has been detected. This line is asserted following a write tape mark command and following any read or space command when a tape mark block is detected. TMS is reset by the next command issued unless that command is a CLR, SNS, or NOP.

#### 4.3.9 Command Reject (REJECT)

The Command Reject line is asserted by the MTS whenever conditions within the MTS are inappropriate to the command operation. The conditions which cause REJECT are given in Section 4.3.15 under the Error Multiplex bus definitions. After the assertion of REJECT and the reset of BUSY, reject codes for the conditions causing the reject are the octal contents of the diagnostic aids register, addressable on the Error Multiplex bus as MUX Byte 2.

Read or write commands given after REJECT is received may result in mispositioning and/or creation of an unreadable portion of tape.

#### 4.3.10 Operation Incomplete (OP INC)

The Operation Incomplete line is asserted by the MTS in conjunction with a reject code in MUX Byte 2 (Section 4.3.15). OP INC indicates that the given command was initiated but was not completed. REJECT includes those commands that were not able to be initiated as well as those not completed.

#### 4.3.11 Overrun Status (OVRNS)

During a write operation, the Overrun Status line is asserted by the MTS when the MTS is not supplied data characters by the user as fast as the MTS requires them. This can occur when previous TREQ/TRAK responses are not within the timing requirements, or when STOP is not asserted. The data block written is then incorrectly encoded. If OVRNS is asserted, DATA CHK is also asserted following the read validity checking.

During a read operation, OVRNS is asserted by the MTS when data characters have backed up in and overflowed the MTS due to the user not accepting data at a high enough rate.

#### 4.3.12 EPROM Error (ROMPS)

The EPROM Error line is asserted by the MTS to indicate that an error in the microprogram code was detected after a diagnostic check sum was performed.

#### 4.3.13 Slave Status Change (SSC)

The Slave Status Change line is asserted by the MTS to indicate that it has gone online, gone offline, or gone from not ready to ready. The MTS asserts SSC if a rewind is issued when tape is positioned at BOT. The MTS resets SSC after accepting any command, other than a NOP or SNS.

#### 4.3.14 Data Check (DATA CHK)

The Data Check line is asserted by the MTS to indicate that one or more of the error conditions of Table 4-7 has occurred. References to more detailed descriptions of each error are included in the table.

Table 4-7. Error Conditions Setting DATA CHK

ERROR CONDITION	REFERENCE SECTION
CRC Error	4.2.15.2, item 1
Write Tape Mark Check	4.2.15.2, item 2
Uncorrectable Error	4.2.15.2, item 3
Partial Record	4.2.15.2, item 4
Multiple Track Error	4.2.15.2, item 5
End of Data Check	4.2.15.2, item 6
Velocity Error	4.2.15.2, item 7
Overrun	4.2.11
BOT Reached	Note 1
PE Postamble Error	Note 2
Single Track Error	Note 3

<p>1 This error indicates that a backward command was initiated with tape positioned off BOT and BOT was reached before the command was completed. ID BRST and BOTS are also set.</p> <p>2 During PE read or write operations, the postamble was not detected to be the correct length.</p> <p>3 During a PE write operation, an error detected in any track sets DATA CHK.</p>
---

#### 4.3.15 Error Multiplex (ERRMX 0-7,P)

The nine Error Multiplex lines are asserted by the MTS to allow transfer of additional error and reject status information. The lines are valid only as a part of the ending status of the most recently completed command (for example, after BUSY is reset). One of four registers is multiplexed to the ERRMX bus, as selected by SLX0, SLX1, and SLX2. Table 4-8 gives the ERRMX decode for functional mode operation.

##### 4.3.15.1 MUX BYTE 0

ERRMX bits P through 0 are asserted upon detecting a dead track during a read or a write operation. A dead track is caused by the inability to detect correct data on a specific track on tape. These bits are reset at the start of each new command.

Table 4-8. Decode of Error Multiplex Bus for Functional Mode Operation

MUX BYTE	ERROR MULTIPLEX BIT									DESCRIPTION
	P	7	6	5	4	3	2	1	0	
0	DTP	DT7	DT6	DT5	DT4	DT3	DT2	DT1	DT0	Dead Track
1	CRC ERR	WTM CHK	UCE	PART REC	NOT MTE	USED	END DATA CHK	VEL ERR	DIAG MODE LTCH	Read/Write Errors
2	TACH	DA7	DA6	DA5	DA4	DA3	DA2	DA1	DA0	Diagnostic Aid Bits
3	WRTS	EOTS	BOTS	NOT USED	FPTS	BWDS	HDNS	RDYS	ONLS	Status

#### 4.3.15.2 MUX BYTE 1

The following bits of MUX Byte 1 are asserted when the conditions defining the bit occur:

##### 1. Cyclic Redundancy Character Error (CRC ERR)

The internal checks of data character CRC registers indicate a loss of data integrity on tape. This error can occur during read or write operations in GCR, or during write operations in PE. DATA CHK is also asserted.

This error is also asserted if the CRC character associated with the buffer memory is found to be in error.

##### 2. Write Tape Mark Check (WTM CHK)

The MTS is unable to write a tape mark correctly. DATA CHK and REJECT may also be asserted (refer to Table 4-9).

Table 4-9. Status Lines Asserted With WTM CHK

ASSERTED LINES			COMMENTS
WTM CHK	DATA CHK	REJECT	
X	X		The tape mark written does not meet ANSI specifications but is readable as a TM.
X		X	The tape mark written is probably not readable as a TM. Noise may be left on tape and may not be detected by any read or space command.

3. Uncorrectable Error (UCE)

An uncorrectable error has been detected. This error can occur during PE or GCR read or write commands. DATA CHK is also asserted.

4. Partial Record (PART REC)

An IBG is detected before detecting end-of-data characters. This error can occur during PE or GCR read or write commands. DATA CHK is also asserted.

5. Multiple Track Error (MTE)

Two or more tracks are detected in error. This error can occur during PE or GCR read or write commands. DATA CHK is also asserted except during a GCR read. In GCR read mode, DATA CHK is set only if the error can not be corrected.

6. End of Data Check (END DATA CHK)

The end-of-data characters are not detected, or the preambles and postambles do not meet format requirements. This error can occur during PE or GCR read or write commands. DATA CHK is also asserted.

7. Velocity Error (VEL ERR)

The MTS speed indication is outside acceptable limits. This error can occur during PE or GCR write commands. DATA CHK is also asserted.

8. Diagnostic Mode Latch (DIAG MODE LTCH)

The diagnostic mode of operation has been set in the MTS.



#### 4.3.15.3 MUX BYTE 2

ERRMX bit P is the digital tachometer (TACH) from the MTS and contains information concerning tape speed and distance. This line is used in certain diagnostic routines and is valid during commands as well as after the command is completed.

ERRMX bits 7 and 6 (DA7 and DA6) are used during diagnostic mode operation only.

Various reject codes are asserted on bits 5 through 0 under their defining conditions. The reject code is the octal equivalent of bits DA5 through DA0 with bit DA5 being most significant and bit DA0 being least significant. Table 4-10 defines Reject Codes 1 through 37 and indicates those that set OP INC.

#### 4.3.15.4 MUX BYTE 3

MUX Byte 3 contains certain MTS status bits. These bits, with the exception of Backward Status (BWDS), are duplicated as separate interface output lines and are defined in Sections 4.3.18 through 4.3.24.

The Backward Status bit is asserted when the command in progress or just completed is a backward tape motion command. If the current or previous command is a forward tape motion command, this bit is unasserted.

#### 4.3.16 Corrected Error (CRERR)

The Corrected Error line is asserted by the MTS to indicate:

1. A single-track error has been corrected during a PE read.
2. A single- or double-track error has been corrected during a GCR read.
3. A Single-track error has been detected during a GCR write.

Table 4-10. Reject Codes (Sheet 1 of 2)

REJECT CODE (OCTAL)	DESCRIPTION
1	The MTS is not in Ready Status.
2*	Internal interface error (Cache Buffer model only).
3*	The TRAK response to the initiating TREQ was not received within 75 milliseconds on a write-type command.
4	Reserved
5	The MTS is in File Protect Status when a write-type command is attempted.
6*	The MTS did not go to Erase Status only.
7	Illegal command sequence.
10*	The MTS did not go to Read Status.
11*	The MTS is unable to read a PE or GCR ID burst either during a read operation or during a read check while writing the ID burst.
12	Reserved
13	Reserved
14*	The MTS did not go to Write Status.
15	Reserved
16	Reserved
17*	Noise (possibly data) was detected during an erase gap command or during a write command following a read-type command.
20*	The host has issued a READ in cache data mode and no record is in the buffer.
21*	The MTS reset Ready Status.
22	Reserved
* OP INC is also set	

Table 4-10. Reject Codes (Sheet 2 of 2)

REJECT CODE (OCTAL)	DESCRIPTION
23	A backward-type command (except a rewind or a rewind/unload command) was given, but tape was already positioned at BOT.
24*	The ARA BURST portion of the GCR ID burst just written did not have all nine tracks active.
25*	An IBG longer than 25 feet in PE mode or longer than 15 feet in GCR mode was detected on a read- or space-type command.
26	More than one speed change requested without intervening motion.
27	Reserved
30*	The MTS is not in the recording density selected.
31	LWR attempted when tape loaded and positioned off BOT.
32*	No tape motion.
33*	During a readback check of a write operation, data was detected in an IBG area.
34	Reserved
35*	The MTS attempted to backspace over a bad record just written but was unable to detect the record.
36*	The ARA ID burst was unreadable during a GCR write command.
37*	During the readback check of a write or write tape mark command, no data was detected.
* OP INC is also set	

#### 4.3.17 Data Bus Parity Error (BUPER)

The Data Bus Parity Error line is asserted by the MTS to indicate that the Bi-Directional Data bus detected an even parity data character during a TREQ/TRAK data transfer. On WRT operations, assertion of this line indicates that the data written on tape is incorrect. On RDF or RDB operations, assertion of this line indicates either an uncorrectable read error or an internal malfunction of the MTS read data processing system. Data transmission is not halted in either write or read operations until the normal ending point is reached. Data check is also set.

#### 4.3.18 Online Status (ONLS)

This line is asserted by the MTS when it is in Online Status. (The MTS can be in Online Status when it is not in Ready Status; for example, Tape Not Loaded.) If the MTS is not in Online Status, all other status is invalid. The MTS accepts interface commands only if it is Online.

The Online key is used to set the MTS to Online Status; the Reset key is used to reset Online Status.

#### 4.3.19 Ready Status (RDYS)

This line is asserted by the MTS when in Ready Status. The MTS is in Ready Status when it has tape loaded, is not rewinding, and is not in Machine Check Status.

#### 4.3.20 Beginning of Tape Status (BOTS)

The Beginning of Tape Status line is asserted by the MTS when tape is positioned at the BOT marker.

#### 4.3.21 End of Tape Status (EOTS)

The End of Tape Status line is asserted by the MTS when the tape is positioned on or past the EOT marker, indicating that tape is within the end-of-recording area.

#### 4.3.22 File Protect Status (FPTS)

The File Protect Status line is asserted by the MTS when tape is loaded and the file reel does not contain a write enable ring.

### 4.3.23 Write Status (WRTS)

This line is asserted by the MTS when in Write Status.

### 4.3.24 High Density Status (HDNS)

The High Density Status line indicates the recording format (density) in which the MTS is operating. GCR format is indicated when HDNS is set; PE format is indicated when HDNS is reset.

On Read or Space commands from BOT, the MTS is first set to PE mode, reads the ID burst, and then sets to the format indicated. Once positioned away from BOT, the MTS reads in the density previously determined by reading the ID burst of the tape in use.

On write operations from BOT, the MTS is set to the density selected by the user.

The MTS is set to PE mode whenever it has just been loaded, unloaded, or powered up.

### 4.3.25 Rewinding Status (REWS)

The Rewinding Status line is asserted by the MTS when in the process of rewinding tape to BOT (for example, the MTS is loaded and in Online Status but not in Ready Status).

## 4.4 INTERFACE COMMAND DESCRIPTIONS

The interface command descriptions given in this section are for functional mode only. The commands are decoded from the four Command Select lines (CMD0, 1, 2, 3) as described in Section 4.1.3.

### 4.4.1 General Information

The information in this section applies to all of the interface commands. Individual command descriptions begin with Section 4.4.2.

#### 4.4.1.1 COMMAND INITIATION

All commands are initiated by asserting the appropriate address, density, and command lines and then asserting START. The AD, DS, and CMD lines must be valid and stable for 90 nanoseconds minimum prior to the assertion of START. START must have had a reset duration of 90 nanoseconds minimum prior to assertion. Upon the assertion of START, the addressed MTS stores the density and

command, and asserts BUSY. START must remain asserted until BUSY is asserted. Once BUSY is asserted, the DS, CMD, and START lines may change state. Refer to Figure 4-4 for command initiation timing. START must be unasserted when the MTS Address lines are changed.

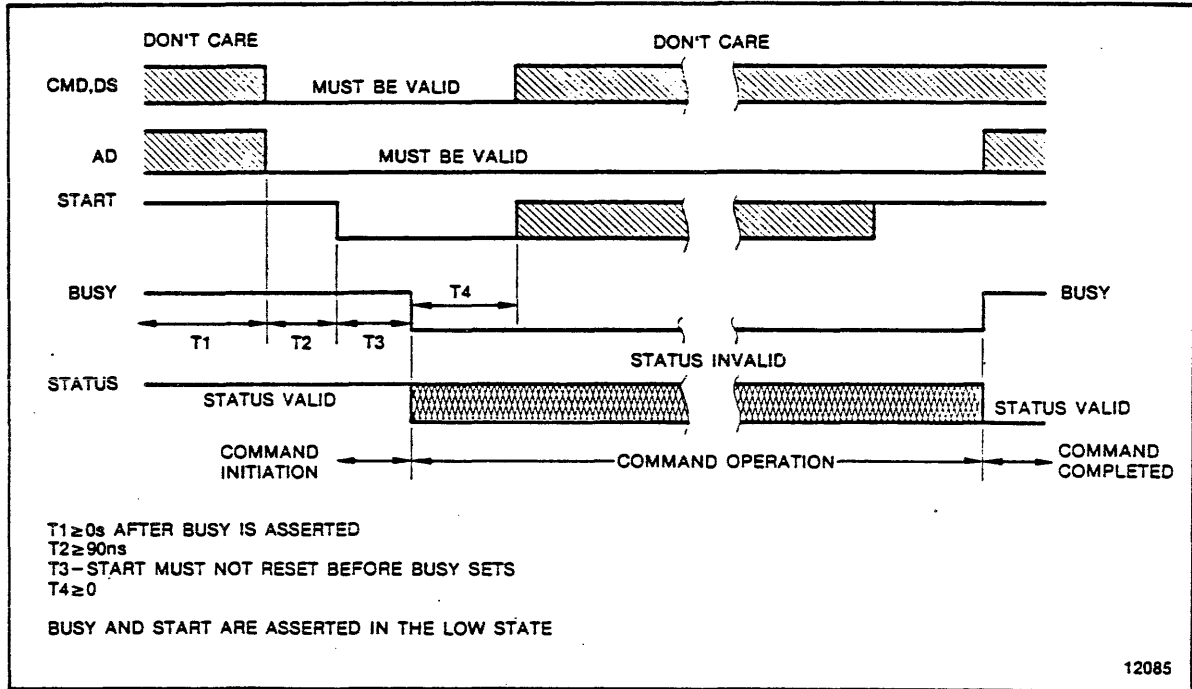


Figure 4-4. Command Initiation, Operation, and Completion

#### 4.4.1.2 REJECT CONDITIONS

When reject conditions occur (as specified in Section 4.3.15.3) during the command operation, REJECT is asserted, BUSY is reset, and the operation is terminated.

#### 4.4.1.3 OPERATION COMPLETED

The command operation can only be considered as completed or terminated after BUSY is reset. A new command can be initiated only when BUSY is reset.

#### 4.4.1.4 ENDING STATUS VALIDITY

All MTS status (and error) lines may change during an operation; however, all lines must be considered invalid while BUSY is asserted, and valid only after completion of the operation when BUSY is reset (Figure 4-4).

#### 4.4.1.5 END OF TAPE STATUS (EOTS)

EOTS (tape positioned in the end-of-recording area) does not inhibit or control any command operations within the MTS. If forward-type commands are repeated (such as WRT) or allowed to continue (such as FSB) when EOTS is asserted and the physical end of tape is reached, the MTS resets Ready Status, the operation terminates, and REJECT is asserted. The tape will be completely removed from the file reel and requires manual loading before a rewind can be performed.

With the Cache Buffer model in use and the tape positioned in the end-of-recording area, the MTS will, during WRITES, wait until the record is successfully written to tape before giving ending status to the host for this record. During READ commands the MTS will not read a record until requested to do so by the host.

#### 4.4.1.6 COMMANDS WITH MTS IN WRITE STATUS

When a backward command (BSB, BSF, REW, RDB, RUN) is initiated and the addressed MTS is in Write Status, the MTS automatically causes an erasure of tape in the forward direction of 1.5 inches (nominal) before commencing the command operation. At 100 IPS, the erasure of tape is at least 0.8 inch.

Forward read commands (FSB, RDF, FSF) with the addressed MTS in Write Status are considered improper command sequences. (See Section 4.4.1.7.)

#### 4.4.1.7 IMPROPER COMMAND SEQUENCES

The tape area forward of a just completed write-type command (WRT, WTM, ERG) is erased for a short distance. When this erasure impinges into another block, this block is partially erased. Write-type commands followed by forward read commands are not prohibited but should be avoided or the user tape operating system should maintain knowledge of the condition.

### 4.4.2 No Operation (NOP) Command

NOP command operations perform essentially no function. The MTS error status outputs do not change. BUSY is asserted only for the short time necessary to accept and process the command.

Other than command initiation, no signal responses are required of the user interface.

### 4.4.3 Drive Clear (CLR) Command

CLR resets the OVRNS, DATA CHK, ID BRST, CRERR, BUPER, and ERRMX error status outputs if they are asserted from the previous operation. CLR also resets SSC. The MTS remains in Online Status if previously in that state.

The functions of a Drive Clear command are always performed automatically by the MTS as the initial part of all commands except a NOP, SNS, or DMS command.

Other than command initiation, no signal responses are required of the user interface.

### 4.4.4 Diagnostic Mode Set (DMS) Command

The DMS command causes the MTS to accept certain commands, most of which are used for diagnostic purposes, but some of which are tailored for functional operation use.

Other than command initiation, no signal responses are required from the user interface.

The change from diagnostic mode to functional mode is accomplished when: (1) the user asserts the Reset line, or (2) when the MTS automatically transfers the mode after certain diagnostic mode command sequences.

The diagnostic mode set command must be followed by the specific command desired. This second command consists of a functional-type command AND an identifying code on SLX 2, 1, and 0 lines in the following format:

DMS/CCC slx

Where CCC is the command following DMS, and slx is the code on the SLX lines.

In most cases (except some parts of the DMS/NOP command), the command following the DMS command is not valid unless it comes with the proper SLX lines code. The available DMS commands are described in the following paragraphs.

#### 4.4.4.1 DMS/NOP (STATUS LINES TEST COMMAND)

This command initiates and sequences the status line test portion of the interface test. Following the initial NOP command which resets all status except the Online Status (ONLS) line, each subsequent NOP command results in the assertion of an individual status line (in addition to ONLS) in the order shown in Table 4-11.



Following the 52nd assertion of NOP, the subsystem enters a command wrap mode. In this mode the host may issue any command (with START assertions) with SLX lines 2, 1, and 0 = XXX. For each subsequent START assertion, BUSY is set and the individual incoming command lines are mapped to the outgoing status lines shown in Table 4-12. This mode of operation is maintained until a reset command is issued. Functional operations can proceed only after a reset command is issued.

#### 4.4.4.2 DMS/WRT (SLX 2, 1, 0 = 000) (WRITE IN PLACE COMMAND)

For the MTS without the Cache Buffer, this command results in a functional write but with tape positioning such that the rewrite occurs at the same place. This command is used in a diagnostic write error recovery sequence which attempts to isolate media as the cause of temporary errors. This command is intended to follow a failing WRT, BSB command sequence. Only the WRT immediately following the DMS occurs at the same place.

For the MTS with the Cache Buffer, this command is functional only in long-record mode.

Table 4-11. Status Line Assertion For DMS/NOP Command  
Sheet 1 of 2

NOP NO.	SLX 210	ASSERTED STATUS
1	XXX	
2	XXX	Identification Burst Status (ID Burst)
3	XXX	File Protect Status (FPTS)
4	XXX	Rewinding Status (REWS)
5	XXX	Expecting Data Status (RECV)
6	XXX	Operation Incomplete Status (OP INC)
7	XXX	None, except ONLS
8	XXX	Tape Mark Status (TMS)
9	XXX	Overrun Status (OVRNS)
10	XXX	Data Check Status (DATA CHK)
11	XXX	EPROM Error Status (ROMPS)
12	XXX	Corrected Error Status (CRERR)
13	XXX	None, except ONLS
14	XXX	High Density Status (HDNS)
15	XXX	Ready Status (RDYS)
16	XXX	Write Status (WRTS)
17	X00	MUX Byte 0 Bit 0 (ERRMX 0)
18	X00	MUX Byte 0 Bit 1 (ERRMX 1)
19	X00	MUX Byte 0 Bit 2 (ERRMX 2)
20	X00	MUX Byte 0 Bit 3 (ERRMX 3)
21	X00	MUX Byte 0 Bit 4 (ERRMX 4)
22	X00	MUX Byte 0 Bit 5 (ERRMX 5)
23	X00	MUX Byte 0 Bit 6 (ERRMX 6)
24	X00	MUX Byte 0 Bit 7 (ERRMX 7)
25	X00	MUX Byte 0 Bit P (ERRMX P)
26	X01	MUX Byte 1 Bit 0 (ERRMX 0)
27	X01	MUX Byte 1 Bit 1 (ERRMX 1)
28	X01	MUX Byte 1 Bit 2 (ERRMX 2)
29	X01	MUX Byte 1 Bit 3 (ERRMX 3)
30	X01	MUX Byte 1 Bit 4 (ERRMX 4)
31	X01	MUX Byte 1 Bit 5 (ERRMX 5)
32	X01	MUX Byte 1 Bit 6 (ERRMX 6)
33	X01	MUX Byte 1 Bit 7 (ERRMX 7)
34	X01	MUX Byte 1 Bit P (ERRMX P)
x = do not care		

Table 4-11. Status Line Assertion For DMS/NOP Command  
Sheet 2 of 2

NOP NO.	SLX 210	ASSERTED STATUS
35	X10	MUX Byte 2 Bit 0 (ERRMX 0)
36	X10	MUX Byte 2 Bit 1 (ERRMX 1)
37	X10	MUX Byte 2 Bit 2 (ERRMX 2)
38	X10	MUX Byte 2 Bit 3 (ERRMX 3)
39	X10	MUX Byte 2 Bit 4 (ERRMX 4)
40	X10	MUX Byte 2 Bit 5 (ERRMX 5)
41	X10	MUX Byte 2 Bit 6 (ERRMX 6)
42	X10	MUX Byte 2 Bit 7 (ERRMX 7)
43	X10	MUX Byte 2 Bit P (ERRMX P)
44	X11	MUX Byte 3 Bit 0 (ERRMX 0)
45	X11	MUX Byte 3 Bit 1 (ERRMX 1)
46	X11	MUX Byte 3 Bit 2 (ERRMX 2)
47	X11	MUX Byte 3 Bit 3 (ERRMX 3)
48	X11	MUX Byte 3 Bit 4 (ERRMX 4)
49	X11	MUX Byte 3 Bit 5 (ERRMX 5)
50	X11	MUX Byte 3 Bit 6 (ERRMX 6)
51	X11	MUX Byte 3 Bit 7 (ERRMX 7)
52	X11	MUX Byte 3 Bit P (ERRMX P)

x = do not care

Table 4-12. Status Line Assertion For Diagnostic Command Wrap Mode

INCOMING COMMAND LINES	MAPPED TO ERRMX LINES
CMD0	7
CMD1	6
CMD2	5
CMD3	4
DS0	3
DS1	2
SLX0	1
SLX1	0
SLX2	P

#### 4.4.4.3 DMS/WRT (SLX 2, 1, 0 = 001) (WRITE NO MOTION COMMAND)

This command initiates data transfer to the subsystem without tape motion, and is part of the interface bus test. TREQ and TRAK are used to sequence data across the data bus at a slower than normal, processor-controlled rate. The last two bytes transferred are stored in the subsystem for later retrieval by the DMS/RDF command. This command terminates in diagnostic mode so that the DMS/RDF command may immediately follow, by issuing an RDF command.

#### 4.4.4.4 DMS/RDF (SLX 2, 1, 0 = 000) (READ NO MOTION COMMAND)

This command results in a diagnostic data transfer to the host system. The transfer rate may be slower than the TREQ/TRAK specifications for functional data transfers. Only the first two bytes transferred are significant, but transfer continues until the user asserts STOP in response to TREQ. These two bytes are the last bytes sent for the write no motion command described above.

#### 4.4.4.5 DMS/WRT (SLX 2, 1, 0 = 111) (FUNCTIONAL MODE SET)

When the MTS receives a Functional Mode Set command, it begins accepting data from the host; until the host sends STOP in response to a TREQ. The last byte sent is interpreted as the Speed/Gap Select Control and the Cache Buffer Mode Control. Table 4-13 shows the mode command combinations.

Table 4-13. Speed/Gap Selection Decodes and Cache Mode Set Decode

BITS OF LAST DATA BYTE								MODE SELECTED
7	6	5	4	3	2	1	0	
X	X	X	X	0	0	0	1	50 IPS, Nominal Gap
X	X	X	X	1	0	0	0	100 IPS, 0.6" PE, 0.3"GCR
X	X	X	X	1	0	0	1	100 IPS, 0.9" PE, 0.6"GCR
X	X	X	X	1	0	1	0	100 IPS, 1.2" PE, 0.9"GCR
0	0	0	1	X	X	X	X	Set to Buffered Mode
0	0	1	0	X	X	X	X	Set to Long-Record Mode
0	1	0	0	X	X	X	X	Set to Cache Data Mode

The set buffered mode command causes normal cache buffer

operation, generally storing multiple records in cache memory. The set long-record mode command causes the opposite mode, keeping physical tape synchronized to the host interface, generally storing less than one record in cache memory. Long-record mode must be selected for records longer than cache memory.

Set cache data mode will cause data to be read from or written to cache memory only, without using physical tape.

For machines without the Cache Buffer installed, Bits 4, 5, 6 and 7 should always be zero in the Byte described in Table 4-13.

Receipt of bit combinations not defined in the above Table will not result in REJECT CODE 7, Illegal Command. This command is used in functional mode operations. The "X" values can be valid bit combinations or should be set to "0" if the mode is not to change. If the MTS is in cache data mode, selecting buffered or long-record mode will cause the MTS to exit cache data mode and begin normal tape data processing.

#### 4.4.4.6 DMS/FSF (SLX 2, 1, 0 = 000) (PERFORM LOADED DIAGNOSTICS)

This command initiates the Loaded subset of internal diagnostics and bypasses all tests that require the MTS to be unloaded. This eliminates all Section 1 routines (power up), and Test 32 (unload/load). Note that this limited set of internal diagnostics results in a lesser detection and isolation of problems than optimum.

The sense bytes resulting from this command are described under the next heading--DMS/FSB command.

#### 4.4.4.7 DMS/FSB (SLX 2, 1, 0 = 000) (PERFORM ALL DIAGNOSTICS)

This command initiates the entire package of internal diagnostics. BUSY is set until successful completion or an error is detected. At this time the user may interrogate termination status by means of the sense (SNS) command.

#### 4.4.4.8 DMS/RUN (SLX 2, 1, 0 = 000) (RESET CACHE ERROR COUNTERS)

This command resets the cache error counters. This command sequence is available only on CB cards with PN 403855308 and above.

## 4.4.5 Read Forward a Block (RDF) Command

### 4.4.5.1 NON-CACHED OPERATION

The RDF command causes tape to be moved in the forward direction and the next block (only) to be read. Non-data characters of the block are detected, decoded, checked for validity, and used for their specific purposes, but not transferred across the interface. Data characters of the block are detected, decoded, checked for validity, corrected if appropriate, and transferred across the interface. Data is transferred until end-of-data is detected, or until STOP is asserted by the user interface, or until REJECT occurs. All characters within the block are checked for validity even if they are not all transferred. Tape motion is then halted. Ending status signals reflect the validity check for the entire block.

#### 4.4.5.1.1 Signal Sequence

After command initiation, the MTS moves tape in the forward direction. When a data block is detected and sufficient data characters have been decoded and deformatted, the MTS asserts a data character on the Bi-Directional Data bus (DATA), delays approximately 90 nanoseconds, and then asserts TREQ.

The user interface must then signal transfer of the data character by asserting TRAK or STOP. Upon sensing the TRAK or STOP assertion, the MTS resets TREQ. The user interface must then reset TRAK or STOP. Responses must meet the timing requirements of Figure 4-5.

If TRAK or STOP does not respond according to the timing requirements, an MTS internal read buffer may be overloaded. If the MTS buffer does become overloaded, data characters may be lost. Although data transfer could resume by asserting TRAK, lost data characters cannot be recovered during the in-process command operation. When data characters are lost in this type of signal sequence, CRC ERR, OVRNS, and DATA CHK are asserted in the ending status. The time between consecutive TREQ signals may vary, thus it is important that the user interface timing is not determined by the time between TREQs. Normal TREQ/TRAK responses and data character transfer continues until: (1) the user interface signals STOP, (2) the MTS transfers the last byte of data, or (3) the MTS sets REJECT and terminates the command. When end-of-data is decoded, the MTS asserts the End of Data Pulse (ENDATP).

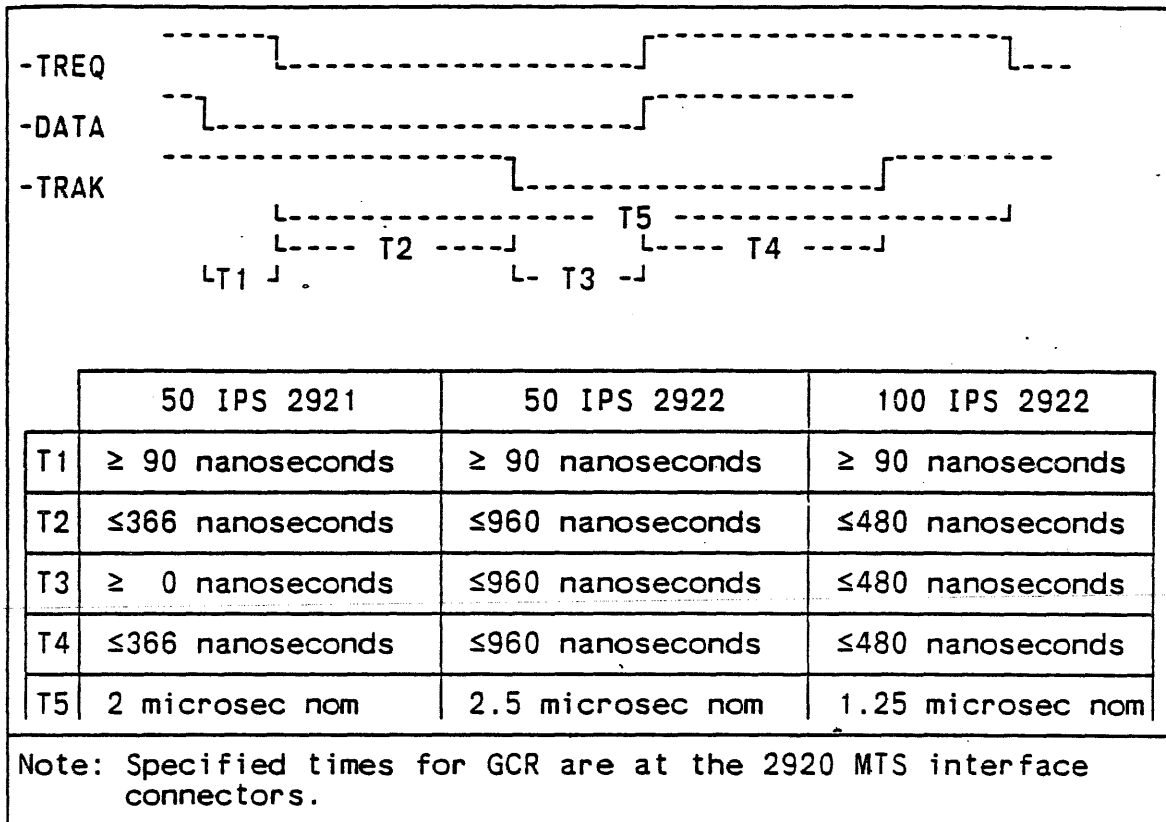


Figure 4-5. RDF or RDB Command TREQ, TRAK, and DATA Timing

Unless the user TRAK timing is greater than the specified maximum, all data is transferred before ENDATP is asserted. Any data not transferred by the time ENDATP is asserted is unrecoverable.

The MTS then halts tape motion, asserts ending status, resets BUSY, and the command operation is complete.

#### 4.4.5.2 CACHED OPERATION (MULTIPLE BUFFERED RECORDS)

The RDF command causes the next block of data to be transferred from the cache memory to the host. Generally, a series of Read records are read ahead from tape and held in the cache memory for later transfer to the host. If an uncorrectable error is encountered when reading ahead from tape, the MTS backspaces and rereads the record, repeating this error recovery process the number of times selected, either 0, 5, 10, or 15 times. If zero

is selected, no retries are attempted. When the host interface requests the block in error, Data Check is asserted at the end of the data transfer. The host can then command further recovery procedures if desired.

When reading ahead from tape, if EOT is encountered, no further blocks are read unless the host interface catches up to physical tape and commands further Reads. Then the MTS only reads one data block from tape at a time.

When reading a record from tape that is presently being requested by the host, any error status is given directly to the host and no retry procedures are automatically attempted.

#### 4.4.5.2.1 Signal Sequence (Buffered Mode)

The TREQ and TRAK (or STOP) interface signal sequence is the same as for long-record mode, except that the timing requirements of Figure 4-5 can be relaxed for slower interfaces. T2 and T4 are determined by the host system and can be longer or shorter than shown in the figure. T5 would change correspondingly. T2 plus T4 cannot exceed 75.0 milliseconds on any data byte. Of course, faster timing results in higher system throughput. Table 4-14 shows the timing requirements to achieve the maximum transfer rate.

Table 4-14. Timing Requirements For Maximum Interface Data Transfer Rate (READ or WRITE), Model 2925

T1	≥ 90 nsec
T2	≤275 nsec
T3	≥100 nsec ≤300 nsec
T4	≤275 nsec
T5	800 nsec and 1000 nsec
Note: Refer to Figures 4-5 and 4-7.	

#### 4.4.5.3 RDF/BOT

When an RDF command is initiated with tape positioned at BOT, the MTS will first process the identification area (ID area) before



proceeding to process the first block. The processing of the ID area is automatic within the operation, requiring no signal responses from the user interface. In the processing, the ID area is detected and interpreted and the MTS is set to the appropriate density. The MTS asserts ID BRST during the process. The following block is then processed. If the ID area is uninterpretable, the MTS asserts the interface signals as defined in Section 4.2.7 and terminates the operation.

#### 4.4.5.4 RDF/TAPE MARK BLOCKS

##### 4.4.5.4.1 Non-Cached Operation

When an RDF operation is initiated, but the next block is a tape mark block, the MTS moves the tape past the tape mark, asserts Tape Mark Status (TMS), asserts BLOCK, and resets BUSY. A data block will not have been processed and no data characters will have been transferred across the interface. No signal responses will have been requested from the user interface.

##### 4.4.5.4.2 Cached Operation (Multiple Buffered Records)

If the switches indicate to synchronize on one tape mark and a tape mark block is read from tape, the MTS will read ahead commands to the tape drive and wait for the host to break the RDF command string or request a read of the tape mark block. If the hardware switches indicate to synchronize on two tape marks in a row and one TM block is detected, the MTS will issue a series of RDF commands as explained in Section 4.4.5.2. If two tape marks in a row are encountered, the MTS will halt tape motion, i.e. not issue any more read ahead commands. The MTS then waits for the host to break the RDF command string or issue a command after reading the second tape mark. At that time the MTS will execute the command issued and begin reading ahead again if appropriate.

#### 4.4.6 Read Backward a Block (RDB) Command

##### 4.4.6.1 NON-CACHED OPERATION

This operation proceeds as in Section 4.4.5.1 for RDF except that tape motion is backward.

##### 4.4.6.1.1 Signal Sequence

The signal sequence is the same as described in Section 4.4.5.1.1 for RDF except that data is transferred in the opposite order of the RDF command.

#### 4.4.6.2 CACHED OPERATION (MULTIPLE BUFFERED RECORDS)

The RDB command causes the physical tape to become synchronized with the host interface and the previous record to be read backward from tape and placed in the Cache memory. The record is then transferred out of Cache memory to the host and ending status is presented to the host. No further tape motion is initiated until requested by the host.

##### 4.4.6.2.1 Signal Sequence (Buffered Mode)

The signal sequence is the same as described in Section 4.4.5.2.1 for RDF except that data is transferred in the opposite order of RDF. This command is not valid in the cache data mode.

##### 4.4.6.3 RDB/BOT

An RDB command initiated with tape positioned at BOT is an invalid command. REJECT is asserted and the operation is terminated.

An RDB command initiated in which tape reaches the ID area without a data or tape mark block being detected, sets DATA CHK and the operation is terminated. Upon completion of this command, the tape is then positioned at BOT.

For both of the above conditions, no signal responses will have been requested from the user interface.

##### 4.4.6.4 RDB/TAPE MARK BLOCKS

This situation is the same as that described in Section 4.4.5.4 except that tape motion is backward and, when the command is completed, the read head is positioned relative to the IBG preceding the tape mark block.

### 4.4.7 Write a Data Block (WRT) Command

#### 4.4.7.1 NON-CACHED OPERATION

The WRT command causes, (1) tape to be moved in the forward direction, (2) the ending portion of the preceding IBG to be generated, (3) the data block to be written, (4) the data block to be read and checked for validity, and (5) the beginning portion of the next IBG to be generated. The data block is written in the format as determined by the Density Status/Select lines and the Density Select switch.

Non-data characters of the data block are automatically generated, encoded, formatted, and written. Data characters to be written are transferred serially across the interface, automatically encoded, formatted, and written.

#### 4.4.7.1.1 Signal Sequence

After the command initiation, the MTS first asserts RECV, signifying that the Bi-Directional Data bus (DATA) is under control of the user interface and that the MTS will receive data transfer on DATA.

The MTS next asserts one initiating TREQ signal sequence. The user interface must respond with assertions of data characters on DATA and by assertion of TRAK within the timing limitations of Figure 4-6. If the user interface does not respond accordingly, the MTS resets TREQ, asserts REJECT, and terminates the command. If the user interface responds correctly, then the MTS starts tape motion. After the ending portion of the IBG is created, the preamble is written. The user interface must respond to TREQ by placing a data character on DATA and then asserting TRAK. The MTS then acknowledges transfer of the data character by resetting TREQ. At this time the user interface may change DATA and must reset TRAK.

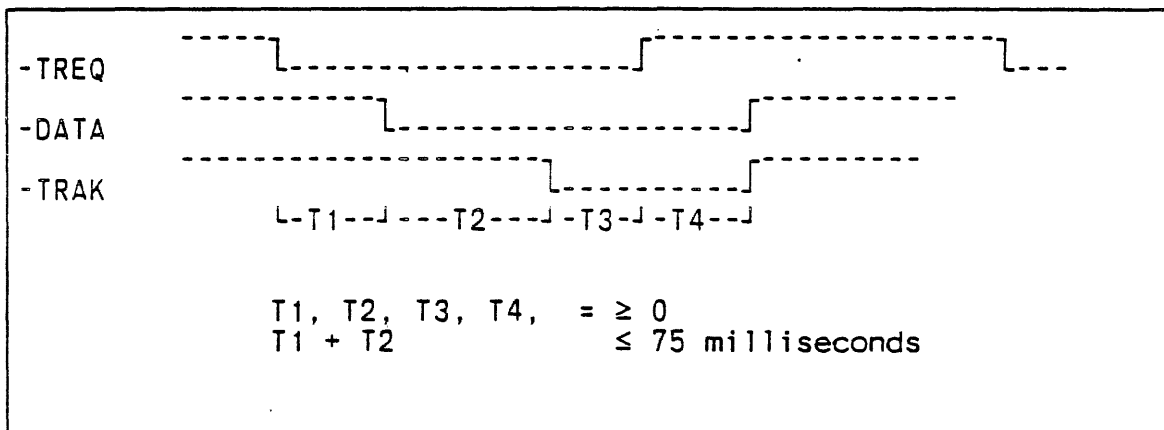


Figure 4-6. Write Commands Initiating TREQ/TRAK/DATA Timing  
(Applies to First Byte of Data)

Normal TREQ/TRAK/DATA response continues until the user interface signals STOP, signifying that the last character to be written is being transferred. The MTS then causes the remainder of the block to be formatted and written. The read-after-write checks are performed and the beginning portion of the next IBG is generated. Ending status is asserted, BUSY is reset, and the

operation is completed. RECV remains asserted until a command other than a WRT or LWR command is initiated. These user interface responses must meet the timing limitations given in Figure 4-7. The time between consecutive TREQ signals may not be uniform. No user interface timing should be developed based on the time between consecutive TREQ signals. If TRAK or STOP does not respond according to the timing limitations, an internal MTS write data character buffer may be overrun. When this occurs, incorrect data encoding has occurred. The MTS then discontinues requesting data, finishes formatting the block, sets Overrun Status (OVRNS), and tape motion halts.

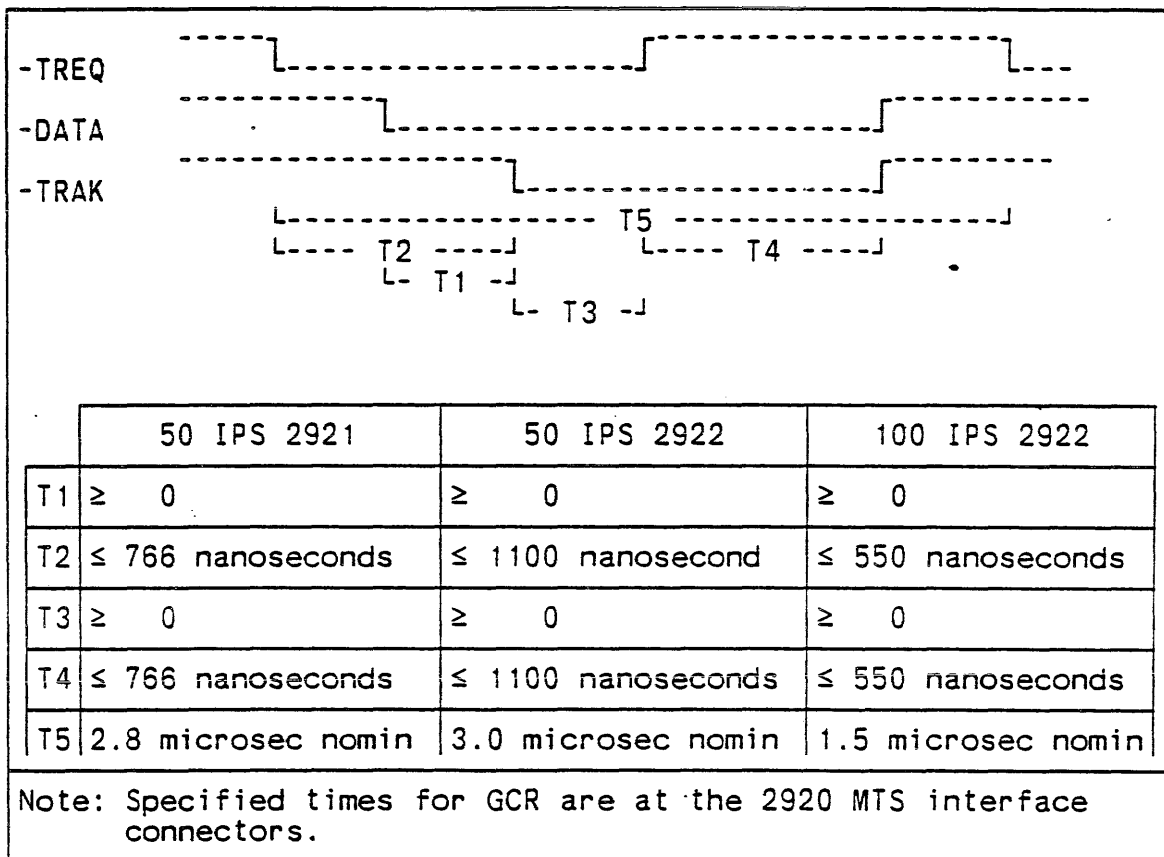


Figure 4-7. WRT Command TREQ, TRAK and DATA  
(Applies to All Subsequent Bytes of Data Transferred)

#### 4.4.7.2 CACHED OPERATION (MULTIPLE BUFFERED RECORDS)

The WRT command causes the next data block to be transferred from the host to the cache memory. Generally, a series of WRT commands causes multiple records to be held in cache memory for later transfer to tape. If an error is encountered when writing to tape, the cache control will backspace, erase a portion of

tape, and try to rewrite the record. This error recovery process is repeated the number of times selected, either 5, 10, or 15 times. If the data cannot be written to tape, REJECT is asserted on the next available command, and no other commands can be executed until a Sense command transfers the appropriate status to the host and a reset is then given to the MTS.

#### 4.4.7.2.1 Signal Sequence (Buffered Mode)

The TREQ and TRAK (or STOP) interface signal sequence is the same for long-record mode, except that the timing requirements of Figure 4-7 can be relaxed for slower interfaces. T1, T2 and T4 are determined by the host system and can be longer or shorter than shown in the figure. T5 would change correspondingly. T1 plus T2 plus T4 cannot exceed 75.0 milliseconds on any data byte. Of course, faster timing results in higher system throughput. Table 4-14 shows the timing required to give the maximum transfer rate.

#### 4.4.7.2.2 WRT/Early EOT (Buffered Mode)

When writing with the Cache Buffer installed and operating in buffered mode, a number of records may be present in the buffer at any given time. When the MTS determines that the tape is approaching the end-of-recording area, the maximum number of records in the buffer is reduced to 1 or 4 as indicated by the switches. This ensures that no more than 1 or 4 records will be written after the end-of-recording area is encountered without the host's knowledge. After the end-of-recording area is reached, only 1 record maximum is allowed in the buffer so that status is not given to the host until this record has been written to tape.

#### 4.4.7.3 WRT/BOT

When a WRT command is initiated with tape positioned at BOT, the MTS writes and checks the ID area before proceeding to the WRT command. The ID area is written and checked automatically within the MTS, requiring no signal responses from the user interface.

For the model 2925, the data for the record is taken into the buffer, transferred to tape, and checked for validity before BUSY is unasserted and status is given to the host. Note that when operating in buffered mode, no record can be written or read that is larger than the buffer.

If the ID area cannot be written and read with validity, the operation is terminated. A data block is not written and the WRT command is not performed. Appropriate ID BRST, REJECT, and DATA CHK signals are included in the ending status.

## 4.4.8 Loop Write-to-Read (LWR) Command

The LWR command operations provide a means of testing the read and write data circuit paths within the MTS. Read signals are derived (looped) within the MTS from the write circuits. There is no tape motion. LWR is not allowed if tape is loaded and positioned away from BOT. Data is transferred over the interface the same as during a Write command.

The signal sequence is the same as that described in Section 4.4.7.1 for a WRT command operation.

## 4.4.9 Backspace a File (BSF) Command

### 4.4.9.1 DESCRIPTION

The BSF command causes tape to be moved backward, passing over data blocks encountered until a tape mark block is detected. Tape motion is halted with the read head positioned relative to the IBG preceding (on the BOT side of) the tape mark. Tape Mark Status is included in the ending status and the operation is completed. No data characters are checked for validity or transferred across the interface. BLOCK is not asserted for any data blocks passed over; BLOCK is only asserted at the Tape Mark.

Other than command initiation, no signal responses are required of the user interface.

### 4.4.9.2 BSF/BOT

If the ID area is reached before finding a tape mark block, the operation is terminated. Tape is positioned at BOT. DATA CHK and BOTS are asserted in the ending status. If BSF is initiated with tape positioned at BOT, the command is invalid, REJECT is asserted, and the operation is terminated.

## 4.4.10 Backspace a Block (BSB) Command

### 4.4.10.1 DESCRIPTION

The BSB command operation causes tape to be moved backward, passing over data blocks until signaled to STOP by the user interface. When signaled to stop, the read head is positioned relative to the IBG preceding the last data block passed over. No data characters are checked for validity or transferred across the interface.

#### 4.4.10.2 SIGNAL SEQUENCE

After the command initiation, the MTS begins backward tape motion. If a data block is detected, the MTS asserts BLOCK pulse at the standard interface. If data block spacing is to be terminated, the user interface must assert STOP. This assertion must occur within 2 microseconds of the assertion of BLOCK and must have a 1 microsecond minimum duration.

If data block spacing is not to be terminated, STOP must not be asserted, tape motion continues, and BLOCK is pulsed (refer to Section 4.3.3 for BLOCK timing) when and if the next block detected is a data block. When STOP is asserted, tape motion is halted with the read head positioned in the preceding IBG, BUSY is reset, and the operation is completed.

#### 4.4.10.3 BSB/BOT

If BOT is reached before STOP is asserted or before a data block is detected, the operation is terminated. Tape is positioned at BOT. DATA CHK and BOTS are asserted in the ending status. If BSB is initiated with tape positioned at BOT, the command is invalid; REJECT is then asserted and the operation is terminated.

#### 4.4.10.4 BSB/TAPE MARK

When a tape mark block is encountered during the operation, tape motion halts with the Read Head positioned relative to the IBG preceding the tape mark block. TMS is included in the ending status.

### 4.4.11 Forward Space a File (FSF) Command

#### 4.4.11.1 DESCRIPTION

This operation is the same as that described in Section 4.4.9.1 for BSF except that tape motion is forward and, at the completion of the command, the read head is positioned relative to the IBG following the tape mark block.

Other than initiating the command, no signal responses are required of the user interface.

#### 4.4.11.2 FSF/BOT

When an FSF command is initiated with tape positioned at BOT, the MTS first processes the ID area as described in Section 4.4.5.3 for RDF/BOT before proceeding to space to the next tape mark block.

### 4.4.12 Forward Space a Block (FSB) Command

#### 4.4.12.1 DESCRIPTION

This operation is the same as that described in Section 4.4.10.1 for BSB except that tape motion is forward and, at the completion of the command, the read head is positioned relative to the IBG following the data block.

The signal sequence is the same as that described in Section 4.3.10.2 for BSB.

#### 4.4.12.2 FSB/BOT

When an FSB command is initiated with tape positioned at BOT, the MTS first processes the ID area as described in Section 4.4.5.3 for RDF/BOT before commencing the FSB operation.

#### 4.4.12.3 FSB/TAPE MARK

When a tape mark block is encountered during the operation, tape motion halts with the read head positioned relative to the IBG following the tape mark block. TMS is included in the ending status.

### 4.4.13 Write Tape Mark (WTM) Command

#### 4.4.13.1 DESCRIPTION

The WTM command causes tape to be moved forward and a tape mark block to be written and checked for validity. If the validity check indicates that the tape mark does not meet ANSI specifications, the MTS automatically backspaces and erases forward over the written tape mark and rewrites the tape mark block. Up to two rewrites are automatically attempted. If the tape mark does not meet ANSI specifications after the rewrite attempt(s), WTM CHK is asserted. Refer to MUX Byte 1.

Other than initiating the command, no signal responses are required of the user interface.



#### 4.4.13.2 WTM/BOT

When a WTM command is initiated with tape positioned at BOT, the MTS first writes and checks the ID area as described in Section 4.4.7.3 for WRT/BOT before commencing the WTM operation.

### 4.4.14 Erase Gap (ERG) Command

#### 4.4.14.1 DESCRIPTION

The ERG command causes tape to be moved in the forward direction and a 3.6 inch nominal (PE) or 3.4 inch nominal (GCR) section of tape to be erased. During the ERG operation, read checks are performed to verify that erasure has occurred. If Read signals are detected, REJECT is asserted in ending status.

Other than initiating the command, no signal responses are required of the user interface.

#### 4.4.14.2 ERG/BOT

When an ERG command is initiated with tape positioned at BOT, the MTS first automatically causes the generation and checking of the ID area as described in Section 4.4.7.3 for WRT/BOT before commencing the ERG operation.

### 4.4.15 Rewind (REW) Command

#### 4.4.15.1 DESCRIPTION

The REW command causes tape to move in the backward direction at rewind speed. Tape motion halts with tape positioned at BOT. BUSY is asserted only until the MTS accepts the REW command. The MTS resets Ready Status and asserts Rewinding Status while performing the rewind operation, and then reasserts Ready Status and resets Rewinding Status when BOT is reached.

Other than initiating the command, no signal responses are required of the user interface.

#### 4.4.15.2 REW/BOT

No tape motion occurs and tape remains positioned at BOT. BUSY is asserted only for the short time required to check that tape was positioned at BOT.

## 4.4.16 Rewind and Unload (RUN) Command

### 4.4.16.1 DESCRIPTION

The RUN command causes tape to move in the backward direction at rewind speed. When BOT is reached, tape motion slows and tape is wound onto the file (supply) reel. BUSY is asserted only until the MTS accepts the RUN command. The MTS resets Online Status upon accepting the command.

Other than initiating the command, no signal responses are required of the user interface.

### 4.4.16.2 RUN/BOT

Tape is wound completely onto the file (supply) reel. The MTS resets Online Status upon accepting the command.

## 4.4.17 Sense Drive Status (SNS) Command

### 4.4.17.1 DESCRIPTION

This command initiates the transfer of the various Drive Status Bytes (DSBs) across the Error Multiplex Bus to the user. The three Select Mux lines must be set for "Drive Sense" (SLX 2, 1, 0 = 011). To start, the first status byte (DSB0) is asserted at the interface. Then the first SNS command causes the next status byte (DSB1) to be asserted at the interface. This DSB remains valid until the MTS is issued a NOP command. At this point the MTS may be issued a CLR command to place DSB0 on the Error Multiplex Bus and return the MTS to the idle mode, or the MTS may be issued a SNS command to request the next sequential DSB. These bytes are defined in Table 4-15.

Note that machines without the Cache Buffer only have defined sense bytes 0 through 55. Attempting to read bytes 56, 57, 58, etc, on these machines will cause the sense data to start over and display DSB 0, 1, 2, etc.

### 4.4.17.2 SIGNAL SEQUENCE

Each SNS must be followed by a NOP command which in turn must be followed by an SNS command or a CLR command. The assertion of the RESET line at any time during this sequence places DSB0 on the Error Multiplex Bus and returns the MTS to the idle mode.

### 4.4.17.3 SENSE BIT DEFINITIONS

"X" indicates "not defined" in Table 4-15. The following definitions apply to the bits shown in Table 4-15.

#### 4.4.17.3.1 DSB0 through DSB4

The various bits are defined in Table 4-16.

#### 4.4.17.3.2 DSB5 and DSB6 Description

These two sense bytes together may be used to reconstruct the specific fault code (as shown in the Fault Code Dictionary, Storage Technology Standard Interface, PN 97712) with the following formula:

$$\text{3-digit fault code} = (\text{DSB5} \times 10 \text{ hex}) + \text{DSB6}$$

For example, when DSB5 = 32, and DSB6 = 11, the specific fault code is calculated as follows:

$$\begin{array}{r} 32 \text{ hex} \times 10 \text{ hex} = 320 \text{ hex} \\ \text{PLUS} \quad \quad \quad 11 \text{ hex} \\ \text{results in a} \quad \quad 331 \text{ hex specific fault code} \end{array}$$

This fault code is the same as appears on the operator panel during machine operation.

#### 4.4.17.3.3 DSB8 through DSB55 Description

These sense bytes hold status information bytes identified in the Fault Code Dictionary as A-0 through C-F. Each information byte (A-0, A-1, etc.) is located in a specific sense byte identified in Table 4-17.

For example, if there is a reference in the Fault Code Dictionary to 'Status A-8: Data Checks' this refers (according to Table 4-17) to Sense Byte 16, where additional data pertinent to this error condition is stored. The type of additional information stored in A-0 through C-F depends on the type of error encountered.

Table 4-15. MTS Status (Sheet 1 of 2)

DRIVE STATUS BYTES "DSB"	MTS STATUS BITS								
	P	7	6	5	4	3	2	1	0
0	WRTS	EOTS	BOTS	0	FPTS	BWDS	HDNS	RDYS	ONLS
1	X	1	1	1	D0	1	0	M1	M0
2	X	0	0	S1	S0	G3	G2	G1	G0
3	X	T3	T2	T1	T0	L11	L10	L9	L8
4	X	L7	L6	L5	L4	L3	L2	L1	L0
BYTES 5 - 55: Diagnostic Information									
5	Last Test Identifier								
6	Last Test Return Code								
7	Reserved								
8-23	Status A-0 through A-F (16 bytes)								
24-39	Status B-0 through B-F (16 bytes)								
40-55	Status C-0 through C-F (16 bytes)								
BYTES 56 - 61: Error Recovery Information For Read/Write Errors									
56	X	X	X	X	X	X	X	CACHE DATA MODE	SYNC MODE
57	X	WRITE ERROR	READ ERROR	DT PARITY	POSITION Lost	RETRY Bit 3	RETRY Bit 2	RETRY Bit 1	RETRY Bit 0
58	X	Number of Records which remain in the Buffer (may include a tape mark)							
59	X	Record Number from BOT in error MSB (includes Tape Marks)							
60	X	Record Number from BOT in error							
61	X	Record Number from BOT in error LSB							

Table 4-15. MTS Status (Sheet 2 of 2)

DRIVE STATUS BYTES "DSB"	MTS STATUS BITS									
	P	7	6	5	4	3	2	1	0	
<b>BYTES 62 - 65: Status Information At The Time Of First Error</b>										
62	X	Dead Tracks 7-0 at time of first Write or Read Retry								
63	X	EOT STATUS	BOT PARITY	CACHE PARITY ERROR	DATA CHECK	DRIVE BUPER	OVER-RUN	REJECT	EPROM ERROR	
64	X	WTM CHECK	UCE	PARTIAL RECORD	MTE	CRC ERROR	EDC	VEL ERROR	CACHE CRC ERROR	
65	X	Diagnostic Aid Bits at time of 1st Write or Read Retry								
<b>Bytes 66-87: Error History Since The Last Unload Or SNS Command</b>										
66	X	Read Forward Retry count since last unload or SNS								
67	X	Read Backward Retry count since last unload or SNS								
68	X	Write Retry Count since last unload or SNS								
69	X	Number of Records which had Read Retries								
70	X	Number of Records which had Write Retries								
71	X	Track 0 Errors (Number of records with Track 0 dead)								
72	X	Track 1 Errors (Number of records with Track 1 dead)								
73	X	Track 2 Errors (Number of records with Track 2 dead)								
74	X	Track 3 Errors (Number of records with Track 3 dead)								
75	X	Track 4 Errors (Number of records with Track 4 dead)								
76	X	Track 5 Errors (Number of records with Track 5 dead)								
77	X	Track 6 Errors (Number of records with Track 6 dead)								
78	X	Track 7 Errors (Number of records with Track 7 dead)								
79	X	Track P Errors (Number of records with Track P dead)								
80	X	CRC Error Count since last unload or SNS								
81	X	Uncorrectable Error Count since last unload or SNS								
82	X	Partial Record Count since last unload or SNS								
83	X	Multiple Track Error Count since last unload or SNS								
84	X	End of Data Check Count since last unload or SNS								
85	X	Velocity Error Count since last unload or SNS								
86	X	Cache CRC Error Count since last unload or SNS								
87	X	Number of records successfully corrected (Corrected Error without Data Check)								

Table 4-16. Various Bits in DSB0-4

DSB1, Bit 3: Distinguishes the 29xx series from the 19xx series.								
<u>S1</u>	<u>S0</u>	<u>MTS Front Panel Density Select</u>						
0	0	Software select						
0	1	Unused						
1	0	1600 (PE)						
1	1	6250 (GCR)						
<u>D0</u>	<u>MTS Mode</u>							
0	1600 (PE)							
1	6250 (GCR)							
<u>M1</u>	<u>M0</u>	<u>MTS Capability</u>						
0	0	50 IPS - PE/GCR						
0	1	50/100 IPS PE/GCR						
1	0	Unused						
1	1	50/100 IPS PE/GCR with Cache Buffer						
<u>I3</u>	<u>I2</u>	<u>I1</u>	<u>I0</u>	<u>Machine Type</u>				
1	0	1	0	2921				
1	0	1	1	2922				
<u>L11 - L0</u>				<u>CODE LEVEL</u>				
<u>G3</u>	<u>G2</u>	<u>G1</u>	<u>G0</u>	<u>G3</u>	<u>G2</u>	<u>G1</u>	<u>G0</u>	<u>Gap/Speed Selection</u>
0	0	0	0	- Not Used	1	0	0	0 - 100 IPS, .6 PE, .3 GCR
0	0	0	1	- 50 IPS	1	0	0	1 - 100 IPS, .9 PE, .6 GCR
				Start/Stop				
0	0	1	0	- Spare	1	0	1	0 - 100 IPS, 1.2 PE, .9 GCR
0	0	1	1	- Spare	1	0	1	1 - Spare
0	1	0	0	- Spare	1	1	0	0 - Spare
0	1	0	1	- Spare	1	1	0	1 - Spare
0	1	1	0	- Spare	1	1	1	0 - Spare
0	1	1	1	- Spare	1	1	1	1 - Spare

Table 4-17. A-0 Through C-F Sense Bytes Cross Reference

STATUS CODE	SENSE BYTE	STATUS CODE	SENSE BYTE	STATUS CODE	SENSE BYTE
A-0	8	B-0	24	C-0	40
A-1	9	B-1	25	C-1	41
A-2	10	B-2	26	C-2	42
A-3	11	B-3	27	C-3	43
A-4	12	B-4	28	C-4	44
A-5	13	B-5	29	C-5	45
A-6	14	B-6	30	C-6	46
A-7	15	B-7	31	C-7	47
A-8	16	B-8	32	C-8	48
A-9	17	B-9	33	C-9	49
A-A	18	B-A	34	C-A	50
A-B	19	B-C	35	C-B	51
A-C	20	B-C	36	C-C	52
A-D	21	B-D	37	C-D	53
A-E	22	B-E	38	C-E	54
A-F	23	B-F	39	C-F	55

SEPARATOR SET PN 83464

THIS SEPARATOR SET CONTAINS 19  
TABS TOTAL IN THE FOLLOWING  
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IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD



# CHAPTER 5

## INDUSTRY STANDARD INTERFACE

### 5.1 INTRODUCTION

This chapter provides a description of the Industry Standard Interface circuits, defines the interface signals, and describes the user commands to the MTS.

The MTS and user interface connections are shown in Tables 5-1 and 5-2. The MTS and USER interface circuits are shown in Figure 5-1. The maximum allowable cable length from the user system to the last MTS in a chain is 40 feet (12.19 meters).

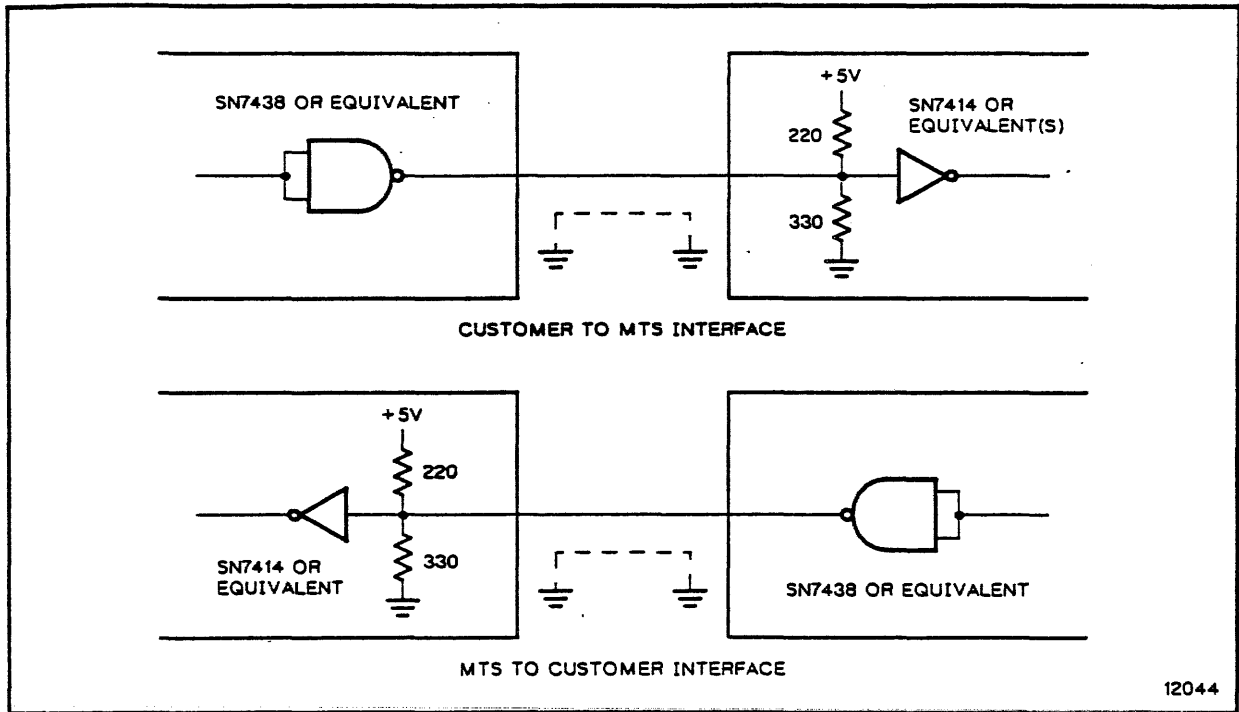
The interface signal levels are:

	<u>TRANSMITTED</u>	<u>RECEIVED</u>
True = 0	0.0V - 0.4V	0.0V - 0.8V
False = 1	2.4V - 5.0V	2.0V - 5.0V

The interface resistive termination for each signal is 330 ohms to ground and 220 ohms to +5 Vdc. The termination for each signal line is provided in the MTS or the user interface at each signal destination point. The termination includes a ground wire, connected in both the MTS and the user interfaces. Only the last MTS in a chain contains terminators.

### 5.2 INPUT LINE DEFINITIONS

The following input line definitions are for functional mode only. The timing specifications given refer to measurements made at the interface connectors.



12044

Figure 5-1. Standard Industry Interface Circuits

Table 5-1. Industry Standard Interface Input Lines

DESCRIPTION (NEG.TRUE)	MNEMONIC	MTS CONNECTOR		
		NO.	SIGNAL PIN	GROUND PIN*
Formatter Enable	FFEN	J6	18	17
Command Offline	FOFL	J6	24	23
Address Bit 1	FTAD1	J6	46	45
Formatter Address	FFAD	J6	48	47
High Speed Select	FHISP	J6	50	49
Last Word	FLWD	J7	04	03
Write Bit 4	FWD4	J7	06	05
Start Command	FGO	J7	08	07
Write Bit 0	FWD0	J7	10	09
Write Bit 1	FWD1	J7	12	11
Spare 3	----	J7	14	13
Spare 2	----	J7	16	15
Command Bit 3	FREV	J7	18	17
Rewind To BOT	FREW	J7	20	19
Write Bit P	FWDP	J7	22	21
Write Bit 7	FWD7	J7	24	23
Write Bit 3	FWD3	J7	26	25
Write Bit 6	FWD6	J7	28	27
Write Bit 2	FWD2	J7	30	29
Write Bit 5	FWD5	J7	32	31
Command Bit 2	FWRT	J7	34	33
Long Gap	FLGAP	J7	36	35
Command Bit 4	FEDIT	J7	38	37
Command Bit 0	FERASE	J7	40	39
Command Bit 1	FWFM	J7	42	41
Spare 1	----	J7	44	43
Address Bit 0	FTADO	J7	46	45

\* All gnd pins are connected to a single gnd bus.

Table 5-2. Industry Standard Interface Output Lines

DESCRIPTION (NEG TRUE)	MNEMONIC	MTS CONNECTOR		
		NO.	SIGNAL PIN	GROUND PIN*
Read Bit P	FRDP	J6	01	
Read Bit 0	FRD0	J6	02	
Read Bit 1	FRD1	J6	03	
Load Point (BOT)	FLDP	J6	04	
Read Bit 4	FRD4	J6	06	05
Read Bit 7	FRD7	J6	08	07
Read Bit 6	FRD6	J6	10	09
Hard Error	FHER	J6	12	11
File Mark	FFMK	J6	14	13
ID Burst	FID	J6	16	15
Read Bit 5	FRD5	J6	20	19
End Of Tape	FEOT	J6	22	21
Density Status	FGCR	J6	26	25
Drive Ready	FRDY	J6	28	27
Rewinding	FRWD	J6	30	29
File Protected	FFPT	J6	32	31
Data Read Strobe	FRSTR	J6	34	33
Data Write Strobe	FDWDS	J6	36	35
Data Busy	FDBY	J6	38	37
High Speed Status	FHSPD	J6	40	39
Corrected Error	FCER	J6	42	41
Online Status	FONL	J6	44	43
Formatter Busy	FFBY	J7	02	01
Read Bit 2	FRD2	J7	48	47
Read Bit 3	FRD3	J7	50	49

\* All gnd pins are connected to a single gnd bus.

Table 5-3. Interface Connector J6 Pin Functions

PIN	MNEMONIC	DESCRIPTION
01	FRDP	Read Bit P
02	FRD0	Read Bit 0
03	FRD1	Read Bit 1
04	FLDP	Load Point (BOT)
06	FRD4	Read Bit 4
08	FRD7	Read Bit 7
10	FRD6	Read Bit 6
12	FHER	Hard Error
14	FFMK	File Mark
16	FID	ID Burst
18	FFEN	Formatter Enable
20	FRD5	Read Bit 5
22	FEOT	End of Tape
24	FOFL	Command Offline
26	GCR	Density Status
28	FRDY	Drive Ready
30	FRWD	Rewinding
32	FFPT	File Protect
34	FRSTR	Data Read Strobe
36	FDWDS	Data Write Strobe
38	FDBY	Data Busy
40	FHSPD	High Speed Status
42	FCER	Corrected Error
44	FONL	Online Status
46	FTAD1	Address Bit 1
48	FFAD	Formatter Address
50	FHISP	High Speed Select

Table 5-4. Interface Connector J7 Pin Functions

PIN	Mnemonic	Description
02	FFBY	Formatter Busy
04	FLWD	Last Word
06	FWD4	Write Bit 4
08	FGO	Start Command
10	FWD0	Write Bit 0
12	FWD1	Write Bit 1
14	----	Spare 3
16	----	Spare 2
18	FREV	Command Bit 3
20	FREW	Rewind to BOT
22	FWDP	Write Bit P
24	FWD7	Write Bit 7
26	FWD3	Write Bit 3
28	FWD6	Write Bit 6
30	FWD2	Write Bit 2
32	FWD5	Write Bit 5
34	FWRT	Command Bit 2
36	FLGAP	Long Gap
38	FEDIT	Command Bit 4
40	FERASE	Command Bit 0
42	FWFM	Command Bit 1
44	----	Spare 1
46	FTAD0	Address Bit 0
48	FRD2	Read Bit 2
50	FRD3	Read Bit 3

### 5.2.1 MTS Address (FFAD, FTAD0, FTAD1)

The MTS Address lines are decoded to select one of the four possible MTSS. (Table 5-5). Controller board switches, corresponding to the address lines, must be set to indicate MTS Address 0,1,2, or 3 to match the address lines coming from the host cpu or controller. The address lines from the host may be switched as long as the Formatter Busy (FFBY) and Data Busy (FDBY) lines are not set. The address must be stable one microsecond before any of the following command lines are activated:

FGO (Start Command)  
 FOFL (Command Offline)  
 FREW (Rewind To BOT)  
 FFEN (Formatter Enable)

These lines must not be activated when switching machine address.

Table 5-5. MTS Address Line Decodes

MTS ADDRESS LINES			SELECTED MTS
FFAD	FTAD1	FTAD0	
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3

### 5.2.2 Initiate Command (FGO)

The assertion of the Initiate Command line causes five user Command lines to be captured and the command operation to begin. All the command lines must be stable at the start of the FGO pulse and are clocked in on the trailing edge of the pulse. The FGO pulse from the host must have a minimum one microsecond width. A commands decode table is given in the next paragraph. The commands themselves are described further down in this chapter.

If the FGO signal comes up while the the Formatter Address (FFAD) or Data Busy (FDBY) signal is still up, The new command is ignored and Command Overrun is set. The FGO signal is also ignored if the MTS is offline.

### 5.2.3 Rewind To BOT (FREW)

A pulse on this line causes the selected MTS to rewind to BOT. The drive drops the Ready (FRDY) signal and asserts the Rewind (FRWD) signal one microsecond after the leading edge of the FREW signal. The FREW signal must be held true for at least one microsecond. This signal is ignored if the MTS is offline and if the formatter is busy.

### 5.2.4 Command Offline (FOFL)

A pulse on this line causes the MTS to go offline and rewind. The drive drops the Ready (FRDY) signal one microsecond after the leading edge of the FOFL signal. The processor then drops Online Status (FONL) and starts to rewind. After the rewind is complete, the tape is unloaded. The FOFL line must be held true for at least one microsecond. This signal is ignored if the MTS is offline and if the formatter is busy.

### 5.2.5 Formatter Enable (FFEN)

This signal enables MTS operations and is usually held true. If the line goes false, drive motion stops and the current command is terminated.

Subsystem programmers should use this line only to terminate a run-away condition. There is no need to use this line as a 'reset' to clear status lines, since all status lines are reset on the acceptance of a new command. Using this line as a 'reset' between commands also forces repositioning between each command, thus causing slower subsystem performance. For system IPL, the drive only needs to be set online and rewound to BOT.

This line is ignored if the MTS is offline.

### 5.2.6 Last Word (FLWD)

During a write command, this line is asserted with Write Bits 0-7,P (FWD 0-7,p) to indicate that the character strobed with Write Strobe (FWDWS) is the last byte of the record.

### 5.2.7 Write Data Lines (FWDO-7,p)

These nine lines transmit data to the MTS. FWDO is the most significant bit.

### 5.2.8 High Speed Select (FHISP) (2922 devices only)

This line selects 100 IPS operation if true, and 50 IPS operation if not true. This line is asserted when a read or write command is issued. If the MTS is in the opposite speed when the command is issued, the unit will first change speed and then execute the command.

### 5.2.9 Long Gap Select (FLGAP) (2922 devices only)

When this line is asserted, an interblock gap of nominal plus +0.3 in. (+0.76 cm) is generated. When this line is not asserted, the gap is nominal. This line has effect in data streaming mode (100 IPS mode) only.

### 5.2.10 Command Select Lines (CMD0, 1, 2, 3, and 4)

The five Command Select lines are decoded in the MTS and cause one of 21 command operations, 15 functional commands and 6 diagnostic commands. These lines must be stable when the FGO line is asserted. Command line decodes are given in Tables 5-6



and 5-7. Detailed description of the commands are given further down in this chapter.

Table 5-6. Functional Command Lines Decodes

CMD4 FEDIT	CMD3 FREV	CMD2 FWRT	CMD1 FWFM	CMD0 FERASE	MNE- MONIC	COMMAND
0	0	0	0	0	RDF	Read Forward
0	1	0	0	0	RDR	Read Reverse
1	1	0	0	1	RDS	Read Sense
0	0	1	0	0	WRT	Write
0	0	1	1	0	WFM	Write File Mark
0	1	1	1	0	WRE	Write Extended
0	0	1	0	1	ERV	Controlled Erase
0	0	1	1	1	ERF	Fixed Erase
1	0	1	1	1	ERT	Data Security Erase
0	0	0	0	1	SPF	Space Forward
0	1	0	0	1	SPR	Space Reverse
0	0	0	1	1	FSF	File Search Forward (ignore data)
0	1	0	1	1	FSR	File Search Reverse (ignore data)
1	0	0	1	1	SPE	Select PE
1	1	0	1	1	GCR	Select GCR

Table 5-7. Diagnostic Command Lines Decodes

CMD4 FEDIT	CMD3 FREV	CMD2 FWRT	CMD1 FWFM	CMD0 FERASE	MNE- MONIC	COMMAND
0	1	1	0	0	INV	Invoke Diagnostics
0	1	1	1	1	LWR	Loop Write To Read
1	0	0	0	0	INS	Initiate Status Sequencer
1	0	0	0	1	WRAP	Command To Status Wrap
1	1	1	0	1	EXS	Read Extended Sense
1	1	1	1	1	LOOP	Data Loopback

## 5.3 OUTPUT SIGNAL DEFINITIONS

The following output line definitions are for functional mode only. The timing specifications given refer to measurements made at the interface connectors.

### 5.3.1 Formatter Busy (FFBY)

This line is used to indicate that a command is being processed. It goes true within one microsecond after the leading edge of the FGO line. The FFBY line remains true until the full completion of the present command.

### 5.3.2 Data Busy (FDBY)

When this line goes true, it indicates that the data transfer part of a command takes place, and data is exchanged. This line goes false upon the completion of data transfer. When the line goes false, tape motion has not stopped yet, but a new command can be received; the new command, if received, is processed after completion of the last command.

When this line goes false and before a new command is asserted, the host must examine for the presence of the Hard Error (FHER) line in order to determine whether to retry the last command or send a new one.

The FDBY line is MTS microprocessor controlled. While this line is asserted, no new command may be issued.

### 5.3.3 Identification Burst (FID)

This line is asserted by the MTS to indicate to the host that an identification burst (ID Burst) procedure is being performed by the MTS. The FID line is asserted from Beginning Of Tape (BOT) marker during read or write operations.

During write operations, the ID Burst procedure writes a PE or GCR tape identification burst at BOT, depending on what mode the MTS is instructed to be in, before writing starts.

During read operations, the ID Burst procedure identifies the type of data on tape (PE or GCR) from the ID Burst written on tape, then sets the MTS to the proper mode before reading of data starts.

The FID and GCR (later described) lines together indicate to the host the mode the MTS is in, PE or GCR.

### 5.3.4 Hard Error (FHER)

If an error is detected while the MTS is busy, this line is pulsed low. When the MTS becomes not busy, this line remains a solid low. See the description of sense bytes in this chapter.

### 5.3.5 File Mark Detected (FFMK)

This line is pulsed while Data Busy (FDBY) is asserted in a read/write operation, when a tape mark pattern is being detected.

### 5.3.6 Corrected Error (FCER)

When correcting an error, A series of pulses are asserted on this line. When Data Busy (FDBY) becomes unasserted, FCER stays a solid low, but is reset prior to the next record.

The type of read error corrections indicated by this line are as follows;

- A single track error correction during PE Read,
- A single track PE error correction after read back check during write,
- A single or double track error correction during GCR Read,
- A single or double track GCR error correction after read back check during write.

### 5.3.7 Ready (FRDY)

This line when asserted indicates that the MTS is ready to accept a read or write type command. This is the case when the tape is loaded, is not rewinding and is not in Machine Check status.

### 5.3.8 Online (FONL)

This line is asserted when the MTS is online and is able to communicate back to the host. If the MTS is offline, all other status back to the host is unasserted.

### 5.3.9 Rewind (FRWD)

When this line is asserted, it indicates to the host that the MTS is rewinding to BOT.

### 5.3.10 End Of Tape (FEOT)

This line is asserted when the EOT marker is detected, and stays asserted past the EOT marker, indicating that the tape is within the end of the recording area. EOT status is reset when the EOT marker is detected in backward or rewind mode.

### 5.3.11 File Protect (FFPT)

When this line is asserted, it indicates that the mounted file reel does not contain a write enable ring, and that no write operation can take place.

### 5.3.12 Load Point (FLDP)

When this line is asserted, it indicates that the tape is loaded and positioned at BOT.

### 5.3.13 High Speed Streaming (FHSPD)

When this line is asserted, it indicates that the selected MTS is in the streaming, 100 IPS mode. When this line is not asserted, the drive is in the Start/Stop, 50 IPS mode. (2922 Model Drives only)

### 5.3.14 High Density Status (GCR)

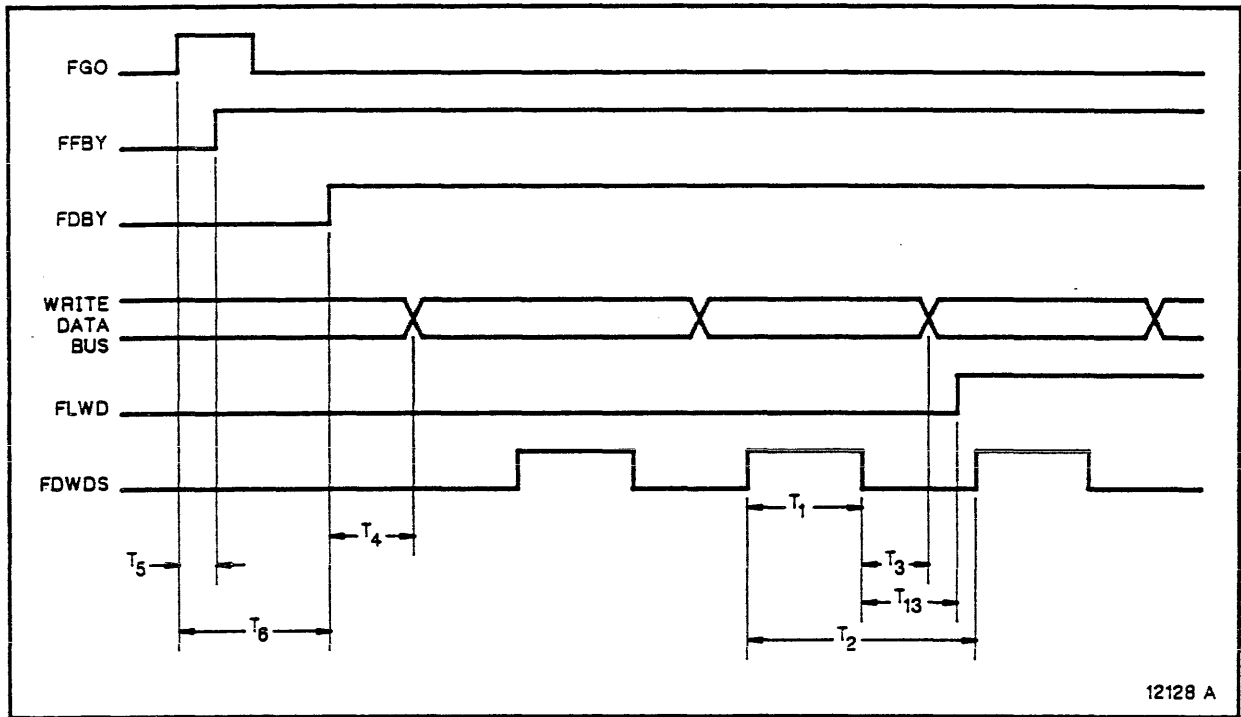
When this line is asserted, it indicates that the selected drive is in the GCR, 6250 BPI mode. When this line is not asserted, the drive is in the PE, 1600 BPI mode.

### 5.3.15 Demand Write Data Strobe (FDWDS)

A pulse is asserted on this line for each character to be written on tape. It functions somewhat differently for 50 IPS and 100 IPS operations, as described below.

#### 5.3.15.1 FDWDS TIMING, 50 IPS OPERATIONS

The first data character must be available on the data input lines no later than ten microseconds after the Data Busy (FDBY) signal has been asserted. The succeeding characters must be placed on the data input lines within 0.7 microseconds of the trailing edge of FDWDS. The FDWDS signal has a pulse width of 1.0 to 1.2 microseconds and a minimum period of two microseconds. (Figure 5-2).



12128 A

Figure 5-2. Interface Timing For 50 IPS Start Stop, Worst Case

### 5.3.15.2 FDWDS TIMING, 100 IPS OPERATIONS

The first data character must be available on the data input lines no later than ten microseconds after the Data Busy (FDBY) signal has been asserted. The succeeding characters must be placed on the data input lines within 0.3 microseconds of the trailing edge of FDWDS. The FDWDS signal has a width of 0.4 to 0.6 microseconds and a minimum period of one microsecond. (Figure 5-3).

### 5.3.16 Read Data Strobe (FRSTR)

A pulse is asserted on this line for each character of read information to be transmitted to the host controller interface and is used to sample the read data lines. This line acts somewhat differently for 50 IPS and 100 IPS operations as described below.

Note that the strobe is switched from hardware to software control during a Read Sense command.

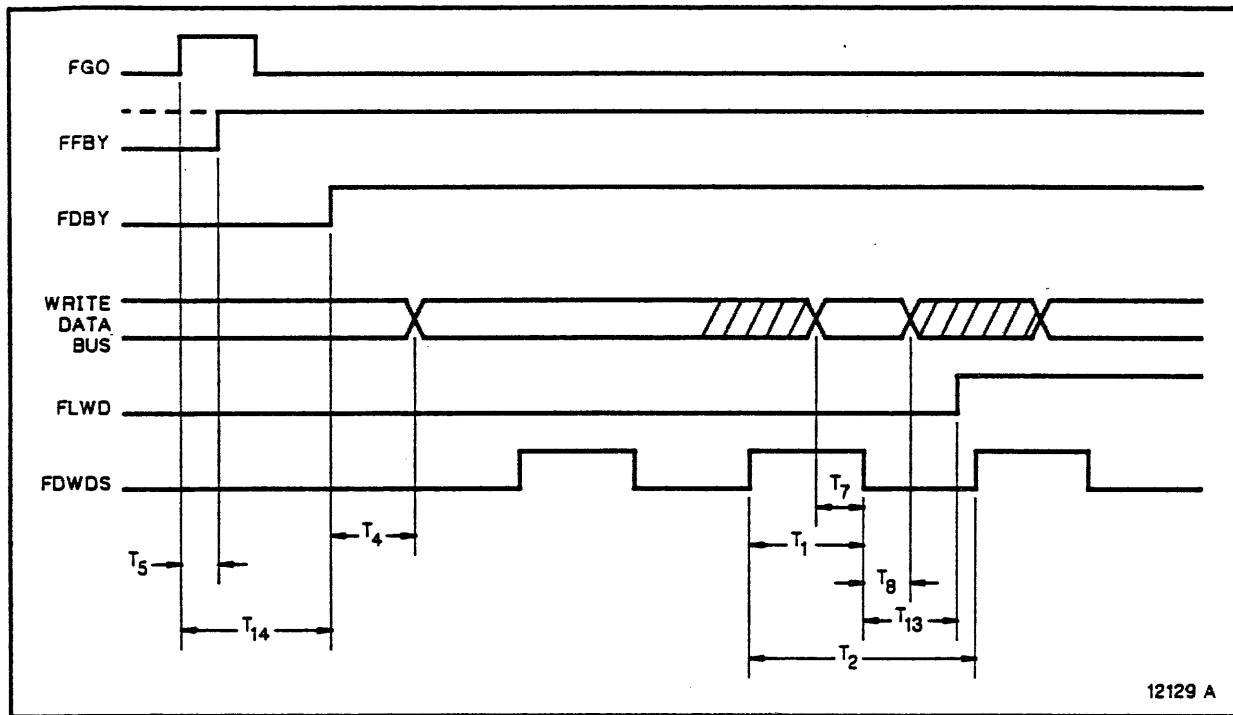


Figure 5-3. Interface Timing For 100 IPS Streaming, Worst Case

### 5.3.16.1 FRSTR TIMING, 50 IPS OPERATION

In 50 IPS operations the FRSTR signal has a pulse width of 0.75 microseconds and a minimum period of two microseconds. Data is valid 0.3 microseconds before the read strobe (Figure 5-2).

### 5.3.16.2 FRSTR TIMING, 100 IPS OPERATION

In 50 IPS operations the FRSTR signal has a pulse width of 0.40 microseconds and a minimum period of one microseconds. Data is valid 0.3 microseconds before the read strobe (Figure 5-3).

### 5.3.17 Read Data Lines 0-7,p (FRD0-7, p)

These nine lines transmit data from the MTS to the customer controller. Each character read from tape is available by sampling these lines in parallel with the read data strobe (FRSTR). FRD0 is the most significant bit of data.

The read data lines FRD0-7,P are also used to transmit the eight bytes of sense information when the Read Sense command is issued.

## 5.4 COMMAND LINES DECODES - FUNCTIONAL COMMANDS DESCRIPTION

The function of the five command lines (CMD0-4) has been previously described (Table 5-6). A detailed description of the decoded functional commands follows.

### 5.4.1 Read Forward Command (00000)

The Read Forward command causes tape to be moved in the forward direction to read a block of data. Non-data characters are detected, decoded, checked for validity, and used for their specific purposes, but are not transferred across the interface. Data is transferred until End Of Data is detected. The Last Word (FLWD) line is ignored if issued during a read operation.

### 5.4.2 Read Reverse Command (01000)

The Read Reverse command causes tape to be moved in the reverse direction to read a block of data. Non-data characters are detected, decoded, checked for validity, and used for their specific purposes, but are not transferred across the interface. Data is transferred until End Of Data is detected. The Last Word (FLWD) line is ignored if issued during a read operation.

When the 50 IPS Read Reverse operation is completed the read head is positioned in the Inter Block Gap (IBG) preceding the data block.

When the 100 IPS, streaming mode, Read Reverse operation is completed, positioning of the read head in the IBG is not guaranteed.

### 5.4.3 Write Command (00100)

The Write command causes tape to be moved in the forward direction and the following to take place;

1. The ending portion of the preceding IBG is written,
2. The data block is written and simultaneously read and checked for validity,
3. The beginning portion of the next IBG is generated

Non-data characters of the data block are automatically generated, encoded, formatted and written. Data characters to be written arrive from the interface, are automatically encoded, formatted, and written.

The overall write command execution sequence is as follows;

1. User asserts the Write command and the FGO line,
2. MTS acknowledges FGO by asserting Formatter Busy (FFBY),
3. MTS acknowledges Write by asserting Data Busy (FDBY) and starts motion,
4. MTS asserts Data Write Strobe (FDWDS) pulses until user asserts Last Word (FLWD); the host does not respond - data is assumed to be correct and on time,
5. MTS continues to move tape to perform read back check. When data transmission and status accumulation are completed, the MTS drops FDBY to enable user to read the status and issue the next command,
6. If the user does not issue a new command, the drive stops and FFBY is dropped.

#### 5.4.4 Write File Mark Command (00110)

This command causes tape to move forward and a tape mark block to be written and checked for validity. Two retries are automatically done.

#### 5.4.5 Write Extended Command (01110)

This command allows the host to change the Inter Block Gap (IBG) length for streaming mode operations (100 IPS). The command requires a one byte write transfer to completely define the operation. Formatter Busy (FFBY) and Data Busy (FDBY) remain asserted throughout the transfer. The byte sent defines the gap size selection as follows;

00 hex = nominal IBG  
 01 hex = nominal IBG + 0.3 in. (0.76 cm)  
 02 hex = nominal IBG + 0.6 in. (1.52 cm)

When a gap length has been selected by the Write Extended command, Long Gap (FLGAP) is ignored until the gap has been set back to nominal by another Write Extended command.

#### 5.4.6 Fixed Erase Command (00111)

This command causes tape to move forward and the following lengths of tape to be erased;

PE = 3.6 in. (9.14 cm) nominal  
 GCR = 3.4 in. (8.64 cm) nominal



During the erase operation, read checks are performed to verify that erasure took place. If read signals are detected, Data Check is asserted in Status Byte 0.

#### 5.4.7 Controlled Erase Command (00101)

This command causes the MTS to move and erase tape continuously until the Last Word signal from the user is asserted. This terminates the erase operation.

When the erase command is given from BOT, an ID Burst is written before erasing starts.

#### 5.4.8 Data Security Erase Command (10111)

This command causes the MTS to erase tape from its present position to a position approximately ten feet (3.05 meters) past the End Of Tape (EOT) marker.

When the erase command is given from BOT, an ID Burst is written before erasing starts.

#### 5.4.9 Space Forward Command (00001)

This command causes tape to move forward and pass over one block of data. If no new command is given while Formatter Busy (FFBY) is still asserted Data Busy (FDBY) is false, the read head is positioned in the IBG following the data block. No data characters are checked for validity or transferred across the interface.

#### 5.4.10 Space Reverse Command (01001)

This command causes tape to move backward and pass over one block of data. If no new command is given while Formatter Busy (FFBY) is still asserted Data Busy (FDBY) is false, the read head is positioned in the IBG preceding the data block. No data characters are checked for validity or transferred across the interface.

#### 5.4.11 File Search Forward Command (Ignore Data) (00011)

This command causes tape to move forward, passing over each data block encountered until a Tape Mark block is detected. Tape motion is halted with the read head positioned in the IBG following the tape mark. No data characters are checked for validity or transferred across the interface.

#### 5.4.12 File Search Reverse Command (Ignore Data) (01011)

This command causes tape to move backward, passing over each data block encountered until a Tape Mark block is detected. Tape motion is halted with the read head positioned in the IBG preceding the tape mark. No data characters are checked for validity or transferred across the interface.

#### 5.4.13 Select PE Command (10011)

This command is issued by the host to put the MTS in PE mode. The dropping of Formatter Busy (FFBY) indicates completion of the command. This command is only accepted when the drive is unloaded or loaded and at BOT.

#### 5.4.14 Select GCR Command (11011)

This command is issued by the host to put the MTS in GCR mode. The dropping of Formatter Busy (FFBY) indicates completion of the command. This command is only accepted when the drive is unloaded or loaded and at BOT.

#### 5.4.15 Read Sense Command (11001)

This command is issued by the host in order to retrieve the sense information accumulated in the MTS registers. Eight sense bytes are issued. See next heading for sense bytes descriptions.

### 5.5 DETAILED FUNCTIONAL SENSE BYTES DESCRIPTION

Eight sense bytes are retrieved from the MTS in response to the Read Sense (11001) command from the host. The processor puts the first byte of data on the read bus, not including the parity bit, then pulses the Read Strobe ((FRSTR) line. The next byte is then put on the read bus and the FRSTR is pulsed again. This sequence is repeated until all eight bytes have been transferred to the host or controller. The status bytes defined below are listed in bit order 0 to 7. The 0 bit represents the most significant bit of data and is transferred on FRD0. Odd parity is sent with each sense byte to ensure data integrity. A description of all the sense bytes bits follows.

### 5.5.1 Sense Byte 0 (Faults, Mode And Not Ready)

BIT	MEANING	DESCRIPTION
0	Command Illegal	Set when the MTS receives an illegal command
1	Not Ready	Set when the MTS is not ready
2	Drive Type	Set when the MTS has the 100 IPS data streaming feature, reset when the MTS is 50 IPS Start/Stop
3	Equipment Check	Set when the MTS has a fault code on the operator display panel.
4	Data Check	Set when the MTS has detected one or more of the error conditions in Sense Byte 3 and Bits 0,1 or 2 of Sense Byte 4
5	Command Overrun	Set if a command was received while Data Busy (FDBY) is true. Also sets Sense Byte 0, Bit 0
6	Unit Check	Set when Bit 0,1,3,4 or 5 of Sense Byte 0 is set
7	Unit Exception	Set when error correction is performed during a read operation (Bits 0, 1 or 2 in Sense Byte 4)

### 5.5.2 Sense Byte 1 (Last Command Issued)

BIT	MEANING	DESCRIPTION
0	Command Bit 7	Spare 1
1	Command Bit 6	High Speed Select
2	Command Bit 5	Long Gap
3	Command Bit 4	Edit
4	Command Bit 3	Reverse
5	Command Bit 2	Write
6	Command Bit 1	Write File Mark
7	Command Bit 0	Erase

### 5.5.3 Sense Byte 2 (Tape Status)

BIT	MEANING
0	Backward Status
1	On Line
2	Rewinding
3	File Protected
4	GCR Density
5	100 IPS Streaming mode
6	Beginning Of Tape (BOT)
7	End Of Tape (EOT)

## 5.5.4 Sense Bytes 3 And 4 (Hard Errors)

### 5.5.4.1 SENSE BYTE 3

#### BIT MEANING

- 0 Write Tape Mark Check
- 1 Uncorrectable Error
- 2 Partial Record
- 3 Multiple Track Error
- 4 Spare (always zero)
- 5 End Of Data Check
- 6 Velocity Error
- 7 CRC Error

### 5.5.4.2 SENSE BYTE 4

#### BIT MEANING

- 0 BOT Reached
- 1 PE Postamble Error
- 2 Single Track Error in PE Write
- 3 Spare (always zero)
- 4 Command Reject; command could not be completed - see reject codes in Sense Byte 5
- 5 Bus Parity Error
- 6 Operation Incomplete
- 7 Overrun Error

## 5.5.5 Sense Byte 5 (Reject Status)

#### BIT MEANING

- 0 Diagnostic Mode Set (MSB)
- 1 Spare (always zero)
- 2 Reject Code Bit 5
- 3 Reject Code Bit 4
- 4 Reject Code Bit 3
- 5 Reject Code Bit 2
- 6 Reject Code Bit 1
- 7 Reject Code Bit 0 (LSB)

Table 5-8 shows the decodes for Reject Code Bits 0-5.

## 5.5.6 Sense Byte 6 (Corrected Error And Dead Track P)

Sense Byte 6 contains the corrected error status information. If the Corrected Error Status line (FCER) is set, either Bit 0, 1, or 2 in Sense Byte 6 is also set.

#### BIT MEANING

- 0 Single track in PE Read corrected
- 1 Single Track in GCR Read corrected
- 2 Double track in GCR Read corrected
- 3 Nominal gap +0.3 in. (0.76 cm) selected by last Write Extended (WRE) command
- 4 Nominal gap +0.6 in. (1.52 cm) selected by last Write Extended (WRE) command
- 5 Spare (always zero)
- 6 Spare (always zero)
- 7 Dead Track P (also see Sense Byte 7)

### 5.5.7 Sense Byte 7 (Dead Track register)

#### BIT MEANING

- 0 Dead Track 0
- 1 Dead Track 1
- 2 Dead Track 2
- 3 Dead Track 3
- 4 Dead Track 4
- 5 Dead Track 5
- 6 Dead Track 6
- 7 Dead Track 7

## 5.6 COMMAND LINES DECODES - DIAGNOSTIC COMMANDS DESCRIPTION

The function of the five command lines (CMD0-4) is described previously in this chapter under input signal definitions (Table 5-7). Detailed descriptions of the decoded commands follows.

### 5.6.1 Invoke Diagnostics (01100)

This command allows the host to invoke the resident diagnostics and specify run-time options. It requires a 2-byte write transfer to completely define the operation. Formatter Busy (FFBY) and Data Busy (FDBY) remain asserted throughout the 2-byte transfer and the subsequent diagnostic execution. The two bytes transferred define the operation (first byte and options (second byte) as follows:

- 1st byte = 01: run complete diagnostic package  
(unloads drive)
- 02: run loaded diagnostic subpackage
- 2nd byte = 00: no option  
(all other values reserved)

Table 5-8. Reject Codes (Sheet 1 of 2)

REJECT CODE (HEX)	DESCRIPTION
1	The MTS is not in Ready Status.
2	Reserved
3*	Reserved
4	Reserved
5	The MTS is in File Protect Status when a write-type command is attempted.
6*	The MTS did not go to Erase Status only.
7	Illegal Command Sequence
8*	The MTS did not go to Read Status.
9*	The MTS is unable to read a PE or GCR ID burst either during a read operation or during a read check while writing the ID burst.
A	Reserved
B	Reserved
C*	The MTS did not go to Write Status.
D	Reserved
E	Reserved
F*	Noise (possibly data) was detected during an Erase Gap command or during a Write command following a read-type command.
10*	The MTS is in Write Overrun Status at EOT.
11*	The MTS reset Ready Status.
12	Reserved
* OP INC is also set	

Table 5-8. Reject Codes (Sheet 2 of 2)

REJECT CODE (HEX)	DESCRIPTION
13	A backward-type command (except a rewind or a rewind/unload command) was given, but tape was already positioned at BOT.
14*	The ARA BURST portion of the GCR ID-burst just written did not have all nine tracks active.
15*	An IBG longer than 25 feet in PE mode or longer than 15 feet in GCR mode was detected on a read or space-type command.
16	More than one speed change requested without an intervening motion command.
17	Reserved
18*	The MTS is not in the recording density selected.
19	LWR attempted when tape loaded and positioned off BOT
1A*	No tape motion.
1B*	During a readback check of a write operation, data was detected in an IBG area.
1C	Reserved
1D*	The MTS attempted to backspace over a bad record just written but was unable to detect the record.
1E*	The ARA ID burst was unreadable during a GCR write command.
1F*	During the readback check of a write or write tape mark command, no data was detected.
* OP INC is also set.	

#### 5.6.1.1 RUN DIAGNOSTIC PACKAGE (BYTE 1 = 01)

This operation invokes the execution of all internal diagnostics. This includes power up (not including memory test), Loop Write to Read, Transport, and Read/Write diagnostics. Formatter Busy (FFBY) is reset when tests are completed or an error is detected. At this time status may be retrieved (see Read Extended command) to determine completion status.

#### 5.6.1.2 RUN LOADED DIAGNOSTICS (BYTE 1 = 02)

This operation invokes the execution of all diagnostics executable on a loaded transport, and which do not require unloading of the MTS. These include Loop Write to Read, Transport, and Read/Write diagnostics. Formatter Busy (FFBY) is reset when test are completed or an error is detected. At this time status may be retrieved (see Read Extended command) to determine completion status.

#### 5.6.2 Loop Write to Read (01111)

This command provides a means of testing the read and write data circuit paths within the MTS. Read signals are looped within the MTS from the write circuits to the read circuits. No tape motion takes place during the execution of this command. This command is not allowed if tape is loaded and positioned away from Beginning Of Tape (BOT). Errors, if any, are reported the same as if a normal write command took place. If the command is issued with the tape loaded and not at BOT, a REJECT will result.

#### 5.6.3 Initiate Status Sequencer (10000)

This operation initiates and sequences the status line test portion of the interface test. Following the initial Initiate Status Sequencer (ISS) command (at which time FGO is also asserted), all status except Online Status (FONL) is reset. Each subsequent assertion of FGO results in the setting of a single status line in addition to FONL, and the resetting of Formatter Busy (FFBY). The order of status assertion is shown in Table 5-9.

To complete this test, the user may issue the 14th FGO (the command sent with FGO will not be performed), or reset the subsystem by dropping Formatter Enable (FFEN). Note that the subsystem must be reset should the testing stop in mid-sequence.



Table 5-9. Status Line Assertion for ISS Command

FGO NO.	ASSERTED STATUS
1	initial FGO, all status except FONL is reset
2	ID Burst (FID)
3	Data Busy (FDBY)
4	Hard Error (FHER) (+ FDBY; 2921 & 2922)
5	File Mark (FFMK)
6	Corrected Error (FCER) (+ FDBY; 2921 & 2922)
7	End Of Tape (FEOT)
8	Load Point (FLDP)
9	File Protected (FFPT)
10	High Speed (FHSPD)
11	Density Status (FGCR)
12	Formatter Ready (FRDY)
13	Rewinding (FRWD)
14	normal (no action on command)

#### 5.6.4 Command to Status Wrap (10001)

This operation initiates a continuous wrapping of incoming command lines to outgoing status lines. This allows the host to verify functionality of command lines via the status lines. The transfer of command to status lines occurs following each FGO and is completed with the reset of Formatter Busy (FFBY). The command to status lines mapping is shown in Table 5-10.

Table 5-10. Status Line Assertion For Diagnostic Wrap Mode

INCOMING COMMAND LINES	MAPPED TO STATUS LINES
Command 0 (FERASE)	ID Burst (FID)
Command 1 (FWFM)	Data Busy (FDBY)
Command 2 (FWRT)	Hard Error (FHER) (+ FDBY;2921/22)
Command 3 (FREV)	File Mark (FFMK)
Command 4 (FEDIT)	Corrected Err (FCER) (+ FDBY;2921/22)
Long Gap (FLGAP)	Load Point (FLDP)
High Speed Select (FHISP)	File Protected (FFPT)
Spare 1	High Speed (FHSPD)
Spare 2	Density Status (FGCR)
Command Offline (FOFL)	Drive Ready (FRDY)
Rewind To BOT (FREW)	Rewinding (FRWD)

Since Command 0 (FERASE) and Command 4 (FEDIT) are active to initiate this operation, the ID Burst (FID) and Corrected Error (FCER) lines are initially asserted. In subsequent commands, however, any combination of command lines may be activated with each assertion of FGO, with resulting output on the status lines. The subsystem remains in this diagnostic mode until Formatter Enable (FFEN) is dropped (subsystem reset). To enable FRDY, pulse FOFL between GO pulses (do not hold FOFL active).  
 .change  
 off

### 5.6.5 Data Loopback (1111)

This operation wraps diagnostic write data back to the read bus with no tape motion. Data is transferred (via the Data Write Strobe -FDWDS- request) until Last Word (FLWD) is asserted. Following each FDWDS, a Data Read Strobe (FRSTR) transfers an identical data byte back to the coupler on the read data lines. If even parity is detected on the write data lines, it is regenerated on the Read Bit P (FRDP) line, allowing host verification of the parity checking circuits.

### 5.6.6 Read Extended Sense (11101)

This command allows the reading of status specifically for use by an external diagnostic package. This command is normally issued following the invocation and completion of internal diagnostics via the Invoke Diagnostics command. This command transfers 56 status bytes with normal Read Sense command protocol. The sense bytes are summarized in Table 5-11 and explained below.

Table 5-11. Diagnostic Sense Bytes Summary

SENSE BYTES	SENSE BYTE DEFINITION
DSB0	Microcode revision (MSBs)
DSB1	Microcode revision (LSBs)
DSB2	Last internal diagnostic executed
DSB3	Return code from last diagnostic
DSB4-7	Reserved
DSB8-23	Status A-0 through A-F (16 bytes)
DSB24-39	Status B-0 through B-F (16 bytes)
DSB40-55	Status C-0 through C-F (16 bytes)

## 5.7 DETAILED DIAGNOSTIC SENSE BYTES DESCRIPTION

The Read Extended Sense command can retrieve the 56 sense bytes summarized in Table 5-11 above, and explained in the following paragraphs.

### 5.7.1 DSB0 and DSB1 Description

These two sense bytes together indicate the operational and diagnostic code level installed in the MTS. DSB0 holds the Most Significant Bits (MSBs) and DSB1 holds the Least Significant Bits (LSBs).

### 5.7.2 DSB2 and DSB3 Description

These two sense bytes together may be used to reconstruct the Fault Code Dictionary specific fault code by the following formula:

$$\text{3-digit fault code} = (\text{DSB2} \times 10 \text{ hex}) + \text{DSB3}$$

For example, when DSB2 = 32 and DSB3 = 11, the specific fault code is calculated as follows:

$$\begin{array}{r} 32 \text{ hex} \times 10 \text{ hex} = 320 \text{ hex} \\ \text{PLUS} \\ \quad \quad \quad \underline{11 \text{ hex}} \\ \text{results in a} \quad \quad \quad \underline{331 \text{ hex}} \text{ specific fault code} \end{array}$$

This fault code is the same as appears on the operator panel during machine operation.

### 5.7.3 DSB8 Through DSB55 Description

These sense bytes hold status information bytes identified in the Fault Code Dictionary as A-0 through C-F. Each information byte (A-0, A-1, etc.) is located in a specific sense byte identified in Table 5-12.

For example, if there is a reference in the Fault Code Dictionary to 'Status A-8: Data Checks' this refers (according to Table 5-12) to Sense Byte 16, where additional data pertinent to this error condition is stored. The type of additional information stored in A-0 through C-F depends on the type of error encountered.

Table 5-12. A-0 Through C-F Sense Bytes Cross Reference

STATUS CODE	SENSE BYTE	STATUS CODE	SENSE BYTE	STATUS CODE	SENSE BYTE
A-0	8	B-0	24	C-0	40
A-1	9	B-1	25	C-1	41
A-2	10	B-2	26	C-2	42
A-3	11	B-3	27	C-3	43
A-4	12	B-4	28	C-4	44
A-5	13	B-5	29	C-5	45
A-6	14	B-6	30	C-6	46
A-7	15	B-7	31	C-7	47
A-8	16	B-8	32	C-8	48
A-9	17	B-9	33	C-9	49
A-A	18	B-A	34	C-A	50
A-B	19	B-B	35	C-B	51
A-C	20	B-C	36	C-C	52
A-D	21	B-D	37	C-D	53
A-E	22	B-E	38	C-E	54
A-F	23	B-F	39	C-F	55

Table 5-12. Reject Codes (Sheet 2 of 2)

REJECT CODE (HEX)	DESCRIPTION
13	A backward type command (except a Rewind or a Rewind/Unload command) was given, but tape was already positioned at BOT.
14*	The ARA BURST portion of the GCR ID burst just written did not have all nine tracks active.
15*	An IBG longer than 25 feet in PE mode or longer than 15 feet in GCR mode was detected on a Read or Space command.
16	More than one speed change requested without an intervening motion command.
17	Reserved
18*	The MTS is not in the recording density selected.
19	LWR attempted when tape loaded and positioned off BOT
1A*	No tape motion.
1B*	During a read back check of a write operation, data was detected in an IBG area.
1C	Reserved
1D*	The MTS attempted to backspace over a bad record just written but was unable to detect the record.
1E*	The ARA ID burst was unreadable during a GCR Write command.
1F*	During the read back check of a Write or Write Tape Mark command, no data was detected.
* Operation Incomplete is also set (sense byte 4, bit 6).	

Table 5-13. Read Controller Sense (Sheet 1 of 2)

BYTE NUMBER	BIT DEFINITIONS							
	7	6	5	4	3	2	1	0
<b>BYTES 0 - 5: Error Recovery Information For Read/Write Errors</b>								
0	X	X	X	X	X	X	CACHE DATA MODE	SYNC MODE
1	WRITE ERROR	READ ERROR	DT PARITY	POSITION Lost	RETRY Bit 3	RETRY Bit 2	RETRY Bit 1	RETRY Bit 0
2	Number of Records which remain in the Buffer (may include a tape mark)							
3	Record Number from BOT in error MSB (includes Tape Marks)							
4	Record Number from BOT in error							
5	Record Number from BOT in error LSB							
<b>BYTES 6 - 9: Status Information At The Time Of First Error</b>								
6	Dead Tracks 7-0 at time of first Write or Read Retry							
7	EOT STATUS	BOT PARITY	CACHE PARITY ERROR	DATA CHECK	DRIVE BUPER	OVER-RUN	REJECT	EPROM ERROR
8	WTM CHECK	UCE	PARTIAL RECORD	MTE	CRC ERROR	EDC	VEL ERROR	CACHE CRC ERROR
9	Diagnostic Aid Bits at time of 1st Write or Read Retry							

Table 5-13. Read Controller Sense (Sheet 2 of 2)

BYTE NUMBER	BIT DEFINITIONS
<b>BYTES 10-31: Error History Since The Last Unload Or SNS Command</b>	
10	Read Forward Retry count since last unload or SNS
11	Read Backward Retry count since last unload or SNS
12	Write Retry Count since last unload or SNS
13	Number of Records which had Read Retries
14	Number of Records which had Write Retries
15	Track 0 Errors (Number of records with Track 0 dead)
16	Track 1 Errors (Number of records with Track 1 dead)
17	Track 2 Errors (Number of records with Track 2 dead)
18	Track 3 Errors (Number of records with Track 3 dead)
19	Track 4 Errors (Number of records with Track 4 dead)
20	Track 5 Errors (Number of records with Track 5 dead)
21	Track 6 Errors (Number of records with Track 6 dead)
22	Track 7 Errors (Number of records with Track 7 dead)
23	Track P Errors (Number of records with Track P dead)
24	CRC Error Count since last unload or SNS
25	Uncorrectable Error Count since last unload or SNS
26	Partial Record Count since last unload or SNS
27	Multiple Track Error Count since last unload or SNS
28	End of Data Check Count since last unload or SNS
29	Velocity Error Count since last unload or SNS
30	Cache CRC Error Count since last unload or SNS
31	Number of records successfully corrected (Corrected Error without Data Check)

## 5.6 INTERNAL DIAGNOSTICS

The subsystem diagnostic package includes an 18-key front panel diagnostic keypad (as shown in Figure 2-1 and Figure 2-2), a four-digit hexadecimal display, and a permanently resident library of diagnostic routines available for diagnosis and repair of machine faults. The keypad functions are available whenever the subsystem is offline. These functions include memory-space examination and modification, and diagnostic routine execution.

A subset of the routine library is automatically executed each time power is applied to the subsystem. The remaining tests (or any of the power-up diagnostics) may be executed individually or, more typically, as a group in a sequential "continue" mode.

Any fault detected, whether it be the result of a power-up test or one initiated from the panel, results in the display of a three-digit hexadecimal code. This code relates to the failure and can be found in the Fault Code Dictionary, Industry Standard Interface, PN 87004. The Fault Code Dictionary describes the failure and indicates one or more field replaceable units (FRUs) that are possible causes of the failure.

## 5.7 EXTERNAL DIAGNOSTICS

In addition to the library of internal diagnostic routines, microcode support is included to aid in the automation of fault diagnosis and the detection of faults within the system-subsystem interface. Minimal user software support is required to initiate these functions and analyze results. These commands are beyond the normal operational requirements of most couplers and, therefore, may require some hardware/software modification.

### 5.7.1 Diagnostic Commands

Table 5-14 below lists those commands which may be invoked by a host resident diagnostic package. All diagnostics CMS are run in SYNC mode.

#### 5.7.1.1 INVOKE DIAGNOSTICS

This command allows the host to invoke the resident diagnostics and specify run-time options. It requires a 2-byte "write" transfer to completely define the operation. Formatter Busy (FFBY) and Data Busy (FDBY) remain asserted throughout the 2-byte transfer and the subsequent diagnostic execution. The 2 bytes transferred define the operation (1st byte) and options (2nd byte) as follows:

1st byte = 01 Hex: Run complete diagnostic package



Table 5-14. Diagnostic Commands

Command	CMD-4 (FEDIT)	CMD-3 (FREV)	CMD-2 (FWRT)	CMD-1 (FWFM)	CMD-0 (FERASE)
Invoke Diagnostics	0	1	1	0	0
Loop Write To Read	0	1	1	1	1
Initiate Status Sequencer	1	0	0	0	0
Command-To-Status Wrap	1	0	0	0	1
Read Extended Sense	1	1	1	0	1
Data Loopback	1	1	1	1	1

(unloads drive)

02 Hex: Run "loaded" diagnostic sub-package

2nd byte = 00 Hex: No option (all other values reserved)

#### 5.7:1.1.1 Run Diagnostic Package (Byte 1 = 01 Hex)

This operation invokes the execution of all internal diagnostics except the memory test. Formatter Busy (FFBY) resets when tests are completed or an error is detected. At this time status may be retrieved to determine completion status.

#### 5.7.1.1.2 Run "Loaded" Diagnostic Sub-Package (Byte 1 = 02 Hex)

This operation invokes the execution of all diagnostics executable on a loaded transport. This includes Loop Write To Read, Transport, and Read/Write diagnostics. Formatter Busy (FFBY) resets when tests are completed or an error is detected. At this time, status may be retrieved to determine completion status

#### 5.7.1.2 LOOP WRITE TO READ

The Loop Write To Read (LWR) command operations provide a means of testing the read and write data circuit paths within the MTS. Write data is transferred over the interface in the same way that a Write command is transferred. Read signals are derived (looped) within the MTS from the write circuits. There is no tape motion. LWR is not allowed if tape is loaded and positioned

away from BOT. Errors, if any, are reported in the same way as the errors that occur during a Write command execution.

### 5.7.1.3 INITIATE INTERFACE STATUS SEQUENCER

This operation initiates a status assertion sequence. Initially all status is reset. Each subsequent assertion of the Go (FGO) command results in a single status line being set (in addition to MTS Online, FONL) and Formatter Busy (FFBY) being reset. The order of status assertion is:

FGO Assertion	Status Asserted
Initial	None
2	FID
3	FDBY
4	FHER
5	FFMK
6	FCER
7	FEOT
8	FLDP
9	FFPT
10	FHSPD
11	FGCR
12	FRDY
13	FRWD
14	Normal (No action on command)

To complete this test the user may either issue the 14th FGO (the command sent with FGO will not be performed) or reset the subsystem by dropping Formatter Enable (FFEN). It is important that the subsystem be reset in case testing stops in mid-sequence.

### 5.7.1.4 COMMAND-TO-STATUS WRAP

This operation initiates a continuous wrapping of incoming command lines to outgoing status. This will allow the host to verify functionality command lines via the above tested status. The transfer of Command-To-Status will occur following each Go (FGO) command and is completed when Formatter Busy (FFBY) is reset. The mapping is as follows:

Command Line	Status Asserted
CMD-0 (FERASE)	FID
CMD-1 (FWFM)	FDBY
CMD-2 (FWRT)	FHER
CMD-3 (FREX)	FFMK
CMD-4 (FEDIT)	FCER
CMD-5 (FLGAP)	FLDP
CMD-6 (FHISP)	FFPT
CMD-7 (Spare 1, RTHR)	FHSPD

Spare 2 (FLOL)  
FOFL  
FREW

FGCR  
FRDY  
FRWD

Since CMD-0 and CMD-4 are active to initiate this operation, the first status lines to go active will be Identification Burst (FID) and Corrected Error (FCER). Following this state, any combination of command lines may be activated with each assertion of FGO. The subsystem remains in this diagnostic mode until it is reset (Formatter Enable, FFEN unasserted).

#### 5.7.1.5 DATA LOOPBACK

This operation involves wrapping diagnostic "write" data (no tape motion) back to the Read Bus. Data is transferred (via Demand Write Data Strobe, FDWDS, requests) until Last Word (FLWD) is asserted. As a result of each Demand Write Data Strobe (FDWDS), a Read Data Strobe (FRSTR) will transfer an identical data byte back to the coupler on the Read Data lines (FRDO-7, FRDP). If even parity is detected on the Write Data lines (FWDO-7, FWDP), it is regenerated on the FRDP line, allowing host verification of parity checking circuits.

#### 5.7.1.6 READ EXTENDED SENSE

The Read Extended Sense command allows the reading of status specifically for use by an external diagnostic package. This command is normally issued following the invocation and completion of internal diagnostics (previously described in the section entitled "Invoke Diagnostics" in this chapter). The status returned includes that referred to as Status A, B, and C in the Fault Code Dictionary, Industry Standard Interface, PN 87004. This status provides additional information about a failure and in some cases, together with the Fault Code Dictionary, helps to isolate the failing subsystem assembly.

The microcode revision level is also returned. This indicates the proper level Fault Code Dictionary to use.

This command transfers, with a normal Read Sense protocol and timing, 56 status bytes in the following order:

Byte	Contents
0	Microcode revision (MSB)
1	Microcode revision (LSB)
2	Last internal diagnostic executed
3	Return code from last diagnostic
4	Reserved
5	Reserved
6	Reserved

7	Reserved
8-23	Status A-0 thru A-F
24-39	Status B-0 thru B-F
40-55	Status C-0 thru C-F

A return code (byte 3) of non-zero, indicates the detection of a fault. A completion code equivalent to those displayed on the panel and applicable to the Fault Code Dictionary, Industry Standard Interface, PN 87004 may be constructed by using the following algorithm:

$$\text{Fault Code (3 hex digits)} = (\text{byte 2} \times 10 \text{ hex}) + (\text{byte 3})$$

## 5.8 EFFECTIVITY

The effectiveness of the 2920 MTS diagnostic system is measured in terms of detection and isolation.

A subsystem fault is considered detected if a fault code is returned, either through the interface or displayed on the front panel, or if the problem is obviously apparent to a minimally trained operator (for example, no front panel response). The percentage of single faults detectable is 80% by the internal package and 92% by the external package.

A subsystem fault is considered isolated if the returned fault code indicates (via the Fault Code Dictionary, Industry Standard Interface, PN 87004) the proper field replaceable unit (FRU) within the first three entries. The percentage of detectable single faults that will be isolated is 85% for both internal and external packages.

SEPARATOR SET PN 83464

THIS SEPARATOR SET CONTAINS 19  
TABS TOTAL IN THE FOLLOWING  
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MAINTENANCE MANUAL

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IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD

# CHAPTER 6

## SMALL COMPUTER SYSTEMS INTERFACE

### 6.1 PHYSICAL AND ELECTRICAL DESCRIPTIONS

#### 6.1.1 Interface Circuits

The 2925 MTS (MTS) is available to interface with either of the Small Computer System Interface (SCSI) driver/receiver alternatives. The MTS's SCSI interface board is available with either single-ended or differential drivers and receivers.

##### 6.1.1.1 SINGLE-ENDED ALTERNATIVE

The MTS uses the NCR-8310 driver/receiver circuit for the single-ended alternative.

Unasserted (ZERO) = 2.5 - 5.25 vdc  
Asserted (ONE) = 0.0 - 0.4 vdc

##### 6.1.1.2 DIFFERENTIAL ALTERNATIVE

The MTS uses National DS3695 or TI 75F165 differential driver/receiver circuits for the differential alternative.

Low-level output = 2.0 vdc max.  
High-level output = 3.0 vdc min.  
Differential voltage = 1.0 vdc min.

#### 6.1.2 Interface Cables

Devices on the SCSI bus are daisy-chained together using a common cable(s) as shown in Table 6-1. The bus must be terminated at both ends. The cable can be either 50-conductor flat or 25-signal twisted-pair. Shielded cable is recommended for intercabinet connection and noisy environments. A maximum cable length of 6 meters is allowed for the single-ended interface. The maximum cable length for the differential interface is 25 meters.

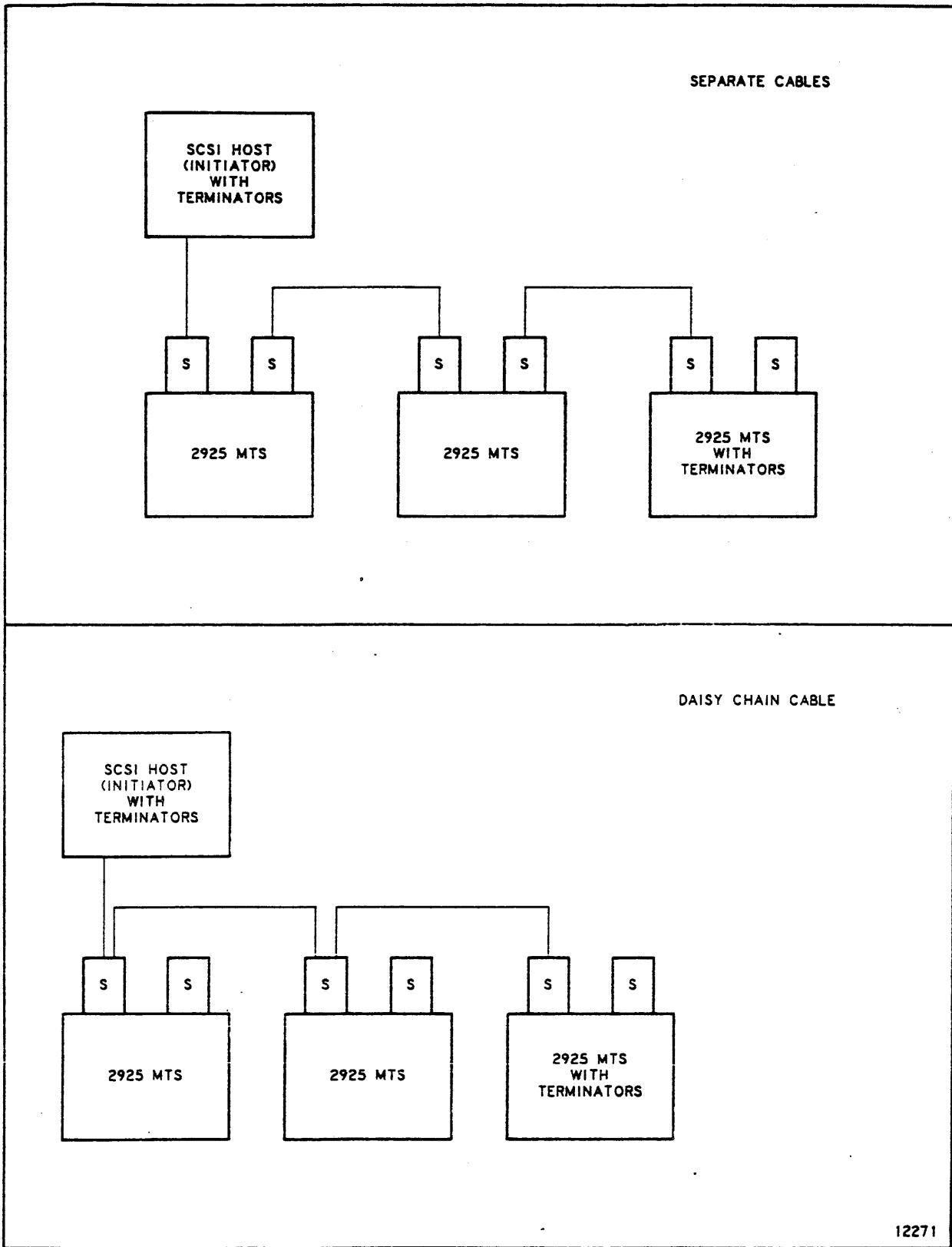


Figure 6-1. 2925 MTS SCSI Bus Cabling

### 6.1.3 SCSI Interface Connector

The MTS uses the SCSI nonshielded 2X25 (50 pin) connector. Two connectors are located on the motherboard. The connectors are connected in parallel to allow daisy-chaining separate SCSI cables.

The pin assignments for the single-ended and differential type interfaces are shown in Tables 6-1 and 6-2.

Table 6-1. Single-Ended Pin Assignments

Signal	Pin Number
-DB(0)	2
-DB(1)	4
-DB(2)	6
-DB(3)	8
-DB(4)	10
-DB(5)	12
-DB(6)	14
-DB(7)	16
-DB(P)	18
GROUND	20
GROUND	22
GROUND	24
TERMPWR	26
GROUND	28
GROUND	30
-ATN	32
GROUND	34
-BSY	36
-ACK	38
-RST	40
-MSG	42
-SEL	44
-C/D	46
-REQ	48
-I/O	50

#### NOTE

All odd pins except pin 25 are connected to ground. Pin 25 is open. The minus sign next to the signals indicates active low.



Table 6-2. Differential Pin Assignments

Signal Name	Pin Number	Pin Number	Signal Name
SHIELD GROUND	1	2	GROUND
+DB(0)	3	4	-DB(0)
+DB(1)	5	6	-DB(1)
+DB(2)	7	8	-DB(2)
+DB(3)	9	10	-DB(3)
+DB(4)	11	12	-DB(4)
+DB(5)	13	14	-DB(5)
+DB(6)	15	16	-DB(6)
+DB(7)	17	18	-DB(7)
+DB(P)	19	20	-DB(P)
DIFFSENS	21	22	GROUND
GROUND	23	24	GROUND
TERMPWR	25	26	TERMPWR
GROUND	27	28	GROUND
+ATN	29	30	-ATN
GROUND	31	32	GROUND
+BSY	33	34	-BSY
+ACK	35	36	-ACK
+RST	37	38	-RST
+MSG	39	40	-MSG
+SEL	41	42	-SEL
+C/D	43	44	-C/D
+REQ	45	46	-REQ
+I/O	47	48	-I/O
GROUND	49	50	GROUND

NOTE

Shield ground is optional.

### 6.1.4 Interface Termination

The SCSI bus must be terminated at both ends with the correct termination network for the type of drivers/receivers used. The termination networks for the single-ended and differential alternatives are shown in Figures 6-2 and 6-3.

The single-ended termination can be installed on the MTS's SCSI interface board or a termination module can be plugged into the second SCSI cable connector on the motherboard. The differential terminator module can only be plugged into the cable connector on the motherboard.

The terminators are included with the MTS.

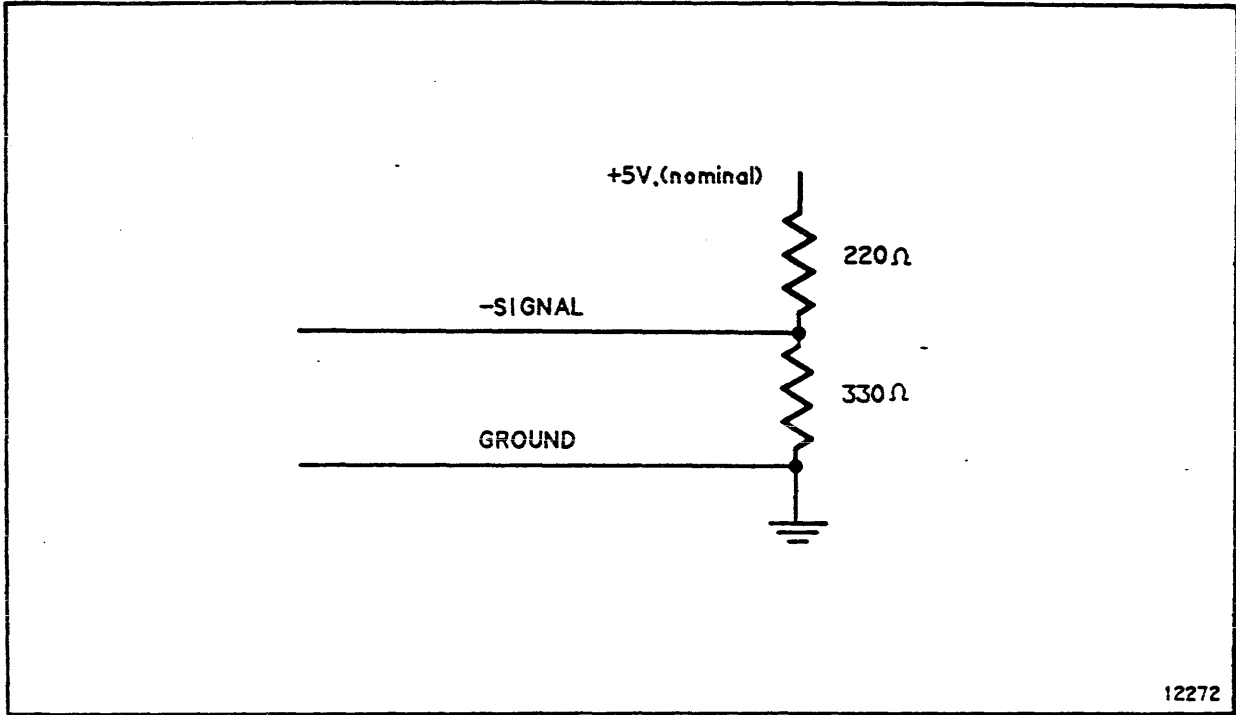


Figure 6-2. Termination for Single-Ended Devices

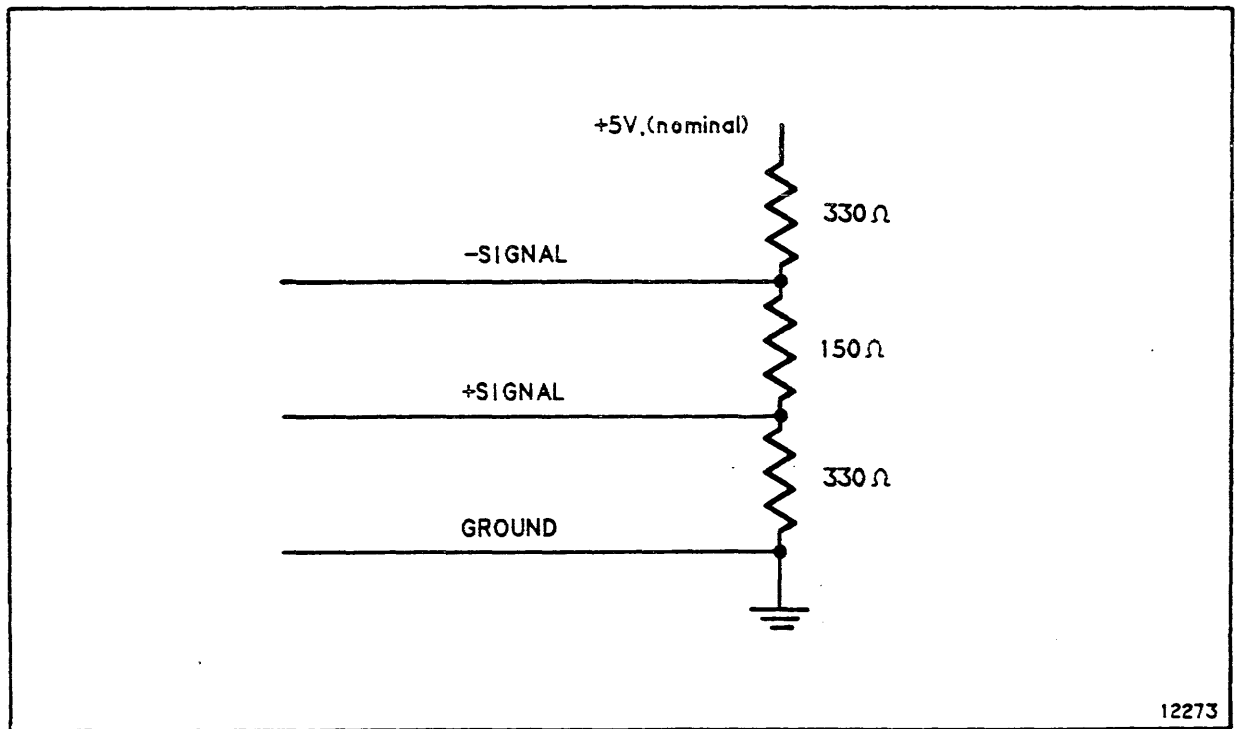


Figure 6-3. Termination for Differential Devices

## 6.1.5 Terminator Power

The MTS implements the terminator power (TERMPWR) option. When enabled, this option supplies power to the termination networks connected to the SCSI bus. This option is enabled by jumpers on the SCSI interface card. On the single-ended interface, a jumper can be installed to connect the +5 (nominal) vdc terminator power source to pin 26. On the differential interface, jumpers can be installed to connect the terminator power source to pin 25 and/or pin 26 as desired. The terminator power source is protected by a diode and fuse.

## 6.1.6 Differential Sense

The MTS implements the Differential Sense option. This option is enabled by a jumper on the differential interface board. When enabled, the DIFFSENS signal (pins 21 and 22) is connected to the differential driver enable logic. Connecting a single-ended device or terminator will ground this signal, preventing damage to the interface.

## 6.1.7 SCSI Device Address

A maximum of eight SCSI devices are allowed on the SCSI bus. Each has a unique SCSI ID or address. Each address is a single bit on the data bus. The SCSI device ID for the MTS is encoded in three switches on the interface board. The MTS is a single embedded controller and tape drive. Its Logical Unit Number (LUN) is always zero. The Logical Unit Number is not set by a switch.

## 6.1.8 Switch-Selectable Options

The following options can be enabled by switches or jumpers placed on the interface card:

- SCSI Bus ID
- Enable SCSI Bus Parity
- Connect TERMPWR to Pin 25
- Connect TERMPWR to Pin 26
- Enable DIFFSENS
- Disable Timeouts
- Report EOM on Read
- Disable GCR Write Correction
- Write Buffer Threshold
- Read Buffer Threshold
- Number of Write Retries
- Number of Read Retries
- Buffer Size After Early EOT
- Sync on 2 Filemarks

## 6.2 SCSI BUS SIGNALS

There are 18 SCSI bus signals. Nine are used for control and nine are used for data. (Data signals include the Parity Signal option.) These signals are described in the paragraphs that follow.

**Busy (BSY).** BSY is an "OR-tied" signal that indicates the bus is being used.

**Select (SEL).** The SEL signal is used by an initiator (host computer) to select the MTS or by the MTS to reselect an initiator.

**Control/Data.** The signal is driven by the MTS to indicate whether Control or Data information is on the data bus. If asserted it indicates control.

**Input/Output (I/O).** The I/O signal is driven by the MTS to control the direction of data movement on the data bus with respect to an initiator. Asserted indicates input to the initiator. This signal is also used to distinguish between Selection and Reselection phases.

**Message (MSG).** The MSG signal is driven by the MTS during the Message phase.

**Request (REQ).** The REQ signal is driven by the MTS to indicate a request for a REQ/ACK data transfer handshake.

**Acknowledge (ACK).** The ACK signal is driven by an initiator to indicate an acknowledgement for a REQ/ACK data transfer handshake.

**Attention (ATN).** The ATN signal is driven by an initiator to indicate the Attention condition.

**Reset (RST).** The RST signal is an OR-tied signal that indicates the Reset condition. The MTS does not drive this signal.

**Data Bus (DB 7-0,P).** The Data Bus consists of eight data-bit signals, plus a parity-bit signal. DB(7) is the most significant bit and has the highest priority during an Arbitration phase. Bit number, significance, and priority decrease downward to DB(0). A data bit is defined as ONE when the signal value is asserted and is defined as ZERO when the signal value is not asserted.

The use of parity is a system option. A system must be configured so that all SCSI devices on a bus generate parity and have parity detection enabled, or all SCSI devices have parity detection disabled or not implemented. SCSI bus parity (generation and detection) for the MTS is enabled by a switch on

the SCSI interface board. Parity is not valid during the Arbitration phase.

## 6.3 SCSI BUS PHASES

The SCSI architecture includes eight distinct phases. These phases are listed here and described in the paragraphs that follow.

- Bus Free Phase
- Arbitration Phase
- Selection Phase
- Reselection Phase
- Command Phase
- Data Phase
- Status Phase
- Message Phase

Refer to the ANSI X3.131-1986 Small Computer System Interface for a complete description of the SCSI bus signals and timing for each of the bus phases.

### 6.3.1 Bus Free Phase

The Bus Free phase is used to indicate that no SCSI device is actively using the the SCSI bus and that it is available for subsequent users.

### 6.3.2 Arbitration Phase

The Arbitration Phase allows one SCSI device to gain control of the SCSI bus so that it can assume the role of the initiator or target. The MTS uses the arbitration phase when reconnecting to continue a data transfer.

The MTS is designed for connection to arbitrating and non-arbitrating systems.

### 6.3.3 Selection Phase

The Selection phase allows an initiator to select the MTS to initiate some function (for example, a Read or Write command). The MTS is designed for connection to both arbitrating and non-arbitrating systems.

### 6.3.4 Reselection Phase

Reselection is an optional phase that allows the MTS to reconnect to an initiator to continue an operation that was previously started by the initiator but was suspended by the MTS. For example, the MTS may disconnect (by going to the Bus Free phase after sending a Disconnect Message) during the Data phase of a multiple Block Write command.

The MTS will not disconnect and reselect if an initiator is not capable, as communicated by the Identify message. Reselection can only be used in systems that have the Arbitration phase implemented.

### 6.3.5 Information Transfer Phases

The Command, Data, Status, and Message phases are grouped together as the Information Transfer Phases because they are all used to transfer data or control information via the data bus.

The C/D, I/O, and MSG signals are used to distinguish between the different information transfer phases as indicated in Table 6-3. The MTS drives these three signals and therefore controls all changes from one phase to another. The initiator can request a Message Out phase by asserting ATN.

Table 6-3. Information Transfer Phases

Signal			Phase Name	Direction of Transfer
MSG	C/D	I/O		
0	0	0	Data Out	Initiator to MTS
0	0	1	Data In	Initiator from MTS
0	1	0	Command	Initiator to MTS
0	1	1	Status	Initiator from MTS
1	1	0	Message Out	Initiator to MTS
1	1	1	Message In	Initiator from MTS
0 = Not Asserted, 1 = Asserted				

The information transfer phases use one or more REQ/ACK handshakes to control the information transfer. Each REQ/ACK handshake transfers one byte of information.

### 6.3.5.1 ASYNCHRONOUS INFORMATION TRANSFER

In asynchronous transfer mode a complete REQ/ACK handshake is used to transfer each byte of information. During a command, Data Out or Message Out phase the MTS requests a byte by asserting REQ. The initiator responds by placing a byte on the data bus and asserting ACK,. The MTS receives the byte and releases REQ. The MTS can not request the next byte until the initiator has released ACK.

During a Status, Data In, or Message In phase the MTS places a byte on the data bus and asserts REQ. The initiator receives the byte and asserts ACK. The MTS can then release REQ. The MTS can not transfer another byte until the initiator has released ACK.

### 6.3.5.2 SYNCHRONOUS DATA TRANSFER

Synchronous data transfer will be implemented for the Data In and Data Out phases at a later date. It will be used only after the transfer period and REQ/ACK offset have been agreed upon using an exchange of synchronous data transfer request messages.

## 6.3.6 Command Phase

The Command phase allows the MTS to request command information from the initiator. Commands are always transferred in asynchronous mode.

## 6.3.7 Data Phase

The Data phase includes both the Data In and the Data Out phases.

### 6.3.7.1 DATA IN PHASE

The Data In phase allows the MTS to request that data be sent to the initiator from the MTS.

### 6.3.7.2 DATA OUT PHASE

The Data Out phase allows the MTS to request that data be sent from the initiator to the MTS.

## 6.3.8 Status Phase

The Status phase allows the MTS to request that status information be sent from the MTS to the initiator.

## 6.3.9 Message Phase

The Message phase refers to either a Message In or Message Out phase. Multiple messages may be sent during either phase. Multiple-byte messages are wholly contained in a single message phase.

### 6.3.9.1 MESSAGE IN PHASE

The Message In phase allows the MTS to request that message(s) be sent to the initiator from the MTS.

### 6.3.9.2 MESSAGE OUT PHASE

The Message Out phase allows the MTS to request that message(s) be sent from the initiator to the MTS. The MTS invokes this phase in response to the Attention condition created by the initiator.

The MTS will handshake byte(s) in this phase until ATN is deasserted, unless an error occurs.

## 6.3.10 SCSI Bus Phase Sequences

The order in which phases are used on the SCSI bus follows a prescribed sequence.

In all systems, the Reset condition can abort any phase and is always followed by the Bus Free phase.

In systems where the Arbitration phase is not implemented, the allowable sequences are as shown in Figure 6-4. The normal progression is from the Bus Free phase to Selection, and from Selection to one or more of the information transfer phases (Command, Data, Status, or Message).

In systems where the Arbitration phase is implemented, the allowable sequences are as shown in Figure 6-5. The normal progression is from the Bus Free phase to Arbitration, from Arbitration to Selection or Reselection, and from Selection or Reselection to one or more of the information transfer phases (Command, Data, Status, or Message).

There are no restrictions on the sequences between information transfer phases. A phase type may even be followed by the same phase type, for example, a data phase may be followed by another data phase.



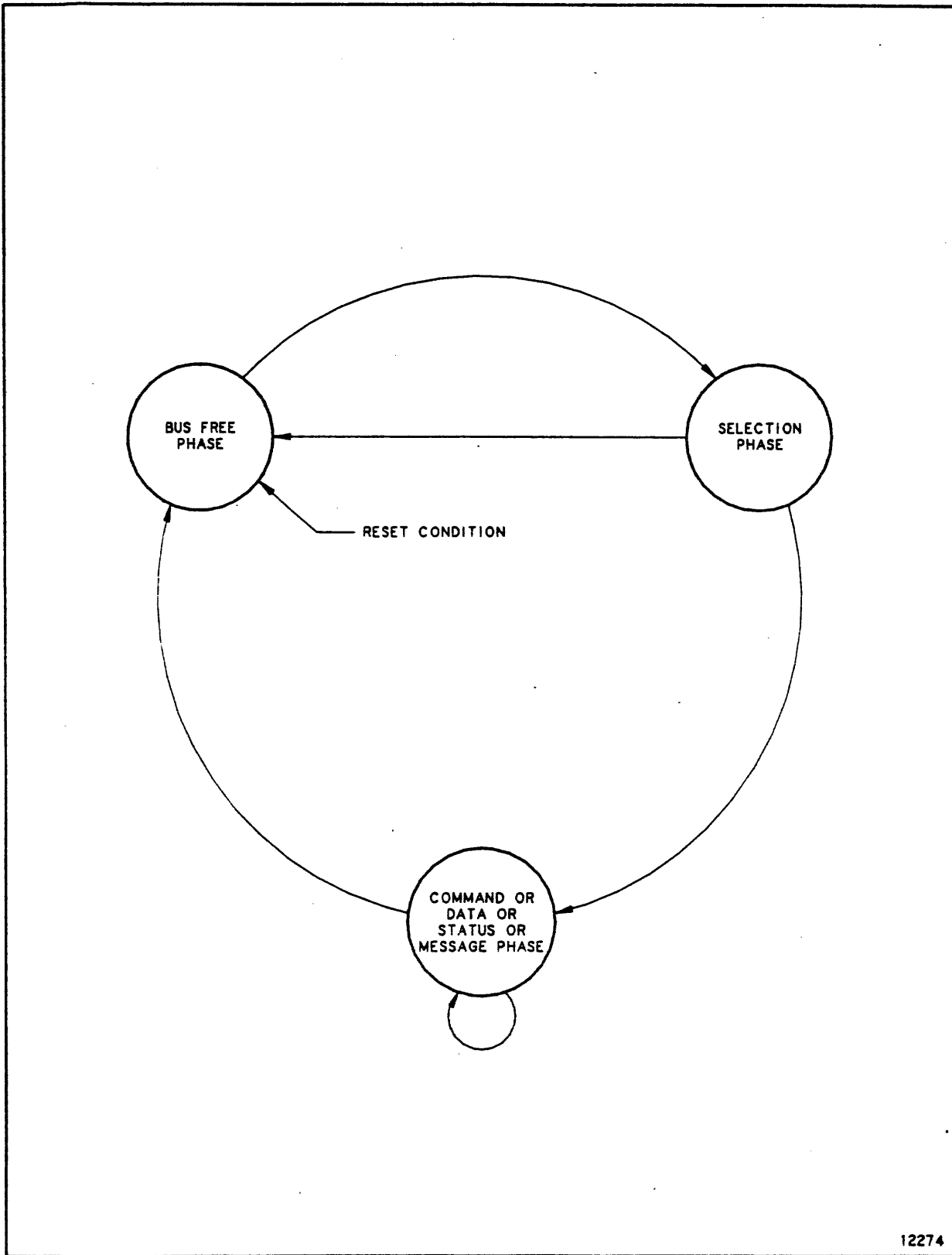


Figure 6-4. Phase Sequences without Arbitration

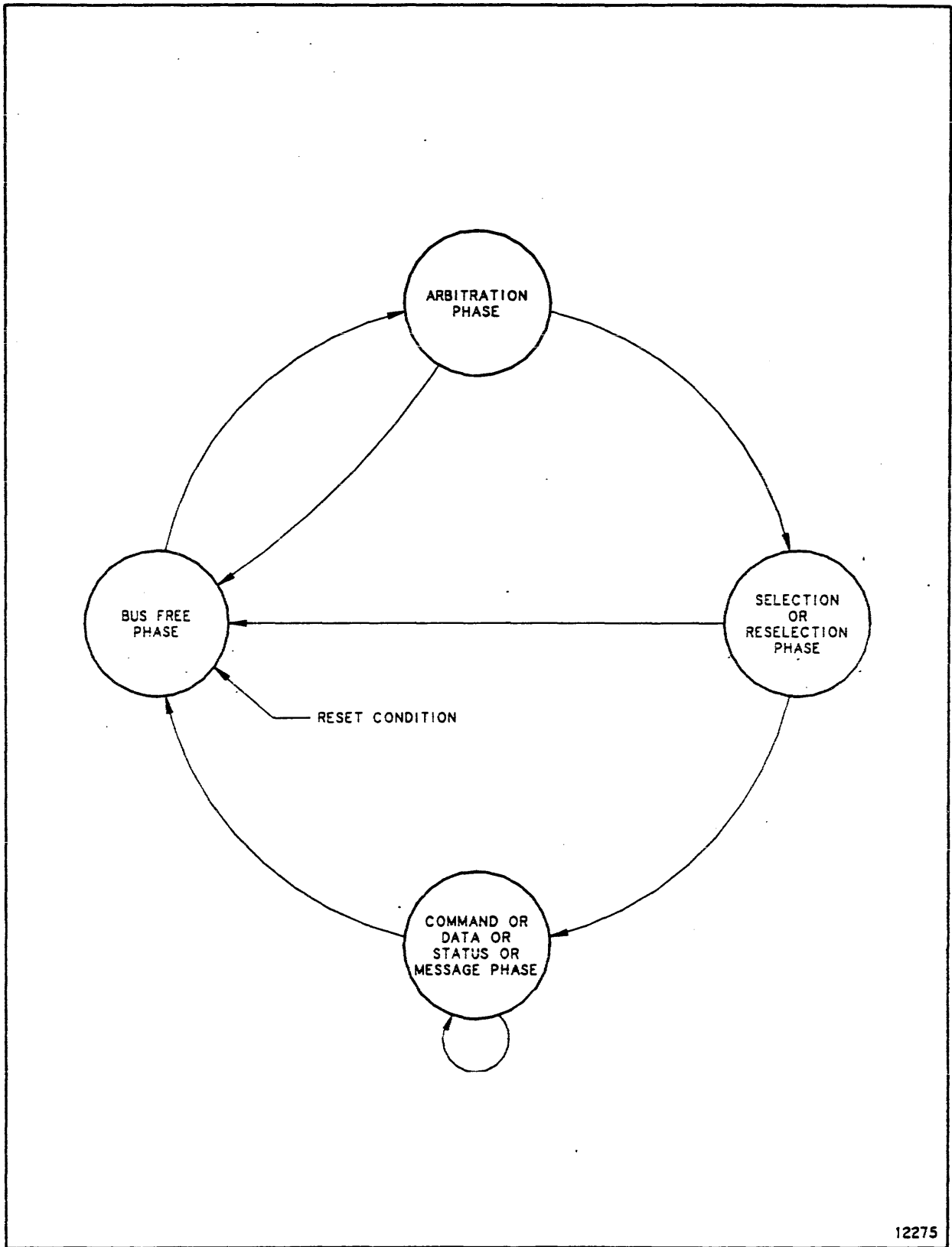


Figure 6-5. Phase Sequences with Arbitration

## 6.4 SCSI BUS CONDITIONS

The SCSI bus has two asynchronous conditions: the Attention condition and the Reset condition. These conditions cause the MTS to perform certain actions and can alter the phase sequence.

The Unit Attention condition is used to inform each initiator on the SCSI bus that the tape on the MTS may have been changed or that the MTS has been reset (by a Bus Device Reset message or a "Hard" Reset condition).

### 6.4.1 Attention Condition

The Attention condition allows an initiator to inform the MTS that the initiator has a message ready. The MTS receives this message by performing a Message Out phase. The initiator creates the Attention condition by asserting ATN at any time except during the Arbitration or Bus Free phase. The MTS responds with the Message Out phase. The initiator must keep ATN asserted if more than one byte is to be transferred.

### 6.4.2 Reset Condition

The Reset condition is used to clear all SCSI devices from the bus. This condition takes precedence over all other phases and conditions. Upon detecting the Reset condition (RST asserted), the MTS releases all SCSI bus signals and goes to Bus Free. The MTS will not generate a Reset condition.

The MTS implements the Hard Reset option. When RST is asserted the MTS clears all uncompleted commands, releases all SCSI device reservations, and returns all operating modes to their default values.

### 6.4.3 Unit Attention Condition

A Unit Attention condition for the MTS's logical unit begins for each initiator whenever the tape has been changed or the MTS has been reset (by a Bus Device Reset message or a "Hard" Reset condition). The tape could have been changed whenever the drive returns to the Online condition from Offline.

The MTS returns Check Condition status in response to any command other than an Inquiry or Request Sense from an initiator for which it has an outstanding Unit Attention condition. The command is not executed. If the next command (following the Check Condition) from that initiator is a Request Sense command, the Unit Attention sense key is set in the sense data returned

and the Unit Attention condition for that initiator is reset. If the next command (following the Check Condition status) from that initiator is not a Request Sense, the command is executed and the Unit Attention condition for that initiator is reset.

If an Inquiry command is received from an initiator for which the MTS has an outstanding Unit Attention condition (before Check Condition status has been reported to that initiator), the command is executed and the Unit Attention condition for that initiator is not reset.

If a Request Sense command is received from an initiator for which the MTS has an outstanding Unit Attention condition (before Check Condition status has been reported to that initiator), any pending sense data is discarded, Unit Attention sense key is returned in the sense data, and the Unit Attention condition for that initiator is reset.

## 6.5 SCSI MESSAGE SYSTEM

The message system allows communication between the initiator and MTS for the purpose of physical path management. The initiator indicates its ability to accommodate more than the Command Complete message by asserting the ATN signal during the Selection phase. The MTS indicates its ability to accommodate more messages by responding to the Attention condition with the Message Out phase after going through the Selection phase. The initiator responds by sending the Identify message. This allows the establishment of the physical path for a particular logical unit specified by the initiator.

The MTS will also accept an Abort message or the Bus Device Reset message instead of the Identify message as the first message. Only one logical unit number is identified for each selection sequence. After the reselection phase, the MTS' first message is an Identify. This allows the physical path to be reestablished for the MTS's specified logical unit number.

The messages implemented by the MTS are listed in Table 6-4 and described in the paragraphs that follow.

Table 6-4. Messages Implemented by the MTS

CODE	DESCRIPTION	DIRECTION
00H	COMMAND COMPLETE	IN
01H	EXTENDED MESSAGE (SYNCHRONOUS DATA TRANSFER REQUEST)	IN OUT
02H	SAVE DATA POINTER	IN
03H	RESTORE POINTERS	IN
04H	DISCONNECT	IN
05H	INITIATOR DETECTED ERROR	OUT
06H	ABORT	OUT
07H	MESSAGE REJECT	IN OUT
08H	NO OPERATION	OUT
09H	MESSAGE PARITY ERROR	OUT
0AH	LINKED COMMAND COMPLETE	IN
0BH	LINKED COMMAND COMPLETE (WITH FLAG)	IN
0CH	BUS DEVICE RESET	OUT
80H-FFH	IDENTIFY	IN OUT

Key: IN = MTS to initiator, OUT = Initiator to MTS.

### 6.5.1 Command Complete (00H)

This message is sent from the MTS to an initiator to indicate that the execution of a command (or series of linked commands) has terminated and that valid status has been sent to the initiator. The status byte indicates whether the command was executed successfully or unsuccessfully.

After successfully sending this message, the MTS will go to the Bus Free phase by releasing BSY.

### 6.5.2 Extended Message (01H)

This message is sent from either the initiator or the MTS as the first byte of a multiple byte message. The Synchronous Data Transfer Request message is the only extended message implemented by the MTS.

### 6.5.3 Save Data Pointer (02H)

This message is sent from the MTS to direct the initiator to save a copy of the present active data pointer for the currently attached logical unit. The Save Data Pointers message is sent by the MTS before disconnecting to break up long data transfers.

## 6.5.4 Restore Pointers (03H)

This message is sent from the MTS to direct the initiator to restore the most recently saved pointers (for the currently attached logical unit) to the active state. Pointers to the command, data, and status locations for the logical unit are restored to the active pointers. Command and status pointers are restored to the beginning of the present command and status areas. The data pointer is restored to the value at the beginning of the data area in the absence of a Save Data Pointer message or to the value at the point at which the last Save Data Pointer message occurred for that logical unit.

## 6.5.5 Disconnect (04H)

This message is sent from the MTS to inform an initiator that the present physical path is going to be broken (the MTS plans to disconnect by releasing BSY), but that a later reconnect will be required in order to complete the current operation. This message will not cause the initiator to save the data pointer. The MTS uses Disconnect messages to break a long data transfer into two or more shorter transfers. The Save Data Pointer is issued by the MTS before each Disconnect message.

## 6.5.6 Initiator Detected Error (05H)

This message is sent from an initiator to inform the MTS that an error (for example, parity error) has occurred. When the MTS receives this message, it will issue a Restore Pointers message or a disconnect followed by a reconnect to cause the pointers to be restored to their defined prior state and attempt to retransmit the data or status to the initiator.

## 6.5.7 Abort (06H)

This message is sent from the initiator to the MTS to clear the present operation. If a logical unit has been identified, all pending data and status for the issuing initiator from the effected logical unit will be cleared. The MTS will go to the Bus Free phase. Pending data and status for other initiators will not be cleared. If a logical unit has not been identified, the MTS goes to the Bus Free phase. No status or ending message is sent for the operation.

## 6.5.8 Message Reject (07H)

This message is sent from either the initiator or the MTS to indicate that the last message it received was inappropriate or has not been implemented.

In order to indicate its intentions of sending this message, the initiator will assert the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message that is to be rejected. When the MTS sends this message, it will change to Message In phase and send this message prior to requesting additional message bytes from the initiator. This provides an interlock so that the initiator can determine which message is rejected.

### 6.5.9 No Operation (08H)

This message is sent from an initiator in response to the MTS's request for a message when the initiator does not currently have any other valid message to send.

### 6.5.10 Message Parity Error (09H)

This message is sent from the initiator to the MTS to indicate that one or more bytes in the last message it received had a parity error.

In order to indicate its intentions of sending this message, the initiator asserts the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message that has the parity error. This provides an interlock so that the MTS can determine which message has the parity error. The MTS will go to the Message In phase and retransmit the message that had the parity error.

### 6.5.11 Linked Command Complete (0AH)

This message is sent from the MTS to an initiator to indicate that the execution of a linked command has completed and that status has been sent. The initiator will then set the pointers to the initial state for the next linked command. Following this message, the MTS will go directly to the command phase rather than going to Bus Free.

### 6.5.12 Linked Command Complete With Flag (0BH)

This message is sent from the MTS to an initiator to indicate that the execution of a linked command (with the flag bit set to One) has completed and that status has been sent. The initiator shall then set the pointers to the initial state of the next linked command. Typically this message would be used to cause an interrupt in the initiator between two linked commands. Following this message, the MTS goes directly to the command phase to receive the next command rather than going to Bus Free.

### 6.5.13 Bus Device Reset (OCH)

This message is sent from an initiator to direct the MTS to clear all current commands. This message forces the MTS to an initial state with no operations pending for any initiator. Upon recognizing this message, the MTS goes to the Bus Free phase.

### 6.5.14 Identify (80H to FFH)

These messages are sent by either the initiator or the MTS to establish the physical path connection between an initiator and the MTS for a particular logical unit.

**Bit 7.** Bit 7 is always set to one to distinguish these messages from the other messages.

**Bit 6.** Bit 6 is only set to one by the initiator. When set to one, it indicates to the MTS that the initiator has the ability to accommodate disconnection and reconnection.

**Bits 5 to 3.** Bits 5 to 3 are set to zero.

**Bits 2 to 0.** Bits 2 to 0 specify a logical unit number (LUN) in the MTS. The LUN must be 0H for the MTS. Only one LUN can be identified for each selection sequence; a second Identify message with a new LUN must not be issued before the bus has been released (Bus Free phase).

When sent from the MTS to an initiator during reconnection, an implied Restore Pointers message must be performed by the initiator prior to completion of this message.

### 6.5.15 Extended Messages

A value of 01H in the first byte of a message indicates the beginning of a multiple byte extended message. The Synchronous Data Transfer Request message is the only extended message that will be implemented on the MTS. This message is described in Table 6-5. The Synchronous Data Transfer Request message will be implemented at a later date.

## 6.6 SCSI BUS ERROR RECOVERY

The MTS automatically retries a Message Out, Command, or Data Out phase when it detects a SCSI bus parity error during these phases. The MTS will retry a Message In, Status, or Data In phase when requested by an initiator.



Table 6-5. Synchronous Data Transfer Request

Byte	Value	Description
0	01H	Extended Message
1	03H	Extended Message Length
2	01H	Synchronous Data Transfer Request Code
3	mH	Transfer period (mH times 4 nanoseconds)
4	xH	REQ/ACK offset

### 6.6.1 Message Out Parity Error

If the MTS detects a parity error during a Message Out phase, it will assert REQ after detecting that ATN has been deasserted, and remain in the Message Out phase. The initiator is expected to respond by resending the entire message. The MTS will change to some other information phase and transfer at least one byte to indicate that it has received the message without error or it does not want to retry again. If the message is an Abort or Bus Device Reset message, it will go to Bus Free. The MTS will retry a Message Out phase five times before aborting the command by returning Check Condition status and setting Aborted Command sense key.

### 6.6.2 Message In Parity Error

If the initiator detects a parity error on the SCSI bus during a Message In phase, it may indicate its desire to retry the message by sending the MTS a Message Parity Error message. The initiator must assert the ATN signal prior to releasing ACK for the REQ/ACK handshake for the message that has the parity error. The MTS will go to a Message Out phase and receive the Message Parity Error message from the initiator. The MTS will then return to the Message In phase and repeat the message. The MTS will retry as many times as requested by the initiator.

### 6.6.3 Information In Parity Error

The initiator may send an Initiator Detected Error message if it has detected a parity error during a Data In or Status phase. The initiator must assert ATN before negating ACK for the last byte of the phase to be retried. The MTS will send a Restore Pointers message to the initiator and retry the phase. For a Data In phase the data transfer will restart from the beginning of the phase or from the point of the last Save Pointers message. The MTS will retry a Data In or Status phase as many times as requested by the initiator.

## 6.6.4 Information Out Parity Error

If the MTS detects a SCSI Bus Parity error during a Command or Data Out phase it will go to the Message In phase and send a Restore Pointers message to the initiator. The initiator should then resend the entire command or the data starting from the last point at which the pointers were saved. The MTS will retry a Command or Data Out phase 5 times before returning Check Condition status and setting the Aborted Command sense key in sense data.

## 6.7 SCSI STATUS

A status byte is sent from the MTS to the initiator during the Status phase at the termination of each command unless the command is cleared by an Abort message, by a Bus Device Reset message, or by a "Hard" Reset condition. The status byte is defined in Table 6-6. A description of the status codes returned by the MTS is given below.

Table 6-6. Status Bytes

Bit Byte	7	6	5	4	3	2	1	0
0	Res'd	Vendor Unique		Status Byte Code				VU

### 6.7.1 Good (00H)

This status indicates that the MTS has successfully completed the command.

### 6.7.2 Check Condition (02H)

This status indicates that the command terminated with an error, exception, or abnormal condition that has set sense data. The Request Sense command should be issued following a Check Condition status to determine the nature of the condition.

### 6.7.3 Busy (08H)

The MTS is busy. This status is returned whenever the MTS is unable to accept a command from an initiator. The normal initiator recovery action is to issue the command again at a later time.

## 6.7.4 Intermediate (10H)

This status is returned for every command in a series of linked commands (except the last command), unless an error, exception, or abnormal condition causes a Check Condition status or a Reservation Conflict status to be set. If this status is not returned, the chain of linked commands is broken; no further commands in the series are executed.

## 6.7.5 Reservation Conflict (18H)

This status is returned whenever a SCSI device attempts to access the MTS while it is reserved to another SCSI device.

## 6.8 SCSI COMMANDS

The SCSI commands implemented by the MTS are listed in Table 6-7. The sections that follow contain a detailed description of the operation of each command.

The reserved fields in each command descriptor block must be set to zero. If a reserved field is not equal to zero, the MTS will reject the command by returning Check Condition status and setting Illegal Request sense key. The MTS does not support any vendor unique fields in the command descriptor block. The vendor unique fields must also be set at zero.

Table 6-7. SCSI Commands

OPERATION CODE	COMMAND NAME
00H	TEST UNIT READY
01H	REWIND
03H	REQUEST SENSE
05H	READ BLOCK LIMITS
08H	READ
0AH	WRITE
0FH	READ REVERSE
10H	WRITE FILEMARKS
11H	SPACE
12H	INQUIRY
13H	VERIFY
14H	RECOVER BUFFERED DATA
15H	MODE SELECT
16H	RESERVE UNIT
17H	RELEASE UNIT
18H	COPY
19H	ERASE
1AH	MODE SENSE
1BH	LOAD/UNLOAD
1CH	RECEIVE DIAGNOSTIC RESULTS
1DH	SEND DIAGNOSTIC
3BH	WRITE BUFFER
3CH	READ BUFFER

### 6.8.1 Test Unit Ready Command (00H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Vendor Unique			Reserved			Flag	Link

The Test Unit Ready command checks the TU for its readiness to accept a medium access command without returning a Check Condition status. Good status is returned if the drive is loaded, ready, and online. Otherwise this command will return a Check Condition status. A self-test is not performed during this command.

## 6.8.2 Rewind Command (01H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved							
5	Vendor Unique		Reserved				Flag	Link

The Rewind command moves tape backwards until tape is positioned at BOT. The MTS disconnects from the SCSI bus after the rewind has started.

If the immediate bit (Immed) is ZERO, the MTS reselects the initiator to return status after the tape is positioned at BOT. If the immediate bit is set to ONE, status is returned after the rewind has been started. If the buffer contains any write data when the command is received, this data will be written to tape before the rewind is started.

### 6.8.3 Request Sense Command (03H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Vendor Unique		Reserved			Flag		Link

The Request Sense command transfers sense data to the initiator. A Request Sense command is usually issued by the initiator immediately following a command that reported a Check Condition status. The sense data describes in detail the reason for the Check Condition status and the current state of the MTS.

The sense data is valid if Check Condition status was returned on the prior command. The sense data may not be completely valid if the previous command did not report Check Condition status.

The sense data is preserved by the MTS until it is retrieved by a Request Sense command from the initiator that received the Check Condition status. If any command other than a Request Sense command is received from the initiator that received the Check Condition status, the sense data is cleared. All commands from other initiators will receive Busy status until the sense data is either returned by a Request Sense command to the initiator that received the Check Condition or is cleared by some other command from the initiator that received the Check Condition.

The allocation length specifies the number of bytes that the initiator has allocated for returned sense data. If the allocation length is ZERO no sense data will be transferred. Any other value indicates the maximum number of bytes that can be transferred. The MTS can return up to 116 bytes of sense data. The MTS will terminate the Data In phase when allocation length bytes have been transferred or when 116 bytes of sense data have been transferred to the initiator, whichever is less.

The Request Sense command returns Check Condition status only to report fatal errors for the Request Sense command. The following are definitions of two fatal errors:

1. The MTS returns Check Condition if the command descriptor block contains a nonzero reserved bit or an invalid Logical Unit Number (other than ZERO). No sense data is returned.

#### NOTE

Check Condition is returned if the MTS is unable to recover a parity error on the data bus after multiple retries.

If any nonfatal error is detected during the execution of the Request Sense command, the MTS will return the sense data with Good status. Following a fatal error on a Request Sense command, sense data may not be valid.

The MTS implements the extended sense data format only. The nonextended sense data format is not implemented. The MTS returns zero bytes of sense data in response to an allocation length of ZERO. This is not an error condition.

The MTS returns up to 116 bytes of Request Sense data in the nonextended format. The Request Sense data returned by the MTS is shown in Tables 6-10 thru 3-14.

The information contained in Request Sense bytes 0-19 is valid if a Check Condition was reported by the previous command. The current tape drive status (Bytes 20-27), the StorageTek cache sense (Bytes 28-59), and the StorageTek drive sense (Bytes 60-115) report the current state of the MTS. Since the buffer is capable of reading ahead, this information may not be accurate for the last command if a Check Condition was not reported.

The error class is set to 7H. The error code is set to 0H indicating that the sense data is in the extended sense format. The MTS always returns these values.

The information bytes are not defined if the valid bit is zero. If the valid bit is one, the information bytes contain valid information as follows:

1. The difference (residue) of the requested length minus the actual length in either bytes or blocks, as determined by the command. (Negative values are indicated by two's complement notation.)
2. The difference (residue) of the requested number of blocks minus the actual number of blocks copied for the current segment descriptor of a Copy command.



The segment number contains the number of the current segment descriptor if the extended sense is in response to a Copy command. Up to 256 segments are supported beginning with segment zero.

The filemark bit indicates that the current command has read a filemark. This bit is not set by a Write Filemark command.

The end-of-medium (EOM) bit indicates that the MTS has encountered an end-of-medium condition. This indicates that the MTS is at or past the early-warning end-of-tape (EOT marker) if the direction was forward or that the command could not be completed because beginning-of-tape (BOT) was encountered if the direction was reverse.

The incorrect length indicator (ILI) bit indicates that the requested block length did not match the block length of the data on the tape.

The sense keys provide information as to why the previous command received a Check Condition status. The sense keys are described in Tables 6-8 and 6-9. The Additional Sense Code (Sense Byte 12) and the Additional Sense Code Qualifier (Sense Byte 13) provide more detail as to why the previous command returned Check Condition status. The codes returned are grouped by the Sense Key they describe. The Additional Sense Code and Additional Sense Code Qualifier bytes are described in Table 6-15, sheets 1 thru 4.

Table 6-8. Sense Key (0H-7H) Descriptions

SENSE KEY	DESCRIPTION
0H	NO SENSE. Indicates that there is no specific sense key information to be reported for the designated logical unit. This sense key is returned for a successful command or a command that received a Check Condition status because one of the filemark, EOM, or ILI bits is set to ONE.
1H	RECOVERED ERROR. Indicates that the last command completed successfully with retry actions performed by the MTS. Additional information is contained in the information bytes and additional sense bytes.
2H	NOT READY. Indicates that the tape drive cannot be accessed. Operator intervention is usually required to correct this condition.
3H	MEDIUM ERROR. Indicates that the command terminated with a nonrecovered error condition that was probably caused by a flaw in the medium or an error in the recorded data.
4H	HARDWARE ERROR. Indicates that the MTS detected a nonrecoverable hardware failure while performing the command or during a self-test.
5H	ILLEGAL REQUEST. Indicates that there was an illegal parameter in the command descriptor block or in the additional parameters supplied as data for the command. A command with an illegal parameter in the command descriptor block is not executed. If an invalid parameter is detected in the additional parameters supplied as data, the command is terminated without altering the parameter values in the MTS. In all cases the tape is not altered nor is its position changed.
6H	UNIT ATTENTION. Indicates that the tape may have been changed or the MTS has been reset by the SCSI bus or the tape drive has been reset from the operator panel.
7H	DATA PROTECT. Indicates that a write-type command was attempted while the tape was file protected (file protect ring removed). The Write operation was not performed.

Table 6-9. Sense Key (8H-FH) Descriptions

SENSE KEY	DESCRIPTION
8H	BLANK CHECK. Indicates that the MTS encountered a blank area on tape while reading or spacing. The minimum length of blank tape required is dependent upon the density recorded.
9H	Vendor unique. This sense key is not used by the MTS.
AH	COPY ABORTED. Indicates a Copy command was aborted due to an error condition on the source device, the destination device, or both.
BH	ABORTED COMMAND. Indicates that the MTS aborted the command. The initiator may be able to recover by trying the command again.
CH	EQUAL This Sense Key is not used by the MTS.
DH	VOLUME OVERFLOW. Indicates that the MTS has reached the end-of-medium (EOT) and data remains in the buffer that has not been written to the tape. A Recovered Buffer Data command(s) may be issued to read the unwritten data from the buffer.
EH	MISCOMPARE. This Sense Key is not used by the MTS.
FH	This sense key is reserved and not used by the MTS.

The additional sense length specifies the number of additional sense bytes to follow. A value of 6CH is returned in this field indicating that up to 108 additional sense bytes are available. The additional sense bytes contain information unique to the MTS. These bytes describe the current status of the drive and the 256K byte cache buffer. They also contain error log data. This information further defines the reason for a Check Condition status on a previous command. If the allocation length of the command descriptor block is too small to transfer all of the additional sense bytes, the additional sense length is not adjusted to reflect the truncation.

The additional sense data returned for a Check Condition on a Copy command is described in the section describing the Copy command.

Table 6-10. Request Sense Data (Bytes 0-19)

BIT BYTE	7	6	5	4	3	2	1	0
0	Valid	Error Class			Error Code			
1	Segment Number							
2	Filemark	EOM	ILI	Reserved	Sense Key			
3	Information Byte (MSB)							
4	Information Byte							
5	Information Byte							
6	Information Byte (LSB)							
7	Additional Sense Length							
8-11	Reserved							
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14- 19	Reserved							

Table 6-11. Current Tape Drive Status (Bytes 20-27)

BIT BYTE	7	6	5	4	3	2	1	0
20	RAM EOT STATUS	RAM BOT STATUS	RAM END OF DATA	RAM DATA CHECK	RAM BUPER	RAM CORR ERR STATUS	RAM REJECT STATUS	RAM TAPE MRK STATUS
21	RAM WRITE STATUS	RAM READY STATUS	RAM EXPECT DATA	RAM ONLINE STATUS	RAM REWIND STATUS	RAM OPERATIN INCOMP	RAM OVERRUN STATUS	RAM EPROM PAR ERR
22	TAPE SSC	TAPE ID BURST	SCSI INTERRPT	CACHE CRC ERR	TAPE BUSY	TAPE HDENS	TAPE FPTS	TAPE EMUX P
23	RAM DEAD TRACKS 7-0							
24	WTM CHECK	UNCORREC ERROR	PARTIAL RECORD	MULTITRK ERROR	NOT USED	END OF DATA CHK	VELOCITY ERROR	DIAG MOD LATCH
25	DIAGNOSTIC AID BITS							
26	EOT STATUS	BOT STATUS	NOT USED	FILE PRT STATUS	BACKWARD STATUS	HIGH DEN STATUS	READY STATUS	ONLINE STATUS
27	RESET BUSY	CLR RESET	NOT USED	NOT USED	EMUX3 P WRT STAT	EMUX2 P TACH	EMUX1 P CRC ERR	EMUX0 P DT PAR

Table 6-12. StorageTek Cache Sense (Bytes 28-43)

BIT BYTE	7	6	5	4	3	2	1	0
28	NOT USED					EARLY EOT MODE	BUFFER DATA MODE	LONG REC MODE
29	WRITE ERROR	READ ERROR	DTP	POSITION LOST	RETRY COUNT ON SINGLE RECORD			
30	NUMBER OF RECORDS LEFT IN BUFFER							
31	NUMBER OF RECORDS PAST BOT (MSB)							
32	NUMBER OF RECORDS PAST BOT							
33	NUMBER OF RECORDS PAST BOT (LSB)							
34	DEAD TRACK REGISTER 7-0							
35	EOT	BOT	CACHE PARITY ERROR	DATA CHECK	DRIVE BUPER	OVRNS	REJECT	EPROM ERROR
36	WTM CHECK	UCE	PARTIAL RECORD	MTE	CRC ERROR	EDC	VEL ERROR	CACHE CRC ERROR
37	DIAGNOSTIC AID BITS							
38	NUMBER OF READ FORWARD RETRIES ATTEMPTED							
39	NUMBER OF READ BACKWARD RETRIES ATTEMPTED							
40	NUMBER OF WRITE RETRIES ATTEMPTED							
41	NUMBER OF RECORDS NEEDING READ RETRIES							
42	NUMBER OF RECORDS NEEDING WRITE RETRIES							
43	NUMBER OF RECORDS WITH DEAD TRACK 0							

Table 6-13. StorageTek Cache Sense (Bytes 44-59)

BIT BYTE	7	6	5	4	3	2	1	0
44	NUMBER OF RECORDS WITH DEAD TRACK 1							
45	NUMBER OF RECORDS WITH DEAD TRACK 2							
46	NUMBER OF RECORDS WITH DEAD TRACK 3							
47	NUMBER OF RECORDS WITH DEAD TRACK 4							
48	NUMBER OF RECORDS WITH DEAD TRACK 5							
49	NUMBER OF RECORDS WITH DEAD TRACK 6							
50	NUMBER OF RECORDS WITH DEAD TRACK 7							
51	NUMBER OF RECORDS WITH DEAD TRACK P							
52	NUMBER OF RECORDS WITH TAPE DRIVE CRC ERRORS							
53	NUMBER OF RECORDS WITH UNCORRECTABLE ERRORS							
54	NUMBER OF RECORDS WITH PARTIAL RECORD ERRORS							
55	NUMBER OF RECORDS WITH MTE ERRORS							
56	NUMBER OF RECORDS WITH EDC ERRORS							
57	NUMBER OF RECORDS WITH VELOCITY ERRORS							
58	NUMBER OF RECORDS WITH CACHE CRC ERRORS							
59	NUMBER OF RECORDS WITH CORRECTIONS							

Table 6-14. StorageTek Drive Sense (Bytes 60-115)

BIT BYTE	7	6	5	4	3	2	1	0
60	EOT	BOT	0	FILE PRT	BACKWARD STATUS	HIGH DEN STATUS	READY STATUS	ONLINE STATUS
61	1	1	1	GCR	1	0	SPD/DENS CAPABLY	
62	0	0	FP DENSITY SEL		SPEED/GAP SWITCH SELECTION			
63	MACHINE TYPE				DRIVE MICROCODE LEVEL (MSB)			
64	DRIVE MICROCODE LEVEL (LSB)							
65	IDENTIFIER FOR LAST DIAGNOSTIC TEST RUN							
66	RETURN CODE FROM LAST DIAGNOSTIC TEST RUN							
67	RESERVED							
68-83	DRIVE STATUS CODES A-0 THROUGH A-F							
84-99	DRIVE STATUS CODES B-0 THROUGH B-F							
100- 115	DRIVE STATUS CODES C-0 THROUGH C-F							



Table 6-15. Additional Sense Code Definitions  
 (Sense Bytes 12 and 13)  
 Sheet 1 of 4

Sense Key NO SENSE (0H)		
Byte # 12 13	Description	
00 00	No additional sense information	
00 01	File mark detected	
00 02	End of tape (EOT) detected	
00 04	Beginning of tape (BOT) detected	

Sense Key RECOVERED ERROR (1H)		
Byte # 12 13	Description	
17 00	Recovered read error	
17 01	Recovered read data with read retries	
17 04	Recovered read data with ECC correction	
18 00	Recovered write error	
18 01	Recovered write with write retries	

Sense Key NOT READY (2H)		
Byte # 12 13	Description	
04 00	Drive not ready (drive not loaded)	
05 00	Drive not selected (drive Offline)	

Table 6-15. Additional Sense Code Definitions  
 (Sense Bytes 12 and 13)  
 Sheet 2 of 4

Sense Key MEDIUM ERROR (3H)		
Byte # 12 13		Description
11	00	Unrecovered read error
11	01	Read retries exhausted
12	00	Unrecovered write error
12	01	Write retries exhausted
13	00	Error during Space command
14	00	No record found
15	00	Can not write tape ID Burst area
30	00	Can not read tape ID Burst area
30	01	Incompatible format
3C	00	Not at BOT (attempted density change)
3B	00	Tape position error
11	03	Incomplete block read
36	00	No Gap found

Sense Key HARDWARE ERROR (4H)		
Byte # 12 13		Description
03	00	Write Fault
03	01	No write current
08	00	Logical unit communication failure
0B	00	Time-error
0B	01	Read time-out error
0B	02	Drive communication error
1B	00	Synchronous transfer error
40	00	Diagnostic failure
40	02	RAM failure
40	04	Checksum error
42	00	Power-on failure
45	00	Select/Reselect failure
51	00	Erase fault
55	00	Drive reported error

Table 6-15. Additional Sense Code Definitions  
 (Sense Bytes 12 and 13)  
 Sheet 3 of 4

Sense Key ILLEGAL REQUEST (5H)		
Byte # 12 13	Description	
20 00	Invalid Command Descriptor Block	
20 01	Illegal opcode	
20 02	Illegal function for device type	
20 03	Unsupported function	
20 04	Reserved bit/field used	
20 06	CDB length error - too long	
20 07	CDB length error - too short	
20 08	Illegal value in CDB field	
20 09	Fixed bit is set while in variable block mode	
20 0A	Fixed bit is not set while in fixed block mode	
25 00	Invalid LUN	
26 00	Invalid field in Parameter List	
26 01	Requested density not available	
26 02	Fixed length not in valid range	
2C 00	Command sequence error	

Sense Key UNIT ATTENTION (6H)		
Byte # 12 13	Description	
28 00	Not ready to ready change, medium could have changed	
29 00	Power-on, Reset, or Bus Device Reset occurred	

Sense Key DATA PROTECT (7H)		
Byte # 12 13	Description	
27 00	Write protected	

Table 6-15. Additional Sense Code Definitions  
 (Sense Bytes 12 and 13)  
 Sheet 4 of 4

Sense Key BLANK CHECK (8H)		
Byte #		Description
12	13	
2E	00	Tape void detected

Sense Key COPY ABORTED (AH)		
Byte #		Description
12	13	
60	00	Status error from second party on copy command
61	00	Copy cannot execute since host cannot disconnect

Sense Key ABORTED COMMAND (BH)		
Byte #		Description
12	13	
43	00	Message retry error
43	01	Message parity error
43	02	Initiator detected error
43	03	Message parity error
47	00	Interface parity error
48	00	Initiator detected error
49	00	Message out error
49	01	Inappropriate message
49	02	Illegal message
4A	00	Command phase error
4B	00	Data out error

Sense Key VOLUME OVERFLOW (DH)		
Byte #		Description
12	13	
63	00	Insufficient capacity

### 6.8.4 Read Block Limits Command (05H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Vendor Unique		Reserved				Flag	Link

The Read Block Limits command returns the minimum and maximum block sizes the MTS can read and write. Both variable- and fixed-length blocks are allowed. Blocks from 1 to 16,277,215 (FFFFFFH) bytes in length can be written and read. This is the maximum block length allowed by the ANSI SCSI specification. The MTS must be in non-buffered mode (as set by the Mode Select command) for block lengths greater than 262,142 (03FFFEH) bytes. The format of the data returned during the data phase of the Read Block Limits command is shown in Table 6-16.

Table 6-16. Read Block Limits Data

BYTE	DESCRIPTION
0	Reserved
1	Maximum Block Length (MSB)
2	Maximum Block Length
3	Maximum Block Length (LSB)
4	Minimum Block Length (MSB)
5	Minimum Block Length (LSB)

The following parameter values are returned in Read Block Limits data:

Maximum Block Length = 16,277,215 (FFFFFFH) bytes  
 Minimum Block Length = 1 (000001H) byte

## 6.8.5 Read Command (08H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				Fixed
2	Transfer Length (MSB)							
3	Transfer Length							
4	Transfer Length (LSB)							
5	Vendor Unique		Reserved				Flag	Link

The Read command transfers one or more block(s) of data to the initiator beginning with the next block on tape or the next block in the data buffer if the MTS has been reading ahead.

The MTS implements both fixed-block and variable-block read commands. The fixed bit specifies both the meaning of the transfer length field and whether fixed-length or variable-length block(s) are to be transferred.

### Variable-Block Read

A Mode Select command is used to set the MTS into variable-block mode. If the fixed bit does not match the current mode set in the MTS, the command returns a Check Condition status and sets the sense key to Illegal Request.

If the fixed bit is zero, a single block will be transferred with the transfer length specifying the maximum number of bytes the initiator has allocated for the returned data. If the actual block length is different from the specified transfer length, a Check Condition status is returned and the incorrect length indicator (ILI) bit and valid bit in request sense data set to one. The information bytes in the request sense data are set to the difference (residue) between the requested transfer length and the actual block length. The MTS returns a negative residue (two's complement notation) when the actual block length exceeds the transfer length. No more than transfer length bytes are transferred to the initiator.

If a filemark is read, the MTS returns a Check Condition status to the initiator and sets the filemark bit to one in the sense

data. In variable-block mode, the valid bit is set to one and the information bytes set to the requested transfer length because no data was transferred to the initiator.

### Fixed-Block Read

The MTS can be set to fixed-block mode with the Mode Select command. The block length is a parameter sent by the Mode Select command. The fixed bit in the command descriptor block is set to one for a fixed block read. If the fixed bit does not match the current mode set in the MTS, the command returns a Check Condition status and sets the sense key to Illegal Request.

If the fixed bit is one, the transfer length specifies the number of blocks to be transferred to the initiator. Therefore, a successful Read command with the fixed bit equal to one transfers the current block length times the transfer length bytes of data to the initiator.

If the fixed bit is one and a block is read that is larger or smaller than the current block length, a Check Condition status is returned to the initiator. The ILI bit and the valid bit in request sense data are set to one. The information bytes are set to the difference (residue) between the requested transfer length and the actual number of blocks read (not including the incorrect length block). Upon termination, the tape is positioned after the incorrect length block (EOT side).

If a filemark is encountered during a Read command, the MTS returns a Check Condition status to the initiator and sets the filemark bit to one in the sense data. If in fixed-block mode, the valid bit is set to one and the information bytes set to the difference (residue) between the requested transfer length and the actual number of blocks read (not including the filemark). Upon termination, the tape is positioned after the filemark (EOT side).

Fixed block read commands can transfer large amounts of data with a single command. The 256K cache buffer allows the MTS to read ahead keeping the tape drive streaming. The buffer also allows the MTS to transfer data on the SCSI bus at higher than tape rates. The MTS disconnects from the SCSI bus during the data transfer to allow other SCSI devices to use the SCSI bus. The disconnects occur on block boundaries. As the buffer becomes full, the MTS arbitrates for the bus and reselects the initiator to continue the data transfer. Switches (Read Buffer Threshold) on the SCSI interface board control the amount of data transferred during each reselection.



If an uncorrectable read error is encountered, the MTS will automatically attempt to recover the failing block with retry actions. The MTS issues a back space block followed by a read to reposition the tape and read the block again. The number of retries (0,5,10, or 15) is determined by switches on the SCSI interface board. If the retry actions are not successful, The block is read once in the reverse direction. The data is transferred to the initiator in the correct order as if the block had been read in the forward direction. If the block is not read successfully, Check Condition status is returned and Media Error sense key is set in the request sense data. The tape is positioned after (EOT side) the failing block.

The MTS does not return Check Condition status when EOT is detected because additional blocks may have been recorded beyond the EOT marker.

If the transfer length is equal to zero, no data is transferred to the initiator and the tape position is not changed. This is not considered an error condition.

## 6.8.6 Write Command (OAH)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved			Fixed	
2	Transfer Length (MSB)							
3	Transfer Length							
4	Transfer Length (LSB)							
5	Vendor Unique		Reserved			Flag		Link

The Write command transfers one or more block(s) of data from the initiator to the MTS. The blocks of data are recorded on tape and checked for validity (read after write) in the order received. The MTS implements both fixed-block and variable-block writes. The MTS can execute Write commands in buffered or not buffered mode. Buffered mode is set by the Mode Select command. The 256K cache buffer is used for all Write commands.

### Buffered Mode

Buffered mode is set by the Mode Select command. In buffered mode the MTS reports Good status after the data specified by the command has been transferred into the cache buffer. The data may not have been completely written to tape. This allows the MTS to store the data from several write commands in the cache buffer before writing the data to tape.

If errors are detected while writing the data to tape, Check Condition status will be returned on the next command received from any initiator. A Reserve Unit command should be used to reserve the MTS to a single initiator to prevent this deferred error status from being presented to the wrong initiator.

The MTS can operate in buffered mode for both fixed-block and variable-block Write commands.

## Not Buffered Mode

The Mode Select command is used to set the MTS into Not Buffered mode. In this mode, status for the command is reported only after the data has actually been written to tape. Data from only one Write command resides in the cache buffer at any time. The MTS can operate in not buffered mode for both fixed-block and variable-block Write commands.

## Variable-Block Write

The fixed bit specifies both the meaning of the transfer length field and whether fixed-length or variable-length block(s) are to be transferred.

If the fixed bit is ZERO, a single block is transferred from the initiator. The transfer length specifies the length of the block to be written (in bytes). If the MTS is not in variable-block mode, a Check Condition status is returned and Illegal Request sense key is set in request sense data.

## Fixed-Block Write

If the fixed bit is one, the transfer length field specifies the number of block(s) to be transferred to the MTS. If the MTS is not in fixed-block mode, Check Condition status is returned and Illegal Request sense key set in the sense data.

A single fixed-block Write command can transfer a large amount of data to the MTS. The MTS disconnects from the SCSI bus after filling the cache buffer to allow other SCSI devices to utilize the bus. It arbitrates for the SCSI bus and reselects the initiator to continue the data transfer when there is sufficient space in the buffer for more data. The data transfer phase is broken on block boundaries. The MTS manages the buffer to keep the tape drive streaming while still allowing other SCSI devices access to the SCSI bus.

The MTS performs automatic write retry actions when errors are detected during the Write operation. The retry involves backspacing over the block in error and issuing an erase gap command to the drive. The block is then rewritten. The number of retry actions performed (0,5,10,15) is determined by switches on the SCSI interface card.

The MTS reduces the size of its cache buffer near EOT to insure that all data stored in the buffer can be written to tape once the EOT marker is detected. If EOT is encountered while writing, the data in the buffer is written to tape and the command is terminated with Check Condition status. The EOM bit is set and the sense key is set to No Sense. If the fixed bit is one, the valid bit is set in request sense data and the information bytes are set to the difference (residue) between the requested

transfer length and the actual number of blocks written to tape.

If the transfer length is zero, no data is transferred and the tape position is not changed. This condition is not considered as an error.

## 6.8.7 Read Reverse Command (OFH)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved			Fixed	
2	Transfer Length (MSB)							
3	Transfer Length							
4	Transfer Length (LSB)							
5	Vendor Unique		Reserved			Flag		Link

The Read Reverse command functions identically to the Read command except that motion is in the reverse direction. Thus, the block(s) and bytes within the block(s) are transferred in the reverse order and the tape position upon termination is before the last block read (BOT side). This command terminates with a Check Condition status and the EOM bit in sense data set to one if BOT is encountered. The sense key is set to No Sense. If the fixed bit is one, then the valid bit is set to one and the information bytes contain the difference (residue) of the requested transfer length and the actual number of blocks transferred before BOT was encountered.

The reporting of incorrect length indication (ILI) is the same as for a Read command. Negative residues are implemented. Filemark handling is the same as in the Read command except that the tape position upon command termination is before the filemark (BOT side).

If the transfer length is zero, no data is transferred and the current position on the tape not changed. This condition is not considered as an error.

The MTS implements both fixed-block and variable-block modes. If the fixed bit does not match the current mode of the MTS, the command returns a Check Condition status and sets the sense key to Illegal Request.

The MTS does not read ahead (in this case toward BOT) after receiving a Read Reverse command.

## 6.8.8 Write Filemarks Command (10H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				
2	Number of Filemarks (MSB)							
3	Number of Filemarks							
4	Number of Filemarks (LSB)							
5	Vendor Unique		Reserved			Flag		Link

The Write Filemarks command writes a specified number of filemarks beginning at the current location on tape. The number of filemarks field specifies the number of filemarks to be written in the current tape density. If a ZERO is in this field, no filemarks are written.

This command writes any buffered write data to tape before writing the specified number of filemarks. The MTS will disconnect from the SCSI bus while writing the buffered data and the filemarks. If the sync on Two Filemarks option is not enabled, Good status is returned only after all the data blocks in the cache buffer and the filemarks have been written correctly. If the MTS is in buffered mode and the sync on Two Filemarks option is enabled, a command to write one filemark will return Good status and place the filemark in the buffer. A Write Zero Filemark command can be used to synchronize the cache buffer.

If EOT is detected, the MTS will finish writing any buffered write data and any buffered filemarks. If the MTS is not able to write all of the filemarks requested by the command, the EOM bit, No Sense sense key and the valid bit will be set. The information bytes will contain the number of unwritten filemarks.

## 6.8.9 Space Command (11H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				Code
2	Count (MSB)							
3	Count							
4	Count (LSB)							
5	Vendor Unique		Reserved				Flag	Link

The Space command positions the tape in the forward or backward direction as specified by the code bits in the command descriptor block. This command provides three methods of moving tape forward or backward. The MTS can space over multiple blocks, multiple filemarks, or to the first occurrence of N consecutive filemarks. The count field defines the number blocks or filemarks to be spaced over. The type of positioning is specified by the code field in the command descriptor block. The MTS does not support positioning to the physical end-of-data because the physical end-of-data is not defined by either the 1600 bpi PE or 6250 bpi GCR tape formats. When spacing over blocks or filemarks, the count field specifies the number of blocks or filemarks to be spaced over. The count field is interpreted as follows:

1. A positive value N in the count field causes forward movement of the tape over N blocks or filemarks. The tape is positioned on the EOT side of the last block or filemark after the completion of the command.
2. A ZERO in the count field does not move the tape.
3. A negative value -N (2's complement notation) in the count field causes backward movement of the tape over N blocks or filemarks. At the completion of the command, the tape is positioned on the BOT side of the last block or filemark.

The code field is defined as follows:

CODE		DESCRIPTION
0	0	Blocks
0	1	Filemarks
1	0	Sequential Filemarks
1	1	Physical End-of-Data (not used)

If a filemark is encountered while spacing over blocks, tape motion is stopped. The tape will be positioned on the EOT side of the filemark if movement was forward or on the BOT side of the filemark if movement was backward. A Check Condition status is returned to the initiator. The filemark and valid bits are set in the sense data. The sense key is set to No Sense. The information bytes will be set to the difference (residue) between the requested count and the actual number of blocks spaced over (not including the filemark).

If BOT is encountered while spacing over blocks or filemarks in backward direction, a Check Condition status is returned to the initiator. The EOM bit and no Sense sense key are set in the sense data. The valid bit will be set to ONE and the information bytes to the difference (residue) between the requested count and the actual number of blocks or filemarks spaced over.

When spacing over sequential filemarks, the count field is interpreted as follows:

1. A positive value N causes forward tape movement to the first occurrence of N or more consecutive filemarks stopping on the EOT side of the Nth filemark.
2. A ZERO causes no tape movement.
3. A negative value -N (2's complement notation) moves tape backward to the first occurrence of N or more consecutive filemarks. The tape is positioned on the BOT side of the Nth filemark at the completion of the command.

On Space commands with the count not equal to ZERO, the MTS disconnects from the SCSI bus after the Command phase. The initiator will be reselected and status presented after completion of the space operation.



## 6.8.10 Inquiry Command (12H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Vendor Unique		Reserved				Flag	Link

The Inquiry command causes the MTS to transfer Inquiry data to the initiator. The Inquiry data defines the basic characteristics on the MTS.

The allocation length specifies the number of bytes that the initiator has allocated for returned Inquiry data. An allocation length of ZERO indicates that no Inquiry data is to be transferred. This condition is not considered as an error. Any other value indicates the maximum number of bytes that can be transferred. The MTS will terminate the Data In phase when allocation length bytes have been transferred or when all available Inquiry data has been transferred to the initiator, whichever is less.

The Inquiry command returns a Check Condition status only when the MTS cannot return the requested Inquiry data. The MTS returns Inquiry data when the tape drive is ready or not ready, online or offline.

If an Inquiry command is received from an initiator with a pending unit attention condition (before the Check Condition status has been reported to that initiator), the MTS will execute the Inquiry command and not clear the unit attention condition.

The Inquiry data (Table 6-17) contains a five byte header, followed by the two bytes of MTS unique parameters.

The peripheral device type field is set equal to 01H, sequential-access device.

The removable medium (RMB) bit is set to one to indicate that the

Table 6-17. Inquiry Data

BIT BYTE	7	6	5	4	3	2	1	0
0	Peripheral Device Type							
1	RMB	Device-Type Qualifier						
2	ISO Version		ECMA Version			ANSI Version		
3	Reserved							
4	Additional Length (n)							
	Vendor Unique Parameters							
5	StorageTek Microcode Level (MSB)							
6	StorageTek Microcode Level (LSB)							

tape is removable.

The device-type qualifier is not implemented by the MTS. This field is set to zero.

The ISO and ECMA version fields are set to zero indicating that the MTS does not claim compliance to these standards at this time.

The ANSI version is set to 1H indicating that the MTS complies with ANSI X3.131-1986 (SCSI REV 17B).

The additional length specifies the length in bytes of the MTS unique parameters. The additional length is set to 02H. The two bytes of MTS unique parameters define the microcode level of the MTS. If the allocation length in the command descriptor block is too small to transfer all of the vendor unique parameters, the additional length is not adjusted to reflect the truncation.

### 6.8.11 Verify Command (13H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved			Bytecmp	Fixed
2	Verification Length (MSB)							
3	Verification Length							
4	Verification Length (LSB)							
5	Vendor Unique		Reserved				Flag	Link

The Verify command will be implemented at a later date.

## 6.8.12 Recover Buffered Data Command (14H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				Fixed
2	Transfer Length (MSB)							
3	Transfer Length							
4	Transfer Length (LSB)							
5	Vendor Unique		Reserved				Flag	Link

The Recover Buffered Data command is used to recover data that was transferred to the cache buffer but has not been written to tape. This command is normally only used by an initiator to recover from an error or exception condition that made it impossible to write the buffered data to tape.

This command functions similarly to the Read command except that the data is transferred from the cache buffer instead of from tape. The order in which block(s) are transferred is the same as if they had been written to the tape (FIFO). One or more Recover Buffered Data commands may be used to read the unwritten buffered data.

This command can operate in either fixed-block or variable-block mode. If the Fixed bit does not match the current mode of the machine (as set by the Mode Select command), the command will be rejected with Check Condition status and Illegal Request set in the sense information.

In fixed-block mode, the transfer length specifies the number of blocks to be transferred from the buffer. If the transfer length is equal to zero, no data is transferred. This is not an error condition. If the length of a block read from the buffer does not match the fixed block length as set by the Mode Select command, Check Condition status is returned and Illegal Length Indication is set in the sense information. The Valid bit is set and the information bytes are set to the difference (residue) between the requested transfer length and the actual number of blocks read (not including the incorrect length block).

In variable-block mode, each Recovered Buffered Data command will transfer one block of data from the cache buffer. The transfer

length specifies the number of bytes to be transferred. If the transfer length is equal to zero, no data is transferred. This is not an error condition.

If an attempt is made to recover more logical blocks of data than are contained in the buffer, the command is terminated with a Check Condition status. The EOM bit in the sense information will be set to ONE. If the fixed bit is ONE, the valid bit will be set to ONE and the information bytes set to the difference (residue) between the requested transfer length and the actual number of blocks transferred. If the fixed bit is ZERO, the valid bit is set to ONE and the information bytes set to the difference (residue) between the requested transfer length and the number of bytes actually transferred.

### 6.8.13 Mode Select Command (15H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Parameter List Length							
5	Vendor Unique		Reserved				Flag	Link

The Mode Select command is used to specify the tape density and operating parameters of the MTS.

The parameter list length specifies the length in bytes of the Mode Select parameter list that is transferred during the Data Out phase of the command. If the parameter list length is equal to ZERO, the MTS will not transfer any parameter data. This is not an error condition.

The Mode Select parameter list (Table 6-18) contains a four-byte header, followed by zero or one eight-byte block descriptor. The MTS will accept a Mode Select command with zero block descriptors. This is useful for setting and re-setting buffered mode. If more than one block descriptor is indicated by the block descriptor length, a Check Condition status is returned and Illegal Request sense key set in the sense information. Vendor unique parameter data is not supported by the MTS.

Buffered mode determines when status is returned on Write commands. If buffered mode is set to ZERO, Good status is not reported on Write commands until the data has actually been written to tape. If buffered mode is set to ONE, Good status is returned as soon as all the data specified by the command has been transferred into the cache buffer. In buffered mode, error conditions can occur after Good status has been presented for the command. These deferred error conditions are reported as Check Condition status on the next command received by the MTS. This next command does not have to originate from the same initiator that sent the Write command. Buffered modes of 2H through 7H are invalid and will result in Check Condition status with Illegal Request set in the sense information.

Table 6-18. Mode Select Parameters

BIT BYTE	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved	Buffered Mode			Speed			
3	Block Descriptor Length							
Block Descriptor(s)								
0	Density Code							
1	Number of Blocks (MSB)							
2	Number of Blocks							
3	Number of Blocks (LSB)							
4	Reserved							
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							
Vendor Unique Parameter(s)								
0-n	Vendor Unique Parameter Byte(s)							

Code values for the speed field are assigned as follows:

0H	Default to 100 ips
1H	50 ips
2H	100 ips

The block descriptor length specifies the length in bytes of all the block descriptors. This value is equal to the number of block descriptors times eight and does not include the vendor unique parameters, if any. A block descriptor length of zero indicates that no block descriptors are included in the parameter list. Only block descriptor lengths equal to zero or eight are

accepted. Other values return Check Condition status and set Illegal Request sense key in the sense information.

The block descriptor is used to set fixed-length or variable-length mode and the tape density. The tape can be written in either of two densities: PE or GCR. The density may be changed only when the tape is positioned at BOT.

The valid density codes are as follows:

00H Default to 6250 GCR (or current density if operator panel switch is not set to System Select.)

02H 1600 PE

03H 6250 GCR

If the operator panel switch is set to System Select, the default density is 6250 bpi GCR. Otherwise, the default density is the current density determined by the switch on the operator panel. When not in System Select, a Mode Select command with a density that does not match the density set in the switches will return Check Condition status and set Illegal Request Sense Key.

A block length of zero puts the MTS in variable-length mode. Fixed-length mode is set by specifying the number of bytes in each block in the block length field. The block length and mode may be changed away from BOT. Block lengths of 1 (000001H) to 16,777,215 (FFFFFFFH) bytes are allowed.

The number of blocks field must equal ZERO to indicate that the specified block length is in effect for the remainder of the tape or until changed.

The mode select parameters are set to the following default values at power on or after a SCSI bus reset.

100 ips

6250 bpi GCR (or current density if operator panel switch is not set to System Select)

Variable length

Buffered mode



## 6.8.14 Reserve Unit Command (16H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			3rdPty	Third Party Device ID			Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Vendor Unique			Reserved			Flag	Link

The Reserve Unit command reserves the MTS for the exclusive use by a single initiator. That initiator may be the one that issued the Reserve Unit command or a third party whose SCSI ID is specified by the command. The third-party option of the command is implemented by the MTS.

The MTS remains reserved for an initiator until that reservation is released. The reservation can be released by a Release Unit command only from the initiator that made the reservation. The reservation can be superceded by another Reserve Unit command from the same initiator. A "Hard" Reset or a Bus Device Reset message will release the reservation. These resets generate a Unit Attention condition that is reported as Check Condition status on the following command. The Reserve Unit Command will return Good status if the MTS is already reserved to the initiator issuing the command.

The Reserve Unit command reserves the specified Logical Unit to an initiator. The MTS has a single Logical Unit which is address 0H. Therefore, the Reserve Unit command will reserve the entire subsystem to a single initiator. The command will return Check Condition status if the LUN is not equal to 0H.

If the MTS is already reserved by another initiator, this command will return Reservation Conflict status and the reservation is not broken. The MTS does not queue reservations. While reserved to an initiator, all commands from other initiators will be rejected with Reservation Conflict status. The only exception is a Release Unit command from another initiator which will return Good status but does not break the reservation.

The third-party reservation option of the Reserve Unit command allows an initiator to reserve the MTS for use by another SCSI device. If the third-party (3rdPty) bit is ZERO, then the third-party reservation option is not requested and the third-party device ID field is ignored. If the 3rdPty bit is ONE, then the command reserves the MTS to the SCSI device specified in the third party device ID field of the the command descriptor block. The reservation will be broken by a Release Unit command only from the initiator that issued the original Reserve Unit command. The MTS can be reserved to a different SCSI ID by another Reserve Unit command (with a different third-party device ID) from the initiator that issued the original Reserve Unit command. This is called a superceding reservation. A Bus Device Reset message or a "Hard" Reset from any initiator releases the third-party reservation. A Release Unit command from any initiator other than the initiator that issued the original third-party reservation command will receive Good status but the reservation will not be broken.

The third-party option of the Reserve Unit command is useful in a multiple-initiator system to reserve the source device and/or destination device to the copy manager. This is necessary to preserve data integrity during a Copy operation.

## 6.8.15 Release Unit Command (17H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			3rdPty	Third Party Device ID			Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Vendor Unique			Reserved			Flag	Link

The Release Unit command releases the MTS if it is currently reserved to the initiator issuing the command. The MTS is then able to execute commands from any initiator. The reservation is not released if the Release Unit command is issued by an initiator other than the initiator holding the current reservation. A Release Unit command from an initiator to which the MTS is not currently reserved will receive Good status without releasing the reservation. When not reserved to any initiator, the MTS will also return Good status in response to a Release Unit command.

The MTS has a single logical unit (LUN), address 0H. A Release Unit command to a LUN other than 0H will receive a Check Condition status with Illegal Request sense key set in sense information and not release the reservation.

The MTS implements the third-party release option of the Release Unit command. This option allows an initiator that used the third-party reserve option to reserve the MTS to some other initiator to release that reservation. The third-party release option is intended to be used with the third-party reserve option in multiple-initiator systems that employ the Copy command. The third-party reserve/release is necessary to preserve data integrity during a Copy operation.

If the third-party (3rdPty) bit is ZERO, then the third-party release option is not requested. If the 3rd-Pty bit is ONE, the MTS will release the third-party reservation only if the initiator issuing the Release Unit command is the same initiator that reserved the MTS using the third-party reservation option of the Reserve Unit command and the same SCSI device is specified in the third-party device ID field of the command descriptor block.

### 6.8.16 Copy Command (18H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				Fixed
2	Parameter List Length (MSB)							
3	Parameter List Length							
4	Parameter List Length (LSB)							
5	Vendor Unique		Reserved				Flag	Link

The Copy command will be implemented at a later date.

## 6.8.17 Erase Command (19H)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				Long
2	Reserved							
3	Reserved							
4	Reserved							
5	Vendor Unique		Reserved				Flag	Link

The Erase command erases tape starting at the current position. This command has two options:

If the long bit is equal to ZERO, a short erase is performed, erasing a normal length erase gap as determined by the current density setting. If the long bit is equal to ONE, tape is erased from the current position to EOT. The Erase command does not rewind the tape to BOT.

If the tape is positioned at BOT, this command writes the correct ID area for the current density setting before performing the erase. The MTS disconnects from the SCSI bus while performing the erase operation. It reselects the initiator to return status when the operation is complete.

## 6.8.18 Mode Sense Command (1AH)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Vendor Unique		Reserved				Flag	Link

The Mode Sense command reports the medium and device parameters of the MTS to the initiator. This is a complementary command to the Mode Select command.

The allocation length specifies the number of bytes that the initiator has allocated for returned Mode Sense data. If the allocation length is equal to ZERO no Mode Sense data is transferred. This is not an error condition. The allocation length is the maximum number of bytes that can be transferred to the initiator. The MTS will terminate the Data In phase of the command when the allocation length bytes have been transferred or when all available Mode Sense data have been transferred, whichever is less.

The Mode Sense data (Table 6-19) contains a four-byte header, followed by an eight-byte block descriptor. The MTS does not return any vendor unique parameter data. The sense data length specifies the length in bytes of the mode sense data that is available to be transferred during the Data In phase of the command. This length does not include itself. An additional sense value of 0BH is returned by the MTS. A value of 00H (default - only one medium type supported) is returned in the Medium Type field.

Table 6-19. Mode Sense Data

BIT BYTE	7	6	5	4	3	2	1	0
0	Sense Data Length							
1	Medium Type							
2	WP	Buffered Mode			Speed			
3	Block Descriptor Length							
Block Descriptor (s)								
0	Density Code							
1	Number of Blocks (MSB)							
2	Number of Blocks							
3	Number of Blocks (LSB)							
4	Reserved							
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							
Vendor Unique Parameter (s)								
0-n	Vendor Unique Parameter Byte(s)							

If the write protected bit (WP) is ZERO, the tape is write enabled. The write protected bit is set to ONE if the tape reel is write protected (write protect ring not installed).

A buffered mode of ZERO indicates that the MTS is not in buffered mode and will report Good status on Write commands only after the data blocks are actually written on tape. A buffered mode of ONE indicates the MTS is in buffered mode and will report Good status on Write commands as soon as the data has been transferred to the cache buffer.

The speed field indicates the present speed setting of the drive. Code values are as follows:

1H	50 ips
2H	100 ips

The block descriptor length specifies the length in bytes of the block descriptors. This length is equal to the number of block descriptors times eight. The MTS returns one block descriptor in the Mode Sense data. Therefore, the value in the block descriptor length field is 08H.

The block descriptor reports the current density settings and block length of the MTS. The density codes are as follows:

02H	1600 bpi PE
03H	6250 bpi GCR

The value returned in the number of blocks field is 000000H to indicate that the density is the same for the entire tape. The density can be changed only when the tape is positioned at BOT. The block length indicates the current block length set in the MTS. A block length of ZERO indicates that the MTS is in variable-block mode. The block length can be changed when the tape is positioned at BOT or away from BOT.



## 6.8.19 Load/Unload Command (1BH)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved							
5	Vendor Unique		Reserved				Flag	Link

The Load/Unload command enables or disables the MTS for future operations. If the load bit is equal to ONE, the tape is threaded and positioned at BOT, and the drive made ready and online. If the immediate bit is ONE, Good status is returned before the tape is actually loaded. If the immediate bit is ZERO, Good status is returned only after the tape is loaded and the drive is ready and online.

If the load bit is ZERO, the tape will be rewound to BOT and unthreaded. The tape can then be removed from the drive. Status for this command is returned as soon as the rewind or unload has begun regardless of the state of the immediate bit.

The Re-tension option is not supported by the MTS. The Re-tension bit must be set to ZERO. If the re-tension bit is set to ONE, this command will return Check Condition status and set Illegal Request in the sense information.

## 6.8.20 Receive Diagnostic Results Command (1CH)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Allocation Length (MSB)							
4	Allocation Length (LSB)							
5	Vendor Unique		Reserved				Flag	Link

The Receive Diagnostic Results command transfers diagnostic data to the initiator. This data was generated by diagnostic tests initiated by a previous Send Diagnostic command.

The allocation length specifies the maximum number of bytes that the initiator has allocated for returned Receive Diagnostics data. The Data In Phase is terminated when allocation length bytes or all available Receive Diagnostic Data has been transferred, whichever is less.

The format of the Receive Diagnostic data is determined by the previous Send Diagnostic command. Receive Diagnostic data is available after executing the following Send Diagnostic commands:

- Perform All Diagnostics (D1)
- Loop Write-To-Read (D2)
- Examine DAR/FAR (F3)

## 6.8.21 Send Diagnostic Command (1DH)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved		SelfTest	DevOf1	UnitOfL
2	Reserved							
3	Parameter List Length (MSB)							
4	Parameter List Length (LSB)							
5	Vendor Unique		Reserved				Flag	Link

### 6.8.21.1 SELF-TEST BIT (1) COMMANDS

When the self-test bit is equal to one, the Send Diagnostic Command requests the MTS to run its self-test diagnostics. Two self-test packages are possible: Loaded Diagnostics and SCSI Card Diagnostics. The unit off line bit (UnitOf1) determines which self-test is executed. If the self-test bit is one, no data is transferred between the initiator and the MTS. If the self-test bit is one and the parameter bit length is not equal to zero, Check Condition status is returned and Illegal Request sense key is set in sense data. Good status is returned if the self-test executes successfully. Check condition status is returned and Hardware Error sense key is set if the self-test does not execute successfully. The initiator must issue a Request Sense Command to get the number of the test that failed (sense byte 86) and the error code (sense byte 87). This information is used with the Fault Code Dictionary to isolate the failure.

#### UnitOf1 Bit (1) - Run Loaded Diagnostics

If the unit off line bit is one, the loaded subset of the internal diagnostics are executed. The tape drive must be loaded for this test. The power up routine and tests that require the tape to be unloaded are bypassed. This self-test does not execute the entire set of MTS internal diagnostics tests. A higher percentage of failure detection and isolation can be achieved by executing the entire diagnostic package. (Self-Test Bit = 0, Diagnostic ID = D1.)

#### UnitOf1 Bit (0) - Run SCSI Card Diagnostics

If the unit off line bit is zero, the SCSI interface board diagnostic tests are executed.

### 6.8.21.2 SELF-TEST BIT (0) COMMANDS

When the self-test bit is zero, the MTS uses parameter data from the initiator to determine the diagnostic to be run. The results of the diagnostic can be obtained with the Receive Diagnostic Results command. The format of the parameter data that is transferred during the Data Out phase of the command is shown in Table 6-20.

Table 6-20. Diagnostic Parameter Data

Byte	Description
0	Diagnostic ID
1	Reserved
2-n	Diagnostic Parameters or Data

The valid Diagnostic IDs are shown in Table 6-21.

Table 6-21. Diagnostic IDs

ID Byte	Description
D1	Run entire diagnostic package
D2	Run Loop Write to Read
F1	Set next write in place
F2	Reset error counters
F3	Examine DAR/FAR
F4	Set dead tracks

## 6.8.22 Write Buffer Command (3BH)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved			Mode (10)	
2	Buffer ID (0)							
3	Buffer Offset (MSB)							
4	Buffer Offset							
5	Buffer Offset (MSB)							
6	Transfer Length (MSB)							
7	Transfer Length							
8	Transfer Length (LSB)							
9	Vendor Unique		Reserved				Flag	Link

The Write Buffer command will be implemented at a later date. The implementation is planned to conform to the Write Buffer command defined in the SCSI-2 working document. Only data mode (MODE = 10) will be implemented.

### 6.8.23 Read Buffer Command (3CH)

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved			Mode (10)	
2	Buffer ID (0)							
3	Buffer Offset (MSB)							
4	Buffer Offset							
5	Buffer Offset (LSB)							
6	Transfer Length (MSB)							
7	Transfer Length							
8	Transfer Length (LSB)							
9	Vendor Unique		Reserved				Flag	Link

The Read Buffer command will be implemented at a later date. The implementation is planned to conform to the Read Buffer command defined in the SCSI-2 working document. Only data mode (MODE = 10) will be implemented.

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SEPARATOR SET PN 83464

THIS SEPARATOR SET CONTAINS 19  
TABS TOTAL IN THE FOLLOWING  
ORDER:

MAINTENANCE MANUAL

1. INTRODUCTION
  2. OPERATION
  3. INSTALLATION
  4. STORAGETEK INTERFACE
  5. INDUSTRY INTERFACE
  6. SCSI INTERFACE
  7. VS INTERFACE
  8. FUNCTIONAL DESCRIPTION
  9. MAINTENANCE
  10. REMOVAL/REPLACEMENT
  11. DIAGNOSTICS
- APPENDICES

IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD



# CHAPTER 7

## VS SIGNAL REQUIREMENTS AND FUNCTIONAL MODE OPERATION

### 7.1 INTERFACE CIRCUITS

The MTS-user interface circuits are shown in Figure 7-1.

### 7.2 INTERFACE LEVELS

The MTS-user interface signal levels are as follows:

	<u>TRANSMITTED</u>	<u>RECEIVED</u>
True = 0	0.0V - 0.4V	0.0V - 0.8V
False = 1	2.4V - 5.0V	2.0V - 5.0V

### 7.3 INTERFACE CONNECTORS

The connectors for this interface are two 50-pin socket connectors (3M<sup>1</sup> 3425-7050 or equivalent). For information on installing cables and daisy-chaining see Figures 7-2 and 7-3.

### 7.4 INTERFACE CABLES

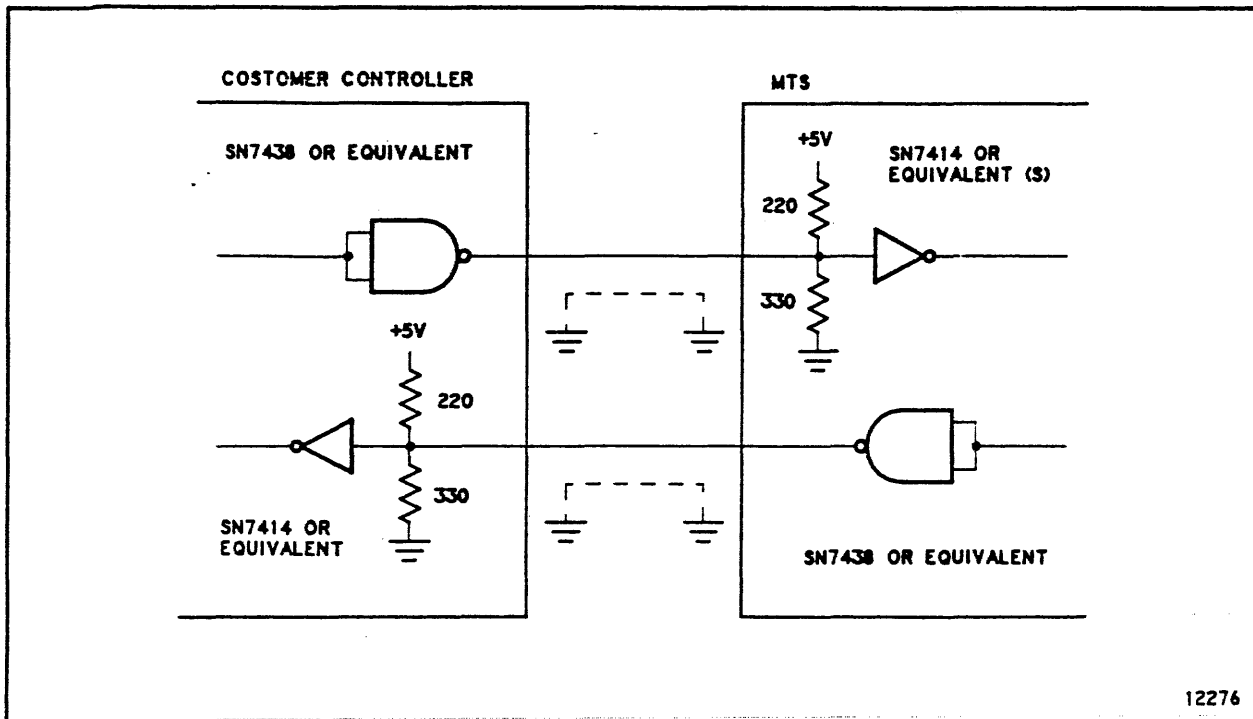
Two 50-wire flat signal cables are used to interface the MTS with the controller/adapter. The maximum cable length is 40 feet (12 meters) from the controller to the last drive.

For electromagnetic compatibility (EMC) purposes, shielded I/O cables are recommended (Spectra-strip<sup>2</sup> 152-2831-050 or equivalent).

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1 A registered trademark of Minnesota Mining and Manufacturing

2 A registered trademark of Eltra Corporation



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Figure 7-1. Interface Circuits

Table 7-1. Interface Connectors

CONNECTORS:	J1A	J1B	J2A	J2B
-------------	-----	-----	-----	-----

## 7.5 SIGNAL LINES

The signal lines to and from the MTS and host/controller, are listed in Table 7-2.

Refer to "Functional Mode Operation" in this manual for signal definitions.

Table 7-2. Interface Lines  
(Sheet 1 of 2)

CONNECTOR J1

Pin	Symbol	Line Name	MTS
1	FFAD	Formatter Addr.	Input
3	FTAD01	Address Bit 1	Input
5	FGO	START Command	Input
7	FREV	Command Bit 3	Input
9	FWRT	Command Bit 2	Input
11	FWFM	Command Bit 1	Input
13	FEDIT	Command Bit 4	Input
15	FERASE	Command Bit 0	Input
17	SPARE		
19	SPARE		
21	SPARE		
23	FFEN	Formatter Enable	Input
25	FREW	Rewind To BOT	Input
27	FOFL	Command Offline	Input
29	FLWD	Last Word	Input
31	FWDP	Write Bit P	Input
33	FWD0	Write Bit 0	Input
35	FWD1	Write Bit 1	Input
37	FWD2	Write Bit 2	Input
39	FWD3	Write Bit 3	Input
41	FWD4	Write Bit 4	Input
43	FWD5	Write Bit 5	Input
45	FWD6	Write Bit 6	Input
47	FWD7	Write Bit 7	Input
49	FTAD0	Address Bit 0	Input

## 7.6 VS INTERFACE INPUT SIGNAL DEFINITIONS

The input line definitions given in this section are for functional mode only. The timing specifications given refer to measurements made at the user's connector. All interface lines are defined low-true or minus-active.

### 7.6.1 MTS Address (FTAD0, FTAD1 and FFAD)

When the Formatter Address line (FFAD) matches the corresponding MTS switch position, the two address lines (FTAD0 and FTAD1) are decoded to select one of the four possible MTSS. Table 7-3 lists the address codes, with "1" being the active or true state.

The two MTS switches corresponding to the two address lines

**Table 7-2. Interface Lines  
(Sheet 2 of 2)**

CONNECTOR J2

Pin	Symbol	Line Name	MTS
1	FFBY	Formatter Busy	Output
3	FDBY	Data Busy	Output
5	FID	ID Burst	Output
7	FHER	Hard Error	Output
9	FCER	Corrected Error	Output
11	FFMK	File Mark Detected	Output
13	FRDY	Drive Ready	Output
15	FONL	Drive Online	Output
17	FRWD	Drive Rewinding	Output
19	FFPT	File Protected	Output
21	FLDP	Load Point (BOT)	Output
23	FEOT	End Of Tape	Output
25	SPARE		
27	SPARE		
29	FDWDS	Data Write Strobe	Output
31	FRSTR	Data Read Strobe	Output
33	FRDP	Read Bit P	Output
35	FRD0	Read Bit 0	Output
37	FRD1	Read Bit 1	Output
39	FRD2	Read Bit 2	Output
41	FRD3	Read Bit 3	Output
43	FRD4	Read Bit 4	Output
45	FRD5	Read Bit 5	Output
47	FRD6	Read Bit 6	Output
49	FRD7	Read Bit 7	Output

(FTAD0 and FTAD1) must be set to indicate MTS 0, 1, 2, or 3 to match the two address lines coming from the host or controller. The FFAD switch must also be set to match the incoming address line. FFAD is shown as "0" in Table 7-3, although "1" can be used if the opposite polarity is desired. For switch settings refer to the 2925 Tape Subsystem Maintenance Manual, PN 95521. The address lines from the host may be switched as long as Formatter Busy (FFBY) and Data Busy (FDBY) are not set. The address must be stable one microsecond before any command lines are activated. That is, Go (FGO), Offline (FOFL), Rewind (FREW), and Formatter Enable (FFEN) must not be changed when switching machine addresses.

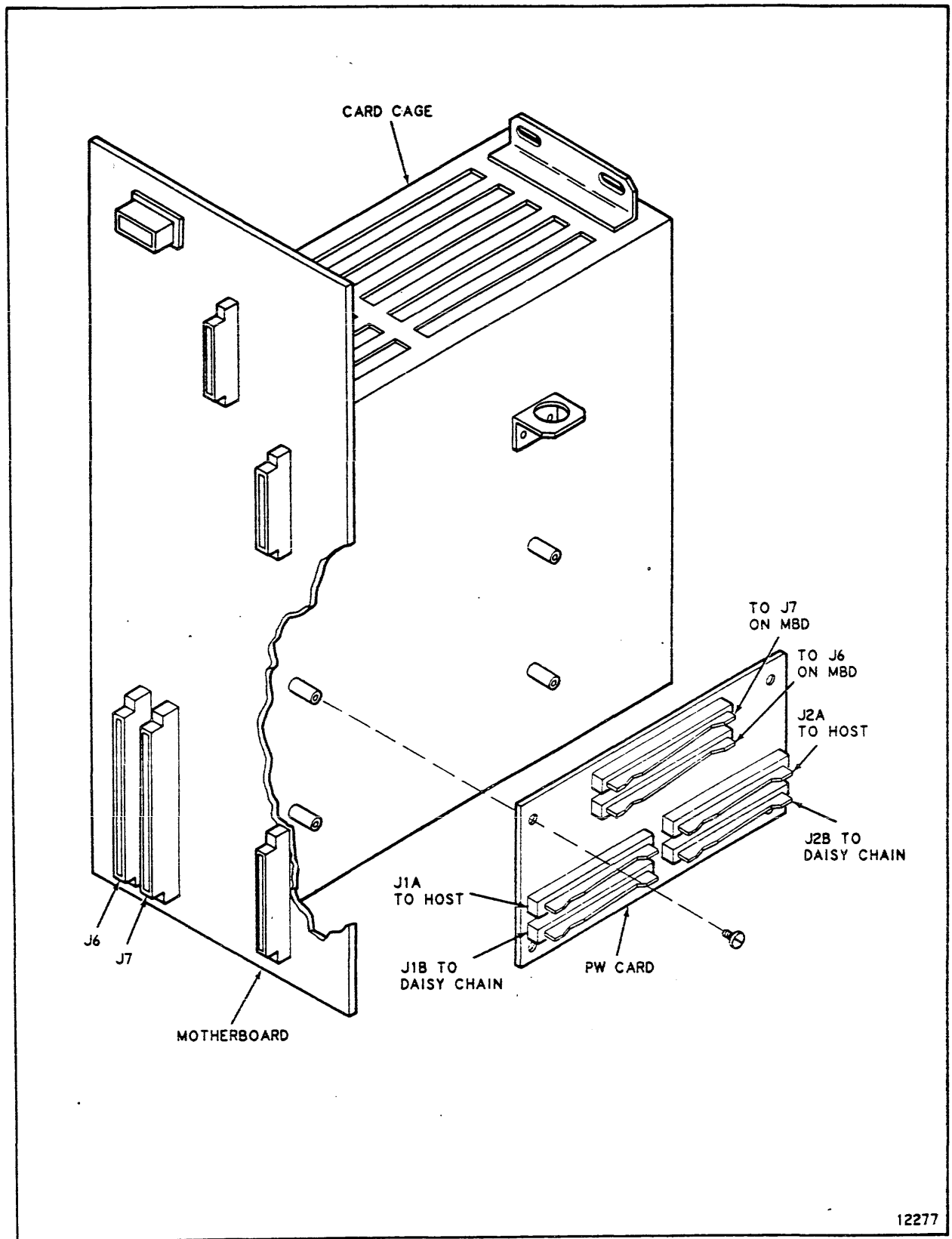
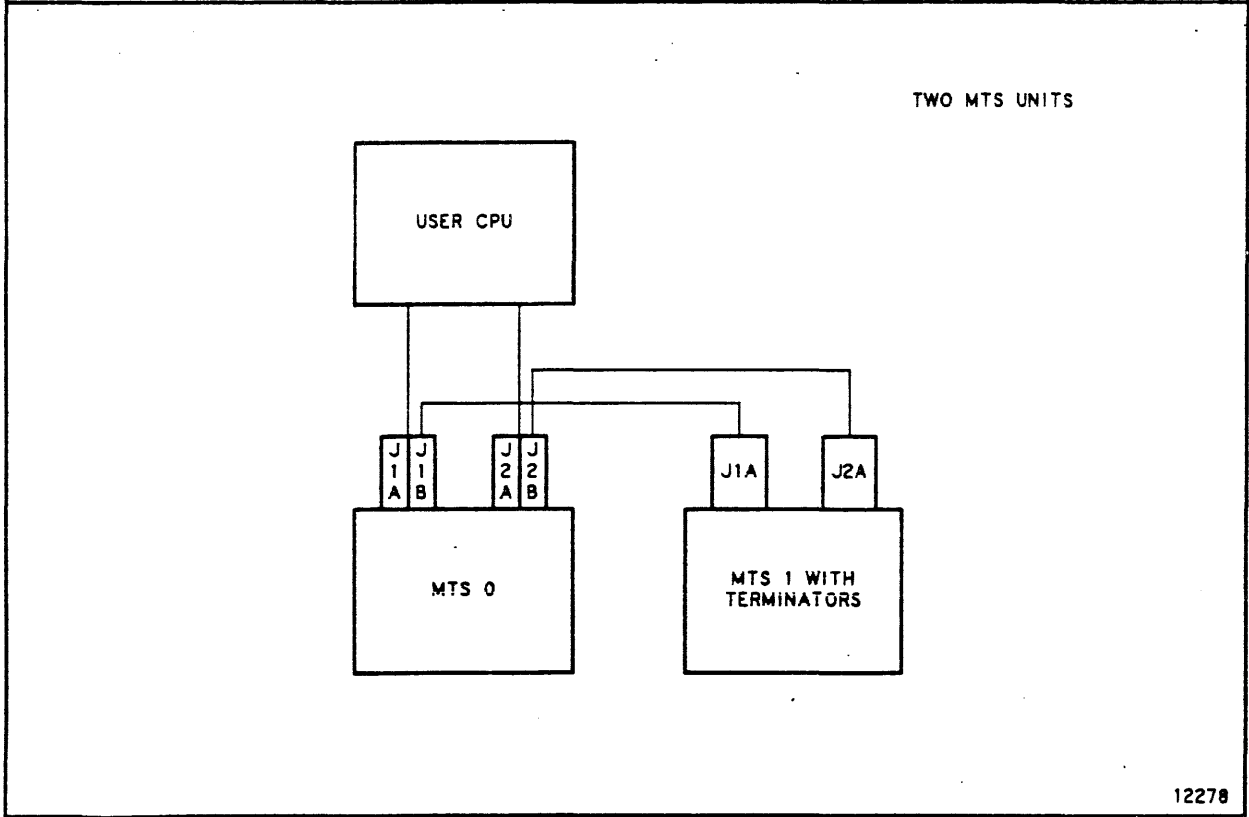
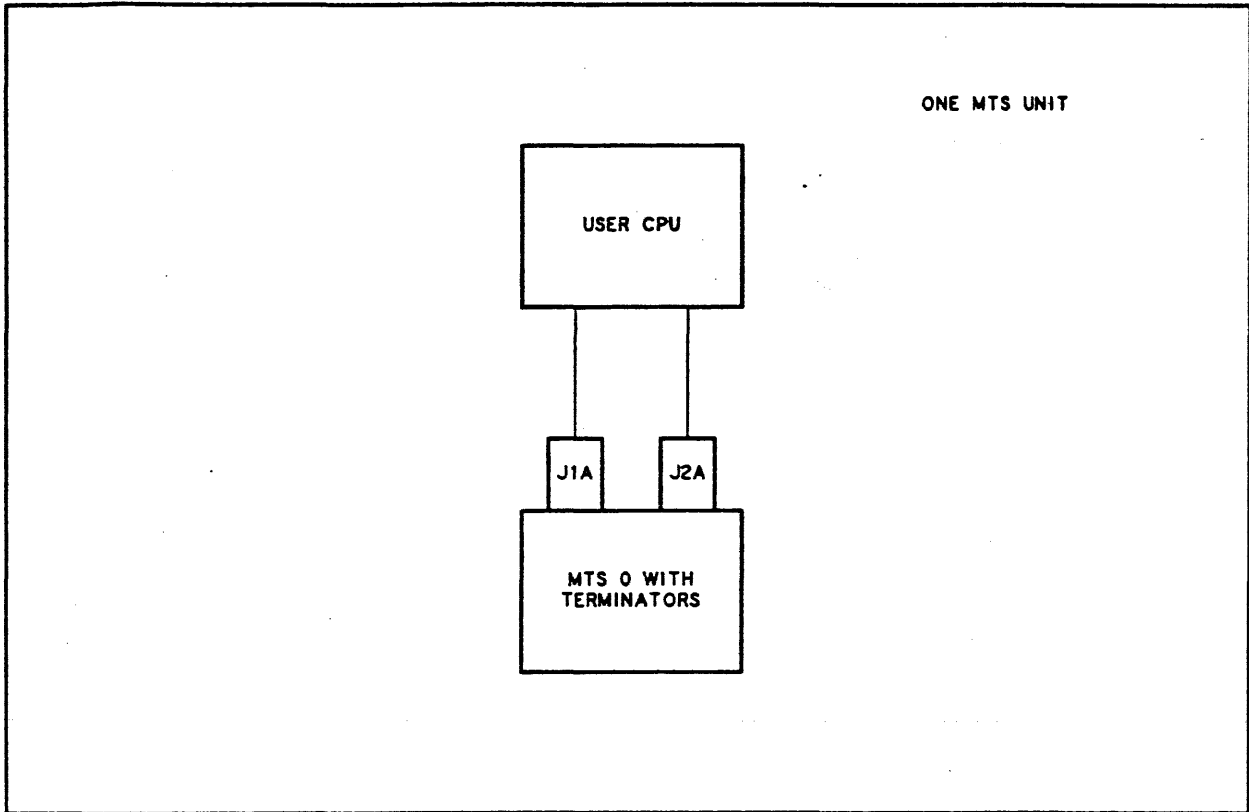


Figure 7-2. Standard Interface Cabling



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Figure 7-3. MTS Interface Cabling  
(Sheet 1 of 2)

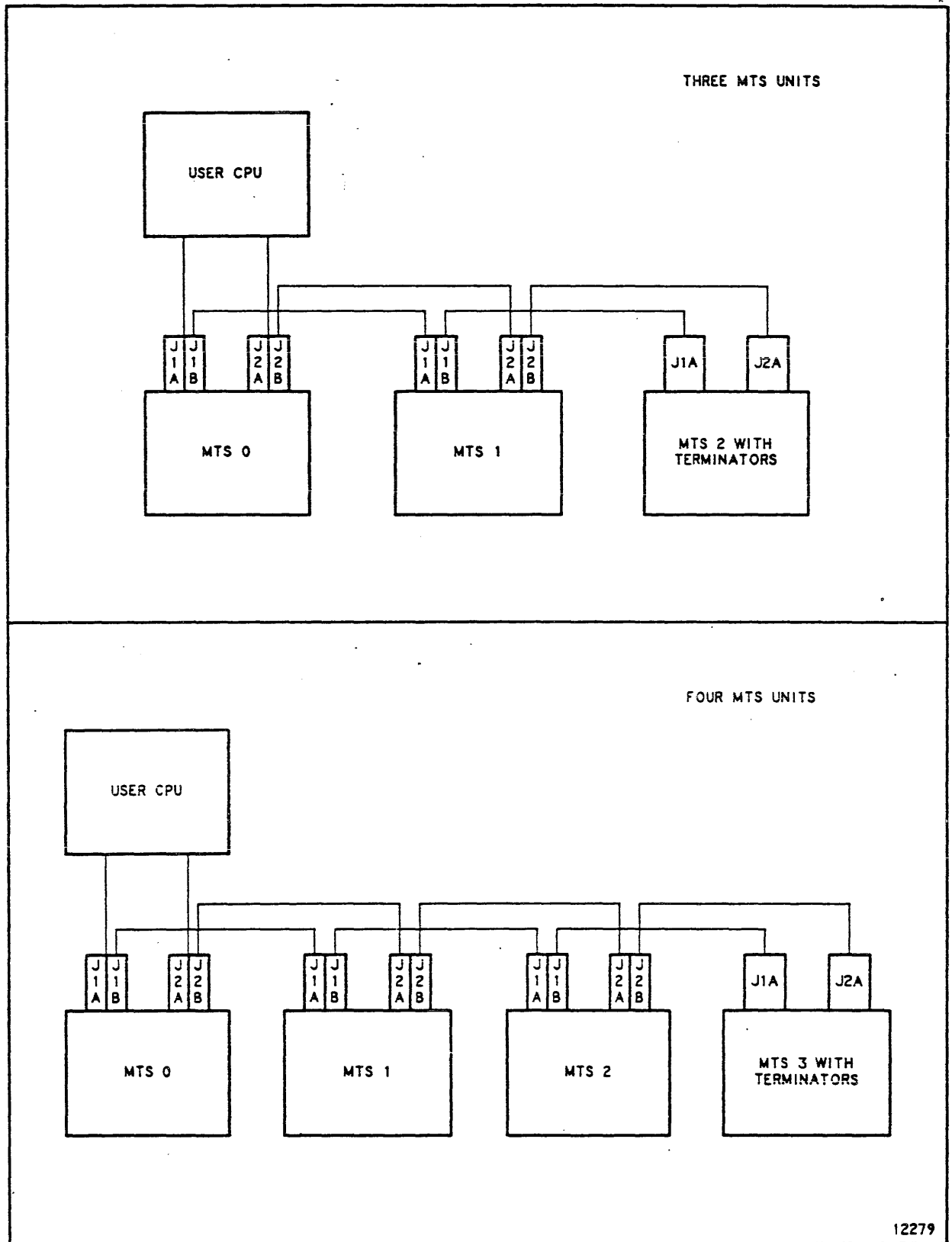


Figure 7-3. MTS Interface Cabling  
(Sheet 2 of 2)

**Table 7-3. MTS Address Lines**

MTS ADDRESS LINES			MTS SELECTED
FFAD	FTADO	FTAD1	
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3

### 7.6.2 Go, Initiate a Command (FGO)

The assertion of the FGO line causes the user command lines to be polled and the command operation to begin. All of the command lines must be stable on the start of the FGO pulse and are clocked in on the trailing edge. The FGO pulse from the host or controller must be a one microsecond (minimum) pulse. The signals that must be stable are:

1. FERASE - Command 0
2. FWFm - Command 1
3. FWRT - Command 2
4. FREv - Command 3
5. FEDIT - Command 4

The other command lines (FOFL, FREW, and FFEN) must not be activated when FGO is used.

Commands 0, 1, 2, 3, 4 are used to encode commands described in the section entitled "Functional Mode Command Descriptions" in this chapter. If the FGO line is asserted before Data Busy (FDBY) is unasserted, the new command will be ignored, Command Overrun will be set, and Hard Error will be pulsed. The FGO line is ignored if the MTS is offline or if Formatter Enable (FFEN) is not asserted.

### 7.6.3 Command Lines (Command 0-4)

Commands 0, 1, 2, 3, 4 are used to encode commands described in Table 7-4, where "1" is the active or true state. These five command lines are decoded in the MTS processor and cause one of the command operations. All eight command lines, however, must be stable when the FGO line is asserted. The section entitled "Functional Mode Command Descriptions" in this chapter contains descriptions and timing information concerning each command operation.



## 7.6.4 Rewind and Offline (FREW, FOFL)

FREW - Rewind. This line must be held true for at least one microsecond. When asserted, this pulse causes the selected transport to rewind to BOT. The drive drops the MTS Ready signal (FRDY) and asserts the MTS Rewind signal (FRWD) one microsecond (maximum) after the leading edge of the FREW signal.

Table 7-4. Command Lines

Command	CMD-4 (FEDIT)	CMD-3 (FREW)	CMD-2 (FWRT)	CMD-1 (FWFM)	CMD-0 (FERASE)
Read Forward	0	0	0	0	0
Read Reverse	0	1	0	0	0
Write	0	0	1	0	0
Write File Mark	0	0	1	1	0
Write Extended	0	1	1	1	0
Controlled Erase	0	0	1	0	1
Fixed Erase	0	0	1	1	1
Data Security Erase	1	0	1	1	1
Space Forward	0	0	0	0	1
Space Reverse	0	1	0	0	1
File Search FWD (Ignore Data)	0	0	0	1	1
File Search Rev (Ignore Data)	0	1	0	1	1
Read Sense	1	1	0	0	1
Read Controller Sense	1	1	0	1	0
Select PE	1	0	0	1	1
Select GCR	1	1	0	1	1

FOFL - Offline and Rewind. This line must be held true for one microsecond (minimum). The drive drops the MTS Ready signal (FRDY) within one microsecond (maximum) after the leading edge of the FOFL signal. The processor then drops Online and starts the rewind. After the rewind is complete, the tape is unloaded.

These two signals are ignored if the MTS is offline and/or the formatter is busy (FFBY is asserted).

## 7.6.5 Formatter Enable (FFEN)

FFEN - Formatter Enable. This signal is usually held true. If the line goes false, the drive stops motion and the current command is terminated.

The FFEN line should be disabled only to terminate a runaway condition. There is no need to use this line as a 'reset' to clear status lines. All status lines are reset on the acceptance of a new command.

Using this line as a 'reset' between commands causes motion to be stopped, forces repositioning between each command, thereby causing slower performance of the drive. Also, for system initialization, the drive only needs to be set online and rewound to BOT.

This line is ignored if the MTS is offline, or the MTS does not have Formatter Busy (FFBY) asserted.

## 7.6.6 Last Word (FLWD)

This line, when asserted during a Write command with Write Data lines (FWDO-7 and FWDP), indicates that the character strobed with FDWDS (Demand Write Data Strobe) is the last byte of the record. When FLWD is asserted during a Controlled Erase command, the MTS stops erasing tape.

## 7.6.7 Write Data lines 0-7, P (FWDO-7, FWDP)

These nine lines transmit data to the MTS. FWDO is the most significant.

## 7.7 VS INTERFACE OUTPUT SIGNAL DEFINITIONS

### 7.7.1 Formatter Busy (FFBY)

Formatter Busy is used to indicate that a command is being processed. It goes true with the leading edge of the FGO line. This line remains true until the full completion of the command. FFBY will remain active until all buffered write data has been written to tape.

### 7.7.2 Data Busy (FDBY)

This line is processor controlled and is used to indicate the 'data transfer' part of the command. When this line goes true on read/write commands, data is being exchanged. It goes false when

data is finished transferring, and although motion has not yet stopped, a new command can be received. The new command is received and processed after the completion of the previous command. Hard Error, Corrected Error, and File Mark Detected are pulsed, if applicable, before FDBY is unasserted. While FDBY is asserted, no new command may be issued.

### 7.7.3 Identification Burst (FID)

The Identification Burst line is asserted by the MTS to indicate that an identification burst procedure is being performed by the MTS. It is asserted on a Read or a Write command from BOT. FID is asserted on Write while the ID burst is being written. On Read, FID is asserted while the ID burst is being read, to determine the density (PE or GCR) of the tape.

### 7.7.4 Hard Error (FHER)

If an error is detected while the MTS is busy, FHER is asserted while FDBY is asserted, and is unasserted before FDBY is unasserted. For further details see the section entitled "Sense Command", sense bytes 3 and 4, in this chapter.

### 7.7.5 File Mark Detected (FFMK)

This line is asserted while Data Busy (FDBY) is asserted when a tape mark pattern has been detected, and is unasserted before FDBY is unasserted.

### 7.7.6 Corrected Error (FCER)

This line is set when:

- A single track error has been corrected during a PE read, or during a PE read back check during a write.
- A single or double track error has been corrected during a GCR read, or during a GCR read back check during a write.

When the error correction occurs, the FCER line is asserted while Data Busy (FDBY) is asserted, and is unasserted before FDBY is unasserted.

### 7.7.7 MTS Ready (FRDY)

This line, FRDY, is asserted when tape is loaded and the MTS is not in a Rewind or a Machine Check status. It indicates that the MTS is ready to accept a read/write type command. The only commands accepted while not ready are sense-type commands and some diagnostic commands.

### 7.7.8 MTS Online (FONL)

This line, FONL, is asserted when the MTS is online and an address match has been detected, meaning it is able to communicate back to the host. If the MTS is offline, all other status back to the host is unasserted.

### 7.7.9 MTS Rewind (FRWD)

This line, FRWD, is asserted when the MTS is rewinding tape to BOT.

### 7.7.10 End of Tape (FEOT)

This line, FEOT, is asserted when the end of tape (EOT) reflective marker is detected and stays asserted past this marker. EOT status is reset when the EOT marker is detected in backward or rewind mode. The MTS will read or write past EOT if commanded to do so. For Early EOT operation refer to the option switch settings described in the 2925 Tape Subsystem Maintenance Manual, PN 95521.

### 7.7.11 File Protect (FFPT)

This line, FFPT, is asserted when the loaded file reel does not contain a write enable ring. This tape cannot be written on, either in functional mode or in diagnostic mode.

### 7.7.12 Load Point (FLDP)

This line, FLDP, is asserted when the tape is loaded and positioned at BOT.

### 7.7.13 High Speed Streaming (FHSPD)

This line, FHSPD, is asserted when the selected MTS is in the streaming mode at 100 ips. It is unasserted when the selected MTS is in the start/stop mode at 50 ips.

### 7.7.14 Demand Write Data Strobe (FDWDS)

This signal, FDWDS, consists of a pulse for each character to be written onto tape. Write timing is specified in Figure 7-4 and Tables 7-5, 7-6, and 7-7. The host interface must be able to maintain a data transfer rate equal to the tape data rate when in non-cached operation. This includes the Model 2925 in long-record mode. Therefore the Model 2925 data rate switches should be set to the minimum values specified in Table 7-8 when in long-record mode.

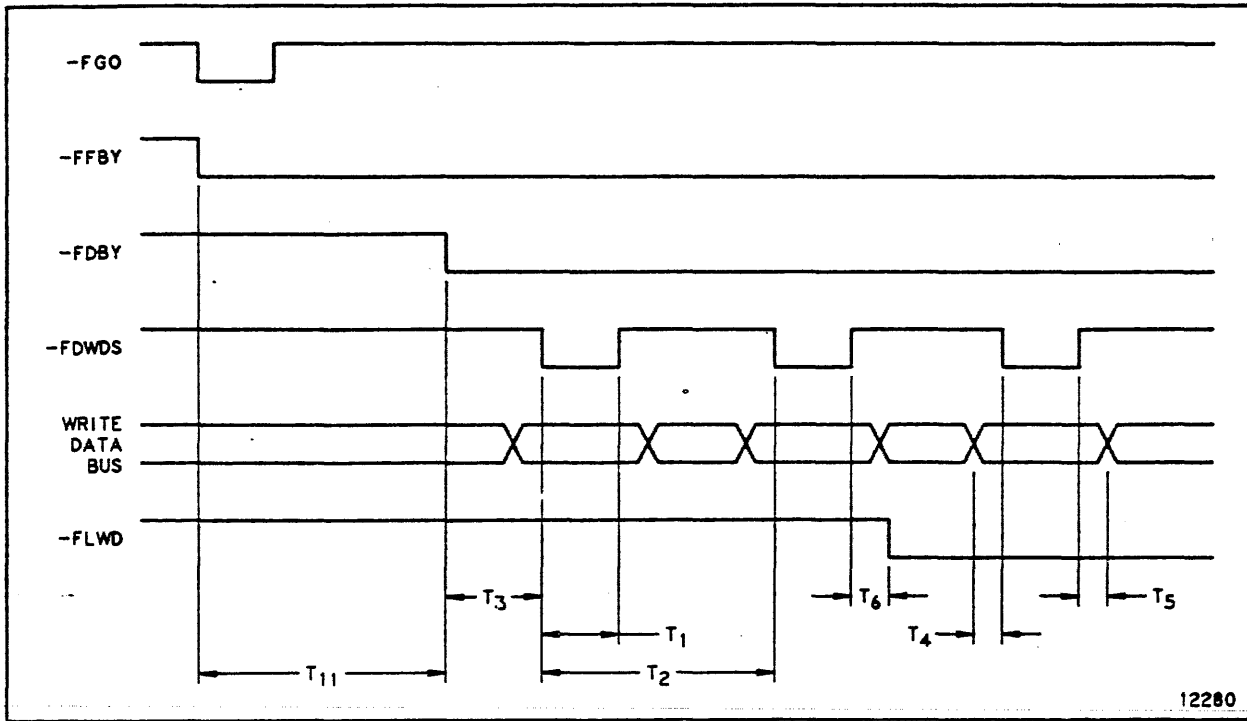
### 7.7.15 Read Data Strobe (FRSTR)

This signal, FRSTR, consists of a pulse for each character of read information to be transmitted to the host controller interface and should be used to sample the Read Data lines (FRD0-7 and FRDP). This signal is also asserted when Demand Write Data Strobe is asserted. Read timing is specified in Figure 7-5 and Tables 7-5, 7-6, and 7-7. The data rate switches should be set to the minimum values specified in Table 7-7 when in long-record mode.

### 7.7.16 Read Data Lines 0-7, P (FRD0-7, FRDP)

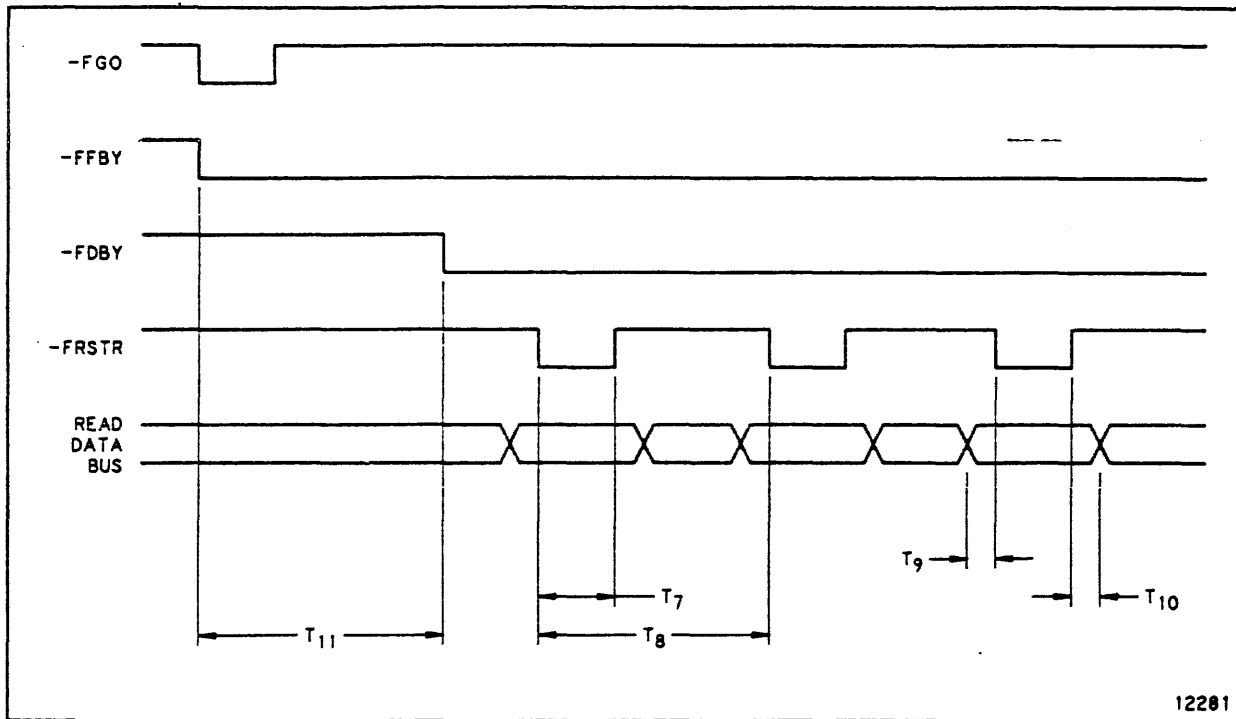
These nine lines transmit read data from the MTS to the customer controller. Each character read from tape is available by sampling these lines in parallel with the Read Data Strobe. FRD0 contains the most significant bit of data.

The Read Data lines (FRD0-7, FRDP) are also used to transfer sense information. Parity is also sent when doing a Sense command. For further information see the section entitled "Sense Command" in this chapter, and the section entitled "Read Extended Sense" in Chapter 5.



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Figure 7-4. Write Timing



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Figure 7-5. Read Timing

Table 7-5. Interface Timing

Time	Description	Tape Speed (IPS)	Models	Min. Time Nanosec.	Max. Time Nanosec.
T1	Write Strobe Pulse Width	50/100	2925	See Table 7-6	
T2	Write Cycle	50/100	2925	See Table 7-6	
T3	Data Busy to First Write Data	50/100	2925	---	10,000
T4	Write Data Setup to Leading Edge of Write Strobe	50/100	2925	200	---
T5	Write Data Hold from Trailing Edge of Write Strobe	50/100	2925	-0-	---
T6	Trailing Edge of FDWDS to FLWD	50/100	2925	10	Before Next FDWD Cycle
T7	Read Strobe Pulse Width	50/100	2925	See Table 7-6	
T8	Read Cycle	50/100	2925	See Table 7-6	
T9	Read Data to Read Strobe Setup	50/100	2925	100	---
T10	Read Data from Read Strobe Hold	50/100	2925	100	---
T11	FGO to FDBY	50/100	2925	See Table 7-7	

## 7.8 FUNCTIONAL MODE COMMAND DESCRIPTIONS

The interface command lines that are active for the following commands are listed in Table 7-4 above.

### 7.8.1 Read Forward Command

#### 7.8.1.1 NON-CACHED OPERATION

The Read Forward command causes:

**Table 7-6. Data Transfer Timing**

Data Rate Switches 7 2 1	Host Data Rate	Data Cycle Time	Read Strobe Width	Write Strobe Width
0 0 0	121 Kb/s	8.26 us	1 us	1 us
0 0 1	151 Kb/s	6.62 us	1 us	1 us
0 1 0	178 Kb/s	5.62 us	1 us	1 us
0 1 1	200 Kb/s	5.00 us	1 us	1 us
1 0 0	227 Kb/s	4.41 us	1 us	1 us
1 0 1	250 Kb/s	4.00 us	1 us	1 us
1 1 0	277 Kb/s	3.61 us	1 us	1 us
1 1 1	385 Kb/s	2.60 us	1 us	1 us

Note: Timings shown in this table are nominal. Worst case is nominal plus or minus 100 nanoseconds.

**Table 7-7. Ramp Times**

Ramp Switch Settings	T14, Ramp Time (millisec.)
4 3	Delay
0 0	0
0 1	1
1 0	2
1 1	5

- The tape to move in the forward direction and read the next block of data, and
- The data to transferred until end-of-data is detected. Note that Last Word (FLWD) is ignored on a Read.

Non-data characters of the block are detected, decoded, and checked for validity, but not transferred across the interface. Data characters of the block are detected, decoded, checked for validity, corrected if appropriate and transferred across the interface.



The Read command sequence is as follows:

1. The user asserts the Read command and FGO line.
2. MTS acknowledges the FGO line was asserted by asserting Formatter Busy (FFBY).
3. MTS sets up for the Read command and motion is started (or continued) and Data Busy (FDBY) is asserted.
4. MTS asserts Read Data Strobe (FRSTR) pulses for each data byte transferred.
5. When data is finished and status is complete, the MTS unasserts Data Busy (FDBY) to enable the user to read the status and issue the next command.
6. If the user does not give another command the drive begins to decelerate and Formatter Busy (FFBY) is unasserted.

#### 7.8.1.2 CACHED OPERATION (MULTIPLE BUFFERED RECORDS)

The RDF command causes the next block of data to be transferred from the cache memory to the host. Generally, a series of Read records are read ahead from tape and held in the cache memory for later transfer to the host. If an uncorrectable error is encountered when reading ahead from tape, the MTS backspaces and rereads the record, repeating this error recovery process the number of times selected, either 0, 5, 10, or 15 times. If zero is selected, no retries are attempted. When the host interface requests the block in error, Data Check is asserted at the end of the data transfer. The host can then command further recovery procedures if desired.

When reading ahead from tape, if EOT is encountered, no further blocks are read unless the host interface catches up to physical tape and commands further Reads. Then the MTS only reads one data block from tape at a time.

When reading a record from tape that is presently being requested by the host, any error status is given directly to the host and no retry procedures are automatically attempted.

The read command sequence is the same as for non-cached operation, except that FFBY may remain asserted between commands.

#### 7.8.1.3 READ FORWARD/TAPE MARK BLOCKS

### 7.8.1.3.1 Non-Cached Operation

When an RDF operation is initiated, but the next block is a tape mark block, the MTS moves the tape past the tape mark and asserts File Mark Detected (FFMK). A data block will not have been processed and no data characters will have been transferred across the interface. No signal responses will have been requested from the user interface.

### 7.8.1.3.2 Cached Operation (Multiple Buffered Records)

If the switches indicate to synchronize on one tape mark and a tape mark block is read from tape, the MTS will read ahead commands to the tape drive and wait for the host to break the RDF command string or request a read of the tape mark block. If the hardware switches indicate to synchronize on two tape marks in a row and one TM block is detected, the MTS will issue a series of RDF commands internally. If two tape marks in a row are encountered, the MTS will halt tape motion, for example, not issue any more read ahead commands. The MTS then waits for the host to break the RDF command string or issue a command after reading the second tape mark. At that time the MTS will execute the command issued and begin reading ahead again if appropriate.

## 7.8.2 Read Reverse Command

Similar to the Read Forward command, but with backward tape motion. Data is not read ahead on Read Reverse when in cached operation.

## 7.8.3 Write Command

### 7.8.3.1 NON-CACHED OPERATION

The Write command causes:

- The tape to move in the forward direction,
- The tape to move to the ending portion of the preceding IBG to be written,
- The data block to be written,
- The data block to be read and checked for validity, and
- The beginning portion of the next IBG to be generated.

Non-data characters of the data block are automatically generated, encoded, formatted, and written. Data characters to

be written are transferred across the interface, automatically encoded, formatted, and written.

The Write command sequence is as follows:

1. The user asserts Write command and FGO line.
2. MTS acknowledges the FGO line was asserted by asserting Formatter Busy (FFBY).
3. MTS acknowledges Write by starting (or continuing) motion and asserting Data Busy (FDBY).
4. MTS asserts Demand Write Data Strobe (FDWDS) pulses until the user asserts Last Word (FLWD). (There are no user responses; data is assumed to be correct and on time.)
5. MTS continues to move the tape to perform a read back check.
6. When data is finished and status is completed, the MTS unasserts Data Busy (FDBY) to enable the user to read the status and issue the next command.
7. If the user does not give another command the drive begins to decelerate and Formatter Busy (FFBY) is unasserted.

#### 7.8.3.2 CACHED OPERATION (MULTIPLE BUFFERED RECORDS)

The WRT command causes the next data block to be transferred from the host to the cache memory. Generally, a series of WRT commands causes multiple records to be held in cache memory for later transfer to tape. If an error is encountered when writing to tape, the cache control will backspace, erase a portion of tape, and try to rewrite the record. This error recovery process is repeated the number of times selected, either 5, 10, or 15 times. If the data cannot be written to tape, Hard Error (FHER) is asserted on the next available command, and no other commands can be executed until a Read Controller Sense command transfers the appropriate status to the host.

#### 7.8.3.3 WRT/EARLY EOT (BUFFERED MODE)

When the unit is writing in buffered mode, a number of records may be present in the buffer at any given time. When the MTS determines that the tape is approaching the end-of-recording area, the maximum number of records in the buffer is reduced to 1 or 4 as indicated by the switches. This ensures that no more than 1 or 4 records will be written after the end-of-recording area is encountered without the host's knowledge. After the end-of-recording area is reached, only 1 record maximum is allowed in the buffer so that status is not given to the host

until this record has been written to tape. A parity generator is selectable by way of a jumper.

### 7.8.4 Write Tape Mark Command

The Write Tape Mark command causes the tape to be moved forward, and a tape mark block to be written and checked for validity. Two retries are automatically done, if required.

### 7.8.5 Write Extended Command

This command allows the user to set the cache mode. A one-byte "write" transfer is required to completely define the operation. Formatter Busy (FFBY) and Data Busy (FDBY) remain asserted throughout the transfer. The FDWDS pulse width may be wider than normal for this transfer. The byte sent is defined in Table 4-6.

Table 7-8. Speed/Gap Selection Decodes and Cache Mode Set Decode

BITS OF LAST DATA BYTE								MODE SELECTED
7	6	5	4	3	2	1	0	
Y3	Y2	Y1	Y0	X3	X2	X1	X0	
Where Allowable 'X' Values Are:								
	X3	X2	X1	X0				
	0	0	0	0				No Change in MTS Mode
	0	0	0	1				Set to Buffered Mode
	0	0	1	0				Set to Long-Record Mode
	0	1	0	0				Set to Cache Data Mode

The set buffered mode command causes normal cache buffer operation, generally storing multiple records in cache memory. The set long-record mode command causes the opposite mode, keeping physical tape synchronized to the host interface, generally storing less than one record in cache memory. Long-record mode must be selected for records longer than cache memory.

Set cache data mode will cause data to be read from or written to cache memory only, without using physical tape.

If the MTS is in cache data mode, selecting buffered or long-record mode will cause the MTS to exit cache data mode and begin normal tape data processing. Bits 4, 5, 6, and 7 should always be zero in the byte described in Table 4-6.

## 7.8.6 Fixed Erase/Erase Gap Command

The Erase Gap command moves the tape forward and erases a 3.6 inch (nominal) section of tape in PE, or a 3.4 inch (nominal) section in GCR. During the erase operation, read checks are performed to verify that erasure has occurred. If Read signals are detected, Data Check is asserted in status byte 0.

## 7.8.7 Controlled Erase Command

The Controlled Erase command causes the MTS to accelerate the tape and erase the tape continuously until the Last Word signal (FLWD) from the user is set true. This terminates the erase operation. The ID burst is written when an Erase command is given from BOT.

Write strobe is not asserted during this command.

## 7.8.8 Security Erase Command

The Security Erase command causes the MTS to erase tape from its present position to a position approximately 10 feet past EOT. The ID burst is written when the command is given from BOT.

## 7.8.9 Space Forward Command

The Space Forward command causes the tape to move forward, passing over one block of data. If no new command is given while Data Busy (FDBY) is unasserted and Formatter Busy (FFBY) is still asserted, tape motion will stop. No data characters are checked for validity or transferred across the interface.

## 7.8.10 Space Reverse Command

The Space Reverse command causes the tape to move backwards, passing over one block of data. If no new command is given while Data Busy (FDBY) is unasserted and Formatter Busy (FFBY) is still asserted, tape motion will stop. No data characters are checked for validity or transferred across the interface.

## 7.8.11 File Mark Search Forward Command (Ignore Data)

File Mark Search Forward command causes the tape to move forward, passing over each data block encountered until a tape mark block is detected. Tape motion is then halted. Data characters are not checked and transferred over the interface.

## 7.8.12 File Mark Search Reverse Command (Ignore Data)

File Mark Search Reverse command causes the tape to move backward, passing over each data block encountered until a tape mark block is detected. Tape motion is then halted. Data characters are not checked and transferred over the interface.

## 7.8.13 Select PE Density Command

This command is issued by the host to put the MTS in PE mode. The dropping of Formatter Busy (FFBY) indicates completion of the command. This command will be accepted only when the tape is either unloaded or loaded at BOT.

## 7.8.14 Select GCR Density Command

This command is issued by the host to put the MTS in GCR mode. The dropping of Formatter Busy (FFBY) indicates completion of the command. This command will be accepted only when the tape is either unloaded or loaded at BOT.

## 7.8.15 Rewind Command

See paragraph 7.6.4.

## 7.8.16 Offline Command

See paragraph 7.6.4.

## 7.9 SENSE COMMANDS

### 7.9.1 Sense Data, 8 Bytes

Eight bytes of sense data are asserted on the Read Bus after a Sense command is issued. The MTS puts the first byte of data on the Read Bus, then asserts and unasserts the Read Data Strobe (FRSTR) line. The FRSTR pulse width may be wider than normal. The next byte is then put on the Read Bus and FRSTR is asserted and unasserted. This procedure is repeated until all 8 bytes have been transferred to the host or controller. The status bits defined below are listed 0 to 7. The 0 represents the most significant bit of data and is transferred on FRD0. Odd parity is also transferred with each sense byte (FRDP) to ensure data integrity. All unused bits are unasserted (zero).

## Sense Byte 0

### Bit

- 0 - Command Illegal - Set when the MTS receives an illegal command
- 1 - Not Ready - Set when the MTS is not ready
- 2 - Drive Type - Set when the MTS has the 100 ips streaming feature; reset when the MTS is start/stop only
- 3 - Equipment Check - Set when the MTS has a fault code on the operator display panel (FXX)
- 4 - Data Check - Set when the MTS has detected one or more of the error conditions in sense byte 3; and bits 0, 1, or 2 in sense byte 4
- 5 - Command Overrun - Set if a command is received with Data Busy (FDBY) true (also sets sense byte 0 bit 0)
- 6 - Unit Check - Set when bit 0, 1, 3, 4, or 5 of this sense byte 0 (this byte) is set
- 7 - Unit Exception - Set when an error correction is performed during a read operation (bits 0, 1, or 2 in sense byte 4)

## Sense Byte 1 (Last Command Issued)

### Bit

- 0 - Command bit 7 Spare 1
- 1 - Command bit 6 High Speed Select
- 2 - Command bit 5 Long Gap
- 3 - Command bit 4 Edit
- 4 - Command bit 3 Reverse
- 5 - Command bit 2 Write
- 6 - Command bit 1 Write File Mark
- 7 - Command bit 0 Erase

## Sense Byte 2 (Tape Status)

### Bit

- 0 - Backward Status
- 1 - Online
- 2 - Rewinding
- 3 - File Protected
- 4 - GCR (Density)
- 5 - High Speed (100 ips Streaming Mode)
- 6 - BOT
- 7 - EOT

### Sense Byte 3 and 4 (Hard Errors)

Sense byte 3 and sense byte 4 contain Data Check and Reject status information. Any error reported in byte 3 or 4 will also cause the Hard Error status line to be set.

### Sense Byte 3 (Hard Error R/W Status)

#### Bit

- 0 - Write Tape Mark Check
- 1 - Uncorrectable Error
- 2 - Partial Record
- 3 - Multiple Track Error
- 4 - Not Used
- 5 - End of Data Check
- 6 - Velocity Error
- 7 - CRC Error

### Sense Byte 4 (Hard Error Status Continued)

#### Bit

- 0 - BOT Reached before Backward Command was Completed
- 1 - Not Used
- 2 - Single Track Error in PE Write
- 3 - Not Used
- 4 - Command Reject (See Sense Byte 5, Reject Codes)  
Command was taken but could not be completed
- 5 - Bus Parity Error
- 6 - Operation Incomplete
- 7 - Overrun

### Sense Byte 5 (Reject Codes)

#### Bit

- 0 - Diagnostic Mode Set (MSB)
- 1 - Not Used
- 2 - Reject Code Bit 5
- 3 - Reject Code Bit 4
- 4 - Reject Code Bit 3
- 5 - Reject Code Bit 2
- 6 - Reject Code Bit 1
- 7 - Reject Code Bit 0 (LSB)

See Table 7-10 for further explanation of Reject Codes.

### Sense Byte 6 (Corrected Error and Dead Track P)

Sense byte 6 contains the Corrected Error status information. If the Corrected Error status line is set, either bit 0, 1, or 2 is set.

#### Bit

- 0 - Single Track in PE Read Corrected



- 1 - Single Track in GCR Read Corrected
- 2 - Double Track in GCR Read Corrected
- 3 - Nominal gap selected by last Write Extended command
- 4 - Nominal gap + 0.3 inch selected by the last Write  
Extended command
- 5 - Nominal gap + 0.6 inch selected by the last Write  
Extended command
- 6 - Not Used
- 7 - Dead Track P

Sense Byte 7 (Dead Track Register)

Bit

- 0 - Dead Track 0
- 1 - Dead Track 1
- 2 - Dead Track 2
- 3 - Dead Track 3
- 4 - Dead Track 4
- 5 - Dead Track 5
- 6 - Dead Track 6
- 7 - Dead Track 7

Table 7-9. Reject Codes  
(Sheet 1 of 2)

REJECT CODE (HEX)	DESCRIPTION
01	The MTS is not in Ready status.
02*	Internal Interface Error
03*	Reserved
04	Reserved
05	The MTS is in File Protect status when a write type command is attempted.
06*	The MTS did not go to Erase status only.
07	Illegal command sequence
08*	The MTS did not go to Read status.
09*	The MTS is unable to read a PE or GCR ID burst either during a read operation or during a read check while writing the ID burst.
0A	Reserved
0B	Reserved
0C*	The MTS did not go to Write status.
0D	Reserved
0E	Reserved
0F*	Noise (possibly data) was detected during an Erase Gap command or during a Write command following a read type command.
10*	The host has issued a READ in cache data mode and no record is in the buffer.
11*	The MTS reset Ready status.
12	Reserved

\* Operation Incomplete is also set (sense byte 4, bit 6).

Table 7-9. Reject Codes  
(Sheet 2 of 2)

REJECT CODE (HEX)	DESCRIPTION
13	A backward type command (except a Rewind or a Rewind/Unload command) was given, but tape was already positioned at BOT.
14*	The ARA BURST portion of the GCR ID burst just written did not have all nine tracks active.
15*	An IBG longer than 25 feet in PE mode or longer than 15 feet in GCR mode was detected on a Read or Space command.
16	More than one speed change requested without an intervening motion command.
17	Reserved
18*	The MTS is not in the recording density selected.
19	LWR attempted when tape loaded and positioned off BOT
1A*	No tape motion.
1B*	During a read back check of a write operation, data was detected in an IBG area.
1C	Reserved
1D*	The MTS attempted to backspace over a bad record just written but was unable to detect the record.
1E*	The ARA ID burst was unreadable during a GCR Write command.
1F*	During the read back check of a Write or Write Tape Mark command, no data was detected.
* Operation Incomplete is also set (sense byte 4, bit 6).	

## 7.9.2 Read Controller Sense

Thirty-two bytes are transferred to the host as defined in Table 7-10. This data could be used by the host system for data recovery procedures.

Table 7-10. Read Controller Sense  
(Sheet 1 of 2)

BYTE	BIT DEFINITIONS							
NUMBER	7	6	5	4	3	2	1	0
BYTES 0 - 5: Error Recovery Information For Read/Write Errors								
0	X	X	X	X	X	X	CACHE DATA MODE	SYNC MODE
1	WRITE ERROR	READ ERROR	DT PARITY	POSITION LOST	RETRY Bit 3	RETRY Bit 2	RETRY Bit 1	RETRY Bit 0
2	Number of Records which remain in the Buffer (may include a tape mark)							
3	Record Number from BOT in error MSB (includes Tape Marks)							
4	Record Number from BOT in error							
5	Record Number from BOT in error LSB							
BYTES 6 - 9: Status Information At The Time Of First Error								
6	Dead Tracks 7-0 at time of first Write or Read Retry							
7	EOT STATUS	BOT PARITY	CACHE PARITY ERROR	DATA CHECK	DRIVE BUPER	OVER- RUN	REJECT	EPROM ERROR
8	WTM CHECK	UCE	PARTIAL RECORD	MTE	CRC ERROR	EDC	VEL ERROR	CACHE CRC ERROR
9	Diagnostic Aid Bits at time of first Write or Read Retry							

Table 7-10. Read Controller Sense  
(Sheet 2 of 2)

BYTE NUMBER	DEFINITIONS
Bytes 10-31: Error History Since The Last Unload Or SNS Command	
10	Read Forward Retry count since last unload or SNS
11	Read Backward Retry count since last unload or SNS
12	Write Retry Count since last unload or SNS
13	Number of Records which had Read Retries
14	Number of Records which had Write Retries
15	Track 0 Errors (Number of records with Track 0 dead)
16	Track 1 Errors (Number of records with Track 1 dead)
17	Track 2 Errors (Number of records with Track 2 dead)
18	Track 3 Errors (Number of records with Track 3 dead)
19	Track 4 Errors (Number of records with Track 4 dead)
20	Track 5 Errors (Number of records with Track 5 dead)
21	Track 6 Errors (Number of records with Track 6 dead)
22	Track 7 Errors (Number of records with Track 7 dead)
23	Track P Errors (Number of records with Track P dead)
24	CRC Error Count since last unload or SNS
25	Uncorrectable Error Count since last unload or SNS
26	Partial Record Count since last unload or SNS
27	Multiple Track Error Count since last unload or SNS
28	End of Data Check Count since last unload or SNS
29	Velocity Error Count since last unload or SNS
30	Cache CRC Error Count since last unload or SNS
31	Number of records successfully corrected (Corrected Error without Data Check)

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IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD

# CHAPTER 8

## FUNCTIONAL DESCRIPTION

### 8.1 INTRODUCTION

This chapter provides brief functional descriptions of the circuit cards of the MTS. Although the circuit cards are not repairable in the field, a basic knowledge of the functions of each card may be useful for troubleshooting and repair of the MTS. Refer to Figure 8-1 for a general block diagram of the MTS circuit cards.

### 8.2 INTERFACE/MICROPROCESSOR (IF CARD)

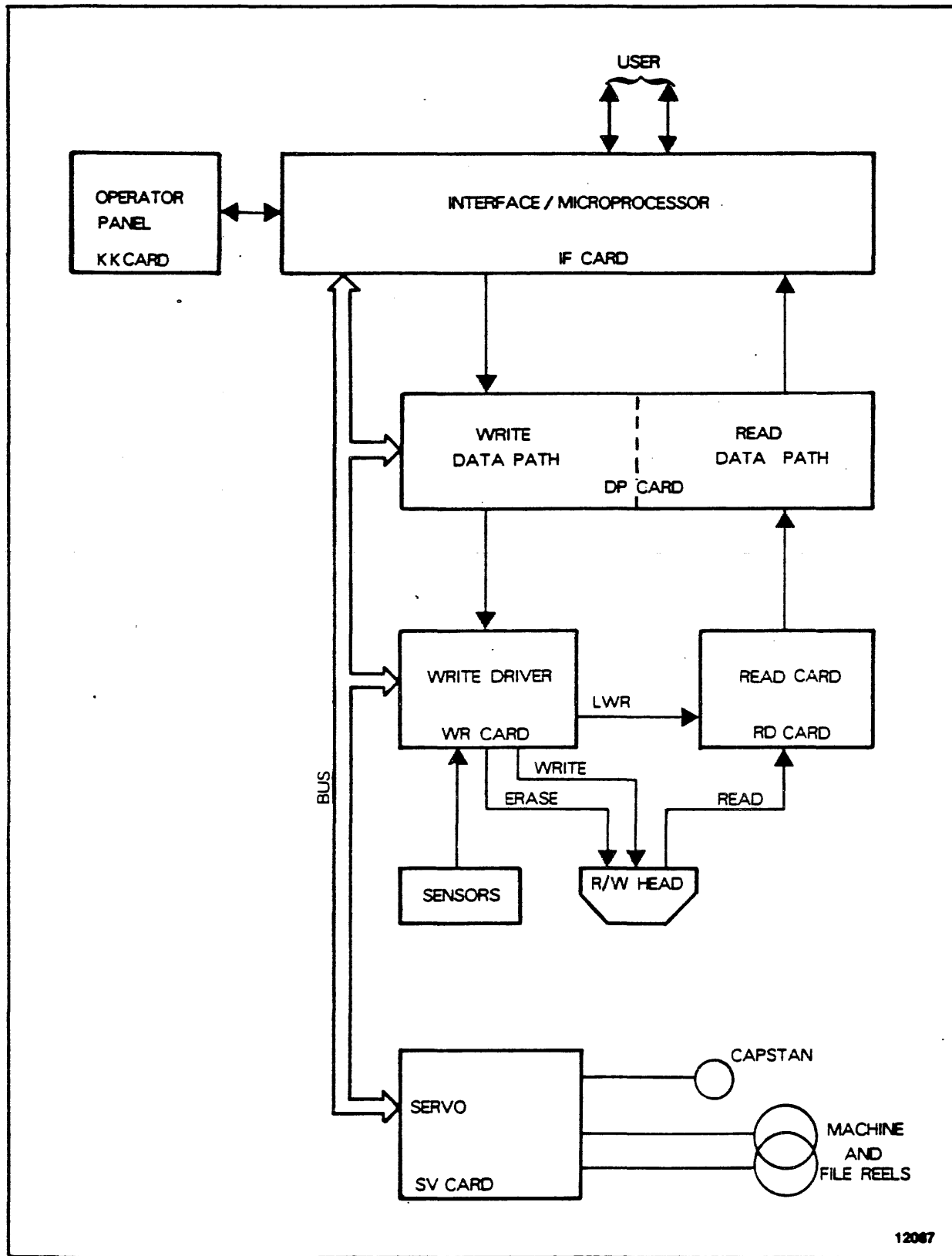
All functions of the MTS are controlled by the IF interface/microprocessor card (Figure 8-2). The microprocessor responds to commands from the operator panel and the USER, generates control signals for the capstan and reel servo systems, monitors the interlock and fault detection circuits, and provides status information to the operator panel and to the USER.

The 2921 memory is comprised of four EPROMs and the 2922 memory is comprised of five EPROMs, all plugged into sockets. One static RAM chip with 2K of RAM is available for functional and diagnostic storage. Two hundred fifty-six bytes of RAM is used for diagnostic storage and internal loop write to read. The 256 bytes of RAM can be shut off from the Z80 and used as a source and receiver of "Simulated Data" to provide the ability to run diagnostics in a standalone mode. All Z80 controls and status are sent to and from other circuit cards through the Z80 bus.

Functional Code		Diagnostics Code	
50 ips	100 ips	50 ips	100 ips
16K	24K	16K	16K

The oscillator provides a 20.48 MHz reference frequency which is then divided by four to provide the Z80 microprocessor with a 5 MHz input clock. The frequency is divided by eight to provide a 2.5 MHz clock with a 25% duty cycle as master and slave clocks for the LSI chips. Power Up Reset clears all TTL status and starts the Z80 at instruction 0000. A Watchdog Timer is generated as a check on the code for the Z80. The Z80 retriggers the Watchdog Timer once every 10 milliseconds; otherwise, a non-maskable interrupt occurs which causes the Z80 to EPO, turning off all servo controls and reinitializing the MTS.





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Figure 8-1. MTS Block Diagram

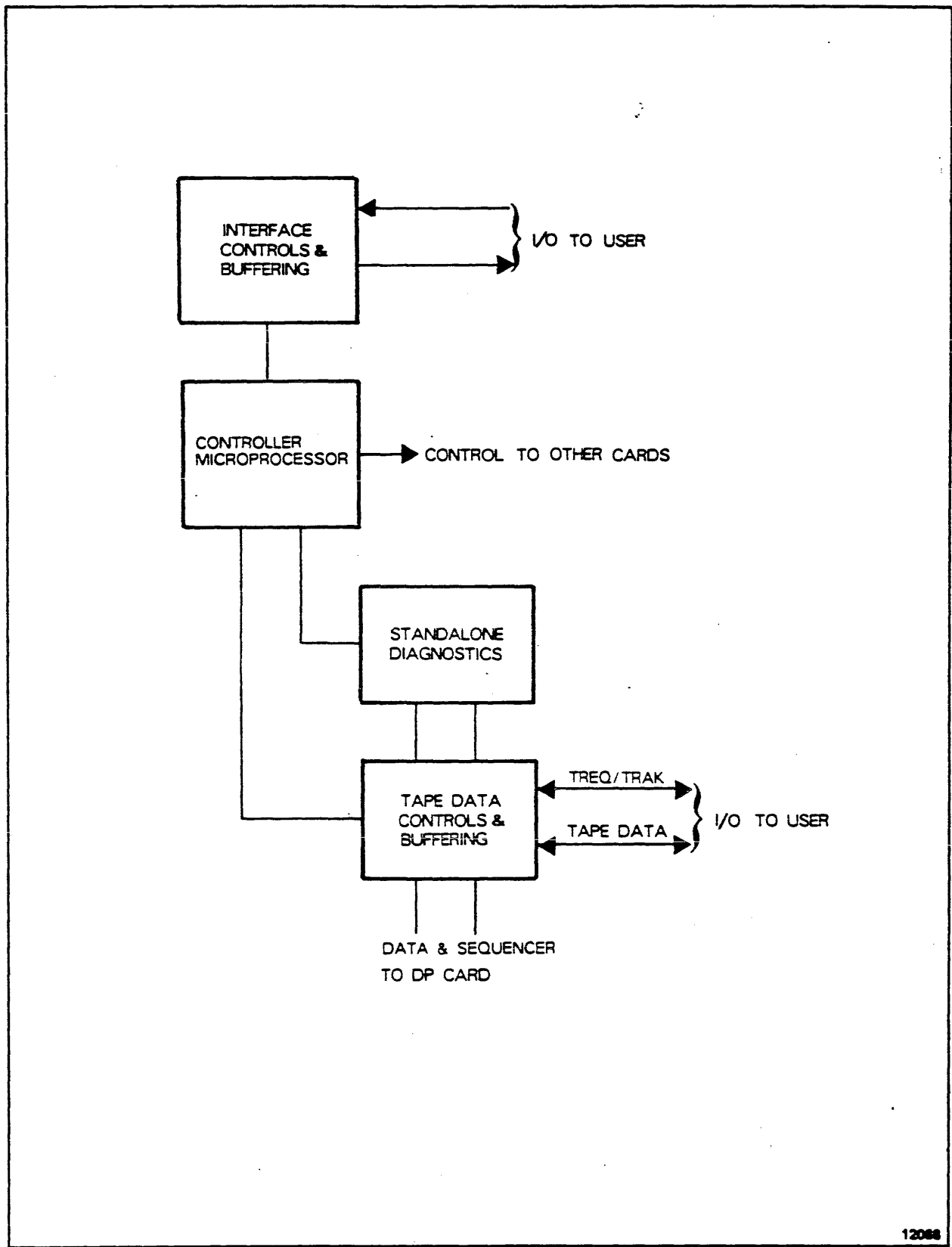


Figure 8-2. Interface/Microprocessor Block Diagram (IF Card)

### 8.3 WRITE DATA PATH (DP CARD)

The write data path of the DP data path card (Figure 8-3) is comprised of two CMOS LSI chips (XWC and XWD) and receives its data from a third dual-purpose LSI chip (XBR). XBR is used in both read and write modes and is used during write operation as a 7-byte FIFO to interface between the IF card and XWC.

Data is input to XBR via TREQ/TRAK handshaking sequences. Once XBR has data ready to be written, it signals XWC by raising Data Available. XWC accepts the data when needed and, upon taking the data, sends XBR a Write Strobe to indicate that the data byte has been accepted. This process continues until the interface raises STOP and XBR signals XWC that the last byte has been taken. Once the data has entered into XWC, check characters are generated for the data and it is clocked into XWD. The data is clocked out of XWD as write triggers.

XWC controls the overall format of data records which are to be written to tape. These records may be written in either PE format (1600 bpi density) or GCR format (6250 bpi density). XWC takes data from an interface data buffer, generates check characters for the data, and strobes the data into XWD.

When writing GCR format records, data bytes are processed in groups of four with the four data bytes being input, strobed into the check character generators, and output to the XWD. When writing PE format records, data bytes are processed one at a time with a data byte being loaded from the interface and then output to XWD.

Four Command lines and one Density Select line are used to control the operation of XWC:

C3	C2	C1	C0	
1	0	0	1	Write Data Record
1	0	1	0	Write ID
1	0	1	1	Write ARA Burst
1	1	0	0	Write ARA ID
1	1	1	1	Write Tape Mark

XWD inputs data from XWC and, in the case of GCR format, performs a 4-to-5 conversion on the data and outputs the data in the form of write triggers. In PE format, data is input from XWC and transformed into two write triggers (Data and Phase).

### 8.4 WRITE DRIVERS (WR CARD)

The basic write circuits are located on the WR write driver card (Figure 8-4). Erase and write functions are controlled by enables from the IF card. The logic establishes the proper head current

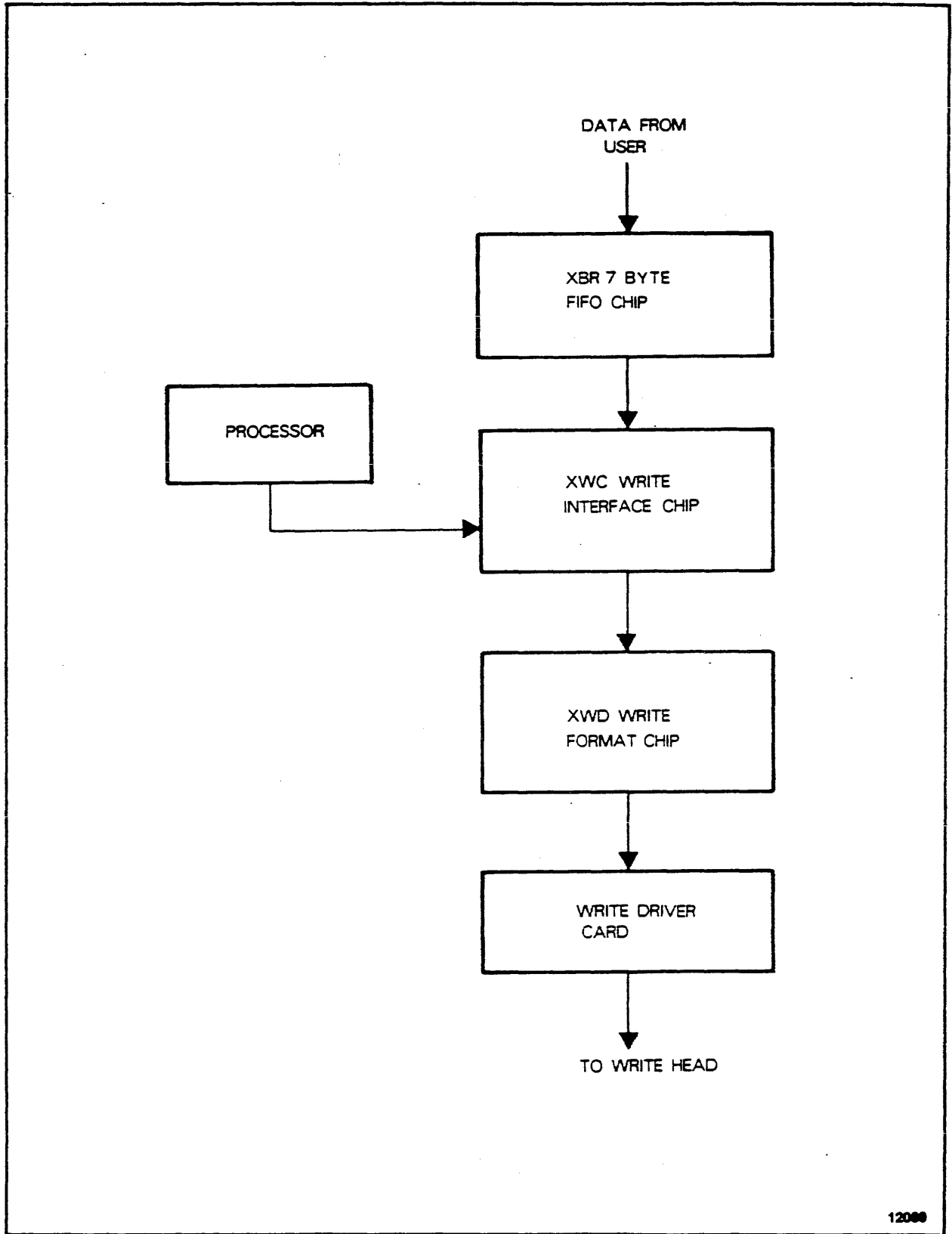


Figure 8-3. Write Path Block Diagram (DP Card)

for the specific density to be recorded and current sensing on each of the nine tracks is used to verify that write currents are of proper magnitude for the density. Hardware failures resulting in incorrect write or erase current produce a hardware interrupt which immediately stops the tape drive.

The WR card is also used for machine sensor circuits. The sensor circuits are used to detect tape present, BOT, EOT, the tape leader as it passes the entrance to the thread path, and the write enable ring (file protect). The machine reel and file reel index channels and the swing arms extended switch sensors are included on the card.

## 8.5 READ (RD CARD)

Each of the nine differential analog signals from the read head is amplified, filtered, and differentiated by the analog signal processing circuits on the RD read card (Figure 8-5). The resulting nine analog read signals at the bandpass filter output (+Dif Analog) are available at test points on the card before they are converted to digital read data by the limiter. The nominal single-ended analog signal amplitude, measured peak-to-valley at the test point, is 1.2 volts.

The analog signal at the bandpass filter output is monitored for amplitude integrity by the amp sensor. The analog signal zero-to-peak amplitude is compared to a threshold voltage level: either a fixed DC level, which represents the minimum acceptable worst-case analog amplitude; or an adaptive DC level, which represents a fixed percentage of the zero-to-peak analog amplitude. Whichever threshold voltage is higher at any instant in time will be the amp sensor threshold level. The threshold level is controlled by -Record Latch (-RL), +Write Mode (+WR), and +Write Triggers Active (+WTA). When the analog signal zero-to-peak amplitude is above the threshold level, the amp sense output switches to a high TTL level; when the analog signal level drops below the threshold level, the amp sense output switches to a low TTL level.

The loop write-to-read (LWR) multiplexer selects either Read Data from the limiter in normal operation or Write Triggers from the DP card in test mode.

Three CMOS LSI chips, each containing three tracks of logic, detect the phase of the data passed through the LWR multiplexer. This phase information is used in the phase-locked loop (PLL) to correct the frequency of the voltage-controlled oscillator (VCO). The VCO output, in turn, clocks the LSI chips at the proper rate in order to track tape velocity. The chips also convert the data from GCR format (6250 bpi density) or PE format (1600 bpi density) to NRZ (non-return-to-zero) format. NRZ data and clocks for each track are output to the DP card.

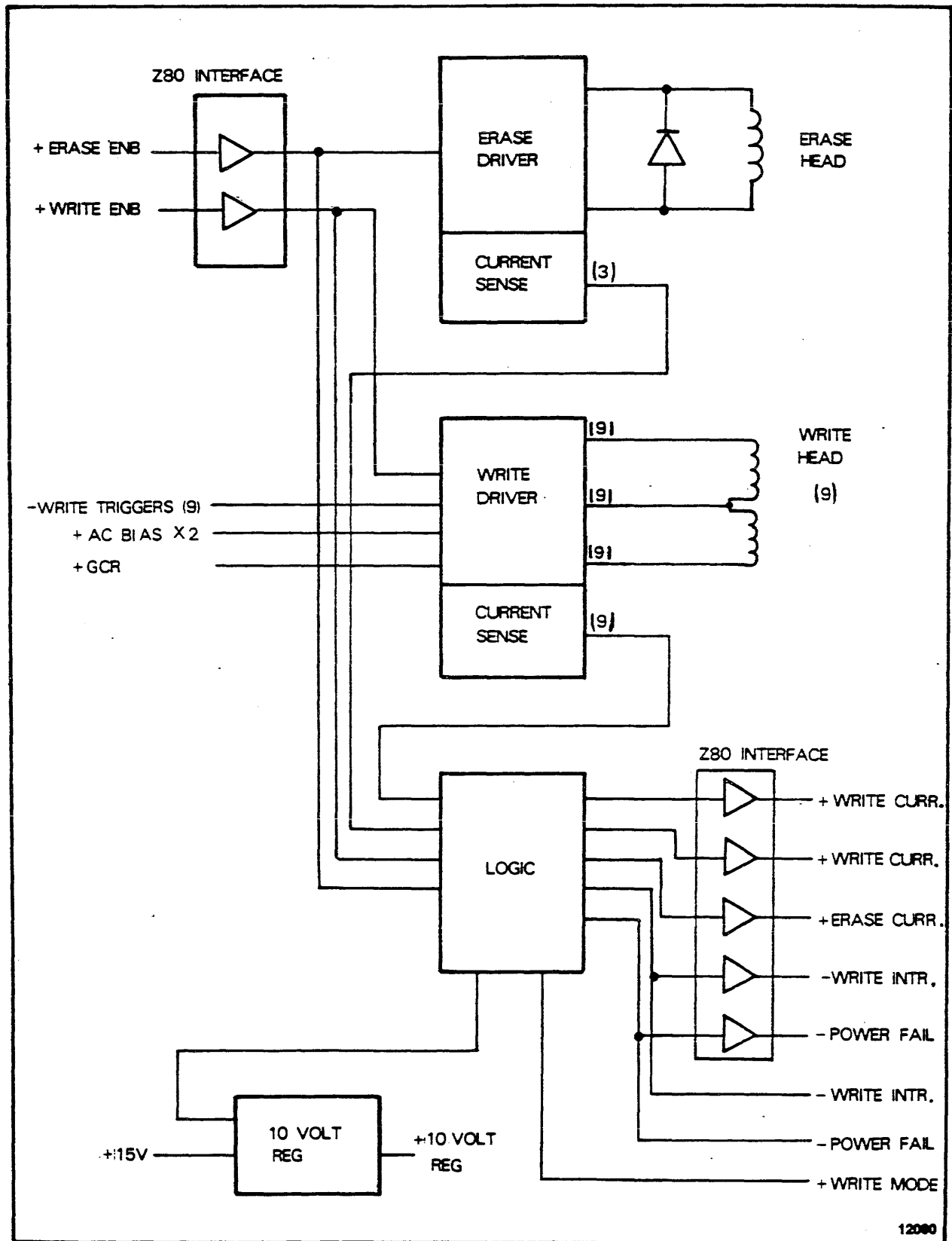


Figure 8-4. Write Driver Block Diagram (WR Card)

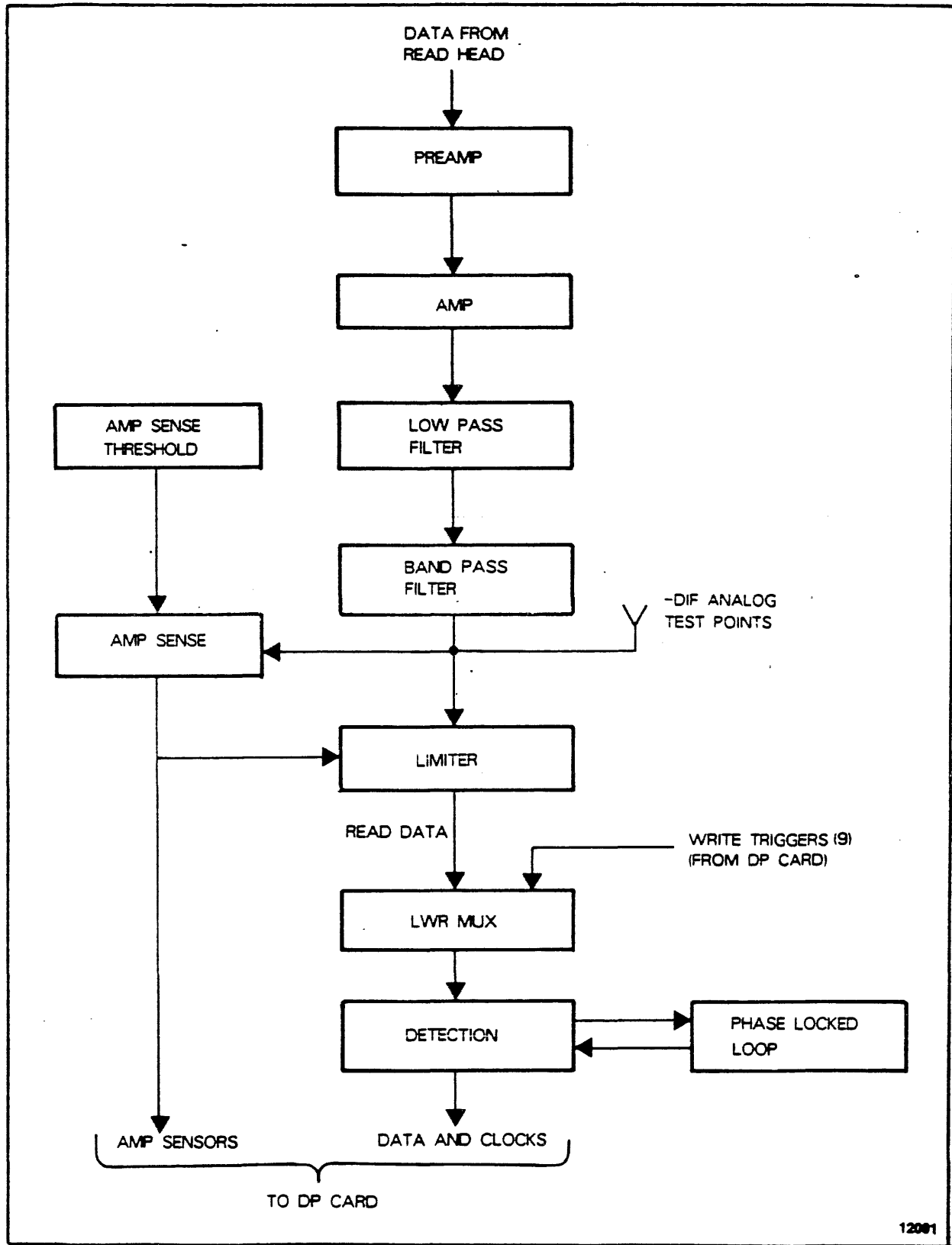


Figure 8-5. Read Block Diagram (RD Card)

## 8.6 READ DATA PATH (DP CARD)

The read data path of the DP card (Figure 8-6) receives its data input from the RD read card. The data is processed on the DP card and output via TREQ/TRAK handshaking sequences to the interface.

### 8.6.1 PE Operation

PE (1600 bpi density) is handled in 5-byte groups. Data is fed into the XRB skew buffer from the digital detection circuit on the RD read card. Each track sets Track Ready when it has these five bytes available. All Track Ready signals feed XCR. With all tracks ready, a Load Group Buffer pulse occurs followed by four Shift Group Buffer pulses. These five pulses transfer the five bytes from XRB to XEC and XBE. The data is actually stored only in XBE while XEC inputs each byte into the error correction system. After the fourth Shift Group Buffer, XEC sets ECC Full, preventing more transfers from XRB.

No correction cycle is required as correction is done on-the-fly; therefore, a Shift Out Mode is immediately initiated. During Shift Out Mode, data in XBE is transferred into the XBR data buffer with XEC supplying the proper correction. After the Shift Out Mode, ECC Full is reset and XRB can supply another 5-byte group to the XEC and XBE.

XBR now contains five bytes of corrected data, ready to be transferred to the interface; however, because of the method of PE end-of-data detection, XBR inhibits data transfer until it sees that ECC Full is set again. This is done so that a look-ahead function can be performed for determining PE end-of-data. This function checks the next group (the one in the XBE buffer) for four bytes of all-ZEROs. If the ending all-ONES byte of PE data is present on the output of XBR and the following four bytes are all-ZEROs, PE end-of-data is declared and the read process is stopped.

With XBR Buffer Full and ECC Full set, the interface data transfer is started via TREQ/TRAK handshake sequences. The XBR buffer will now be empty, allowing XEC to transfer another group out of the XBE buffer and into the XBR buffer. End of Data is set by XBR immediately after the last byte of data has been transferred to the interface.

### 8.6.2 GCR Operation

Handling of GCR (6250 bpi density) data differs slightly from that of PE. The major difference is that GCR data is handled in 8-byte groups. XRB assembles a 4-byte subgroup and sets Track Ready. These four bytes are then transferred to XEC and XBE with the four Shift Group Buffer pulses. The Load Group Buffer signal



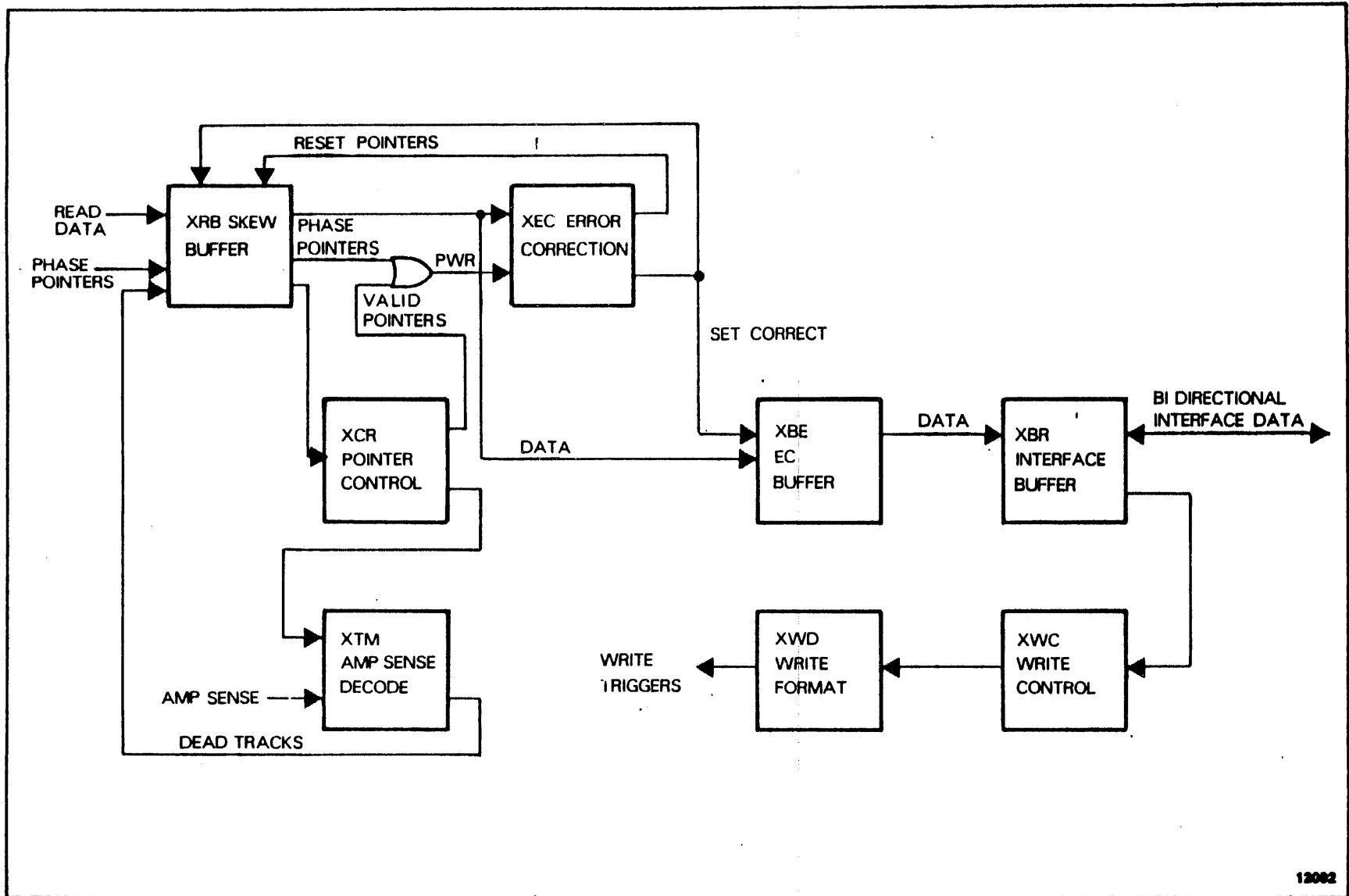


Figure 8-6. Read Path Block Diagram (DP Card)

does occur but data is not transferred with it; it is used by XEC to initialize registers between groups and by XBE to count groups. The next 4-byte subgroup is transferred from XRB and then ECC Full is set. XEC handles inputting of data to XBE by propagating Shift Group Buffer pulses. The ECC byte present in each 8-byte group is stripped from the group by XEC by blocking the last Shift Group Buffer (first Shift Group Buffer when reading backward) to XBE.

XEC now determines if a correction cycle is necessary and, if not, Shift Out Mode begins immediately. If correction is required, Shift Out Mode will be delayed by as much as 2.8 microseconds for 50 ips and 1.75 microseconds for 100 ips, the maximum duration of a correction cycle. Shift Out Mode is set for seven cycles (2.8 microseconds for 50 ips and 1.75 microseconds for 100 ips), during which time the seven bytes in XBE are transferred to the XBR data buffer while being corrected. XBR does not need to wait for another ECC Full to transfer data, so it will do seven transfers to the interface. The Shift Out Mode which filled the XBR buffer causes XBR Buffer Full to set and also causes ECC Full to reset. While XBR is transferring data to the interface, XRB may start filling XEC and XBE again. XEC may not do another Shift Out Mode until XBR has completed the seven transfers at which time it will reset XBR Buffer Full.

XBE determines the presence of the GCR format groups based on information supplied by XRB and XCR. XCR determines when End Mark is in XRB by looking at Sync Mark and Format signals from XRB. When End Mark is in XRB, XCR issues a Load Group Buffer pulse without any Shift Group Buffer pulses. End Mark is not loaded into XEC and XBE. In read forward, the next group is the Residual Group which is transferred from XBE to XBR while the Residual Group signal is on. This causes XBR to hold the Residual Group until the following CRC Group can be received and the residual byte of the CRC Group can be determined. The residual byte informs XBR how many bytes in the residual group are data and which are pads. At this time the last data transfers of the record occur and End of Data is set.

In GCR backward operations, the CRC and residual groups must be handled first and then operate as in forward read operations. The CRC Group comes into the XBR buffer first. The residual character is saved and the buffer waits for the residual group to be loaded. When it is in XBR, it determines the number of valid data bytes in the group and transfers them to the interface. The rest of the record is then processed normally. XBR does not do End of Data detection in GCR for read backward; XBE performs this function by sensing that the Mark 1 character has been detected and the appropriate number of ONEs in the preamble have been checked. End of Data is set after the last data byte has transferred.

## 8.7 SERVO SYSTEM (SV CARD)

The SV servo card contains the analog and digital circuits which comprise the capstan servo system, the two reel servo systems, the swing-arm retraction motor control, the emergency power-off (EPO) logic and relay control, and the servo power failure detector.

The SV card interfaces to the system microprocessor (which resides on the IF card); to the optical encoders, which are the servo transducers for the capstan motor and the swing-arms; to the capstan, reel, and arm retraction motors; to the EPO relay; and to the power supply. All of the interfaces are via connectors on the motherboard.

The capstan servo system (Figure 8-7) consists of a CMOS LSI controller which operates in conjunction with the system microprocessor. This LSI circuit generates digital commands which are converted to an analog voltage via a digital-to-analog converter (DAC). A linear power amplifier converts this voltage to motor drive current.

The reel servo system (Figure 8-8) consists of a CMOS LSI controller which operates in conjunction with the microprocessor. Digital commands to a set of twin DACs and pulse-width modulated power amplifiers generate the currents for the two reel motors.

The swing-arm retraction motor control is a bipolar power switch which operates under logical control of the microprocessor together with the reel servo controller chip.

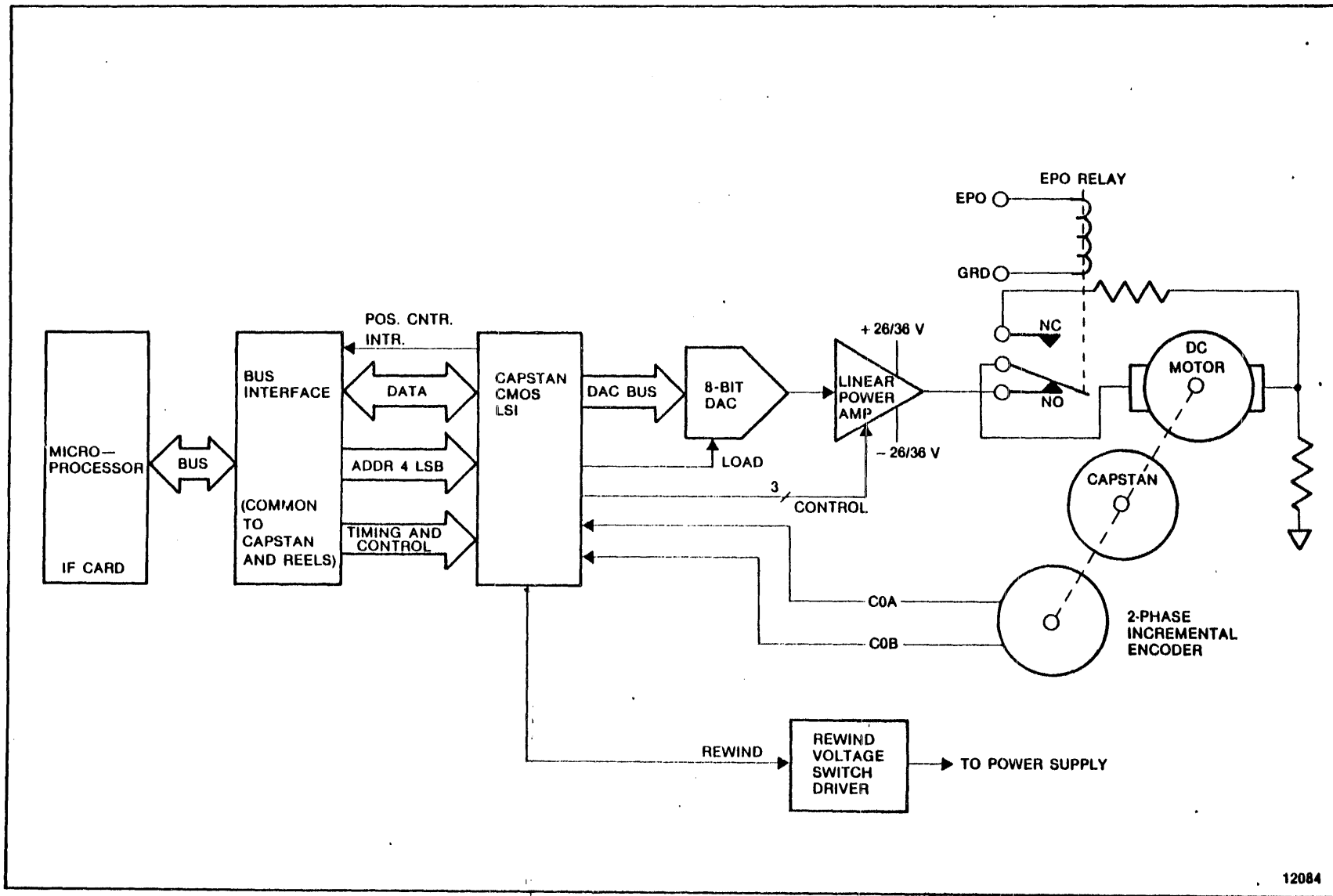
The EPO relay control consists of logic in the reel servo controller chip which generates the logical function that controls a regulated relay driver.

The power failure detector is a set of voltage comparator circuits which monitor the  $\pm 26/36$  volt and  $\pm 15$  volt power supplies for undervoltage. This circuit generates a logic signal which is one of the elements of the EPO control.

## 8.8 POWER SYSTEM

The power system is comprised of the main circuit breaker, the Power On/Off switch on the operator panel, a line filter, transformer, AK regulator card, PK protection card, and NK regulator card. Refer to Figure 8-11 for a simplified block diagram of the power system.

The power system provides logic voltages for the electronics and power voltages for the capstan and reel motor drives as well as the vacuum blower motor. In addition, 120 Vac is provided for the the cooling fan.



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Figure 8-7. Capstan Servo System Block Diagram

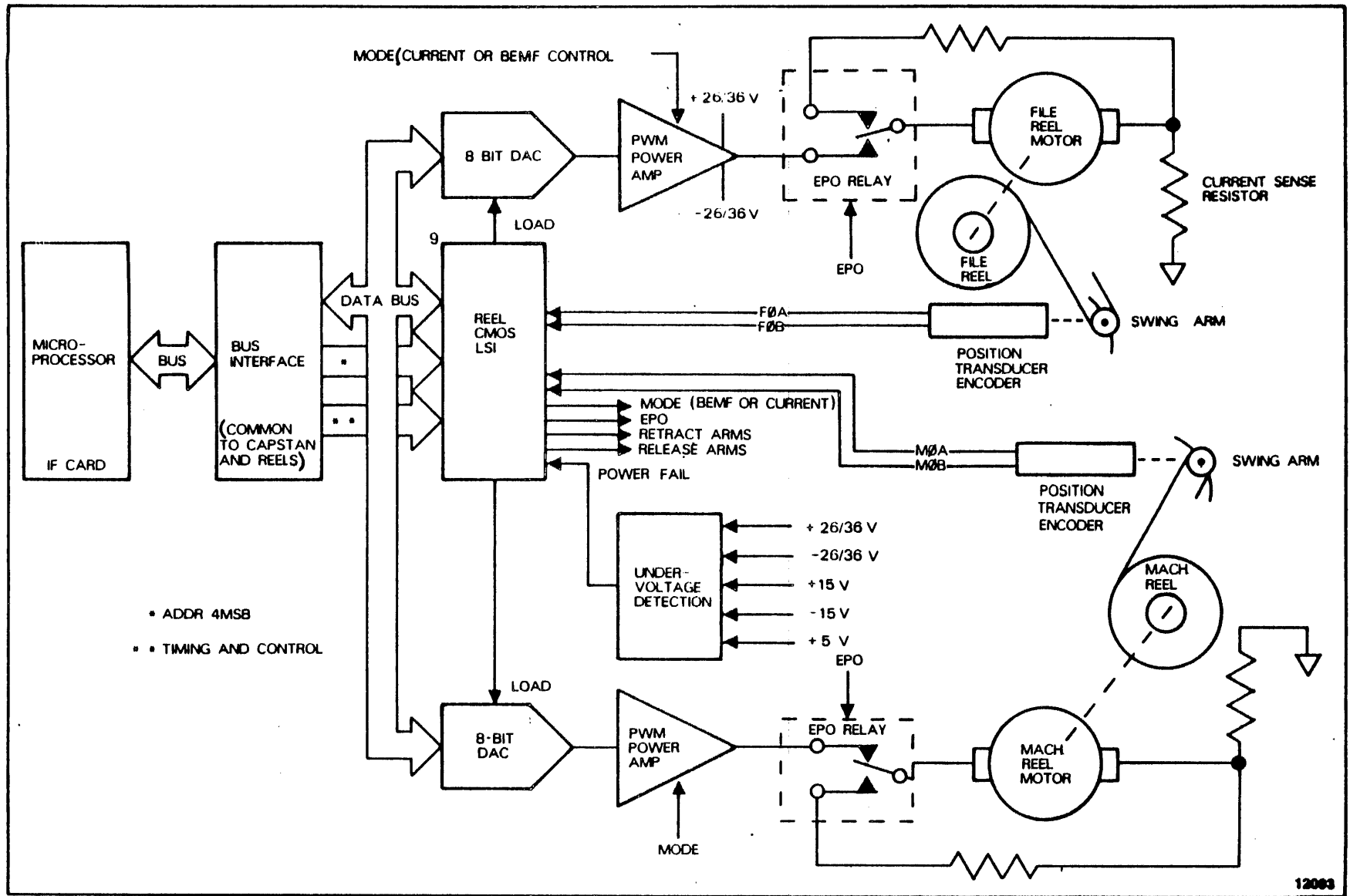


Figure 8-8. Reel Servo System Block Diagram

Overcurrent protection is provided by the PK protection card which will trip the main circuit breaker remotely if any power system output is shorted. A short on the primary will also trip the main circuit breaker. If an overvoltage of 5.7 volts (or higher) occurs on the +5 Vdc output, fuse F2 on the AK regulator card will open.

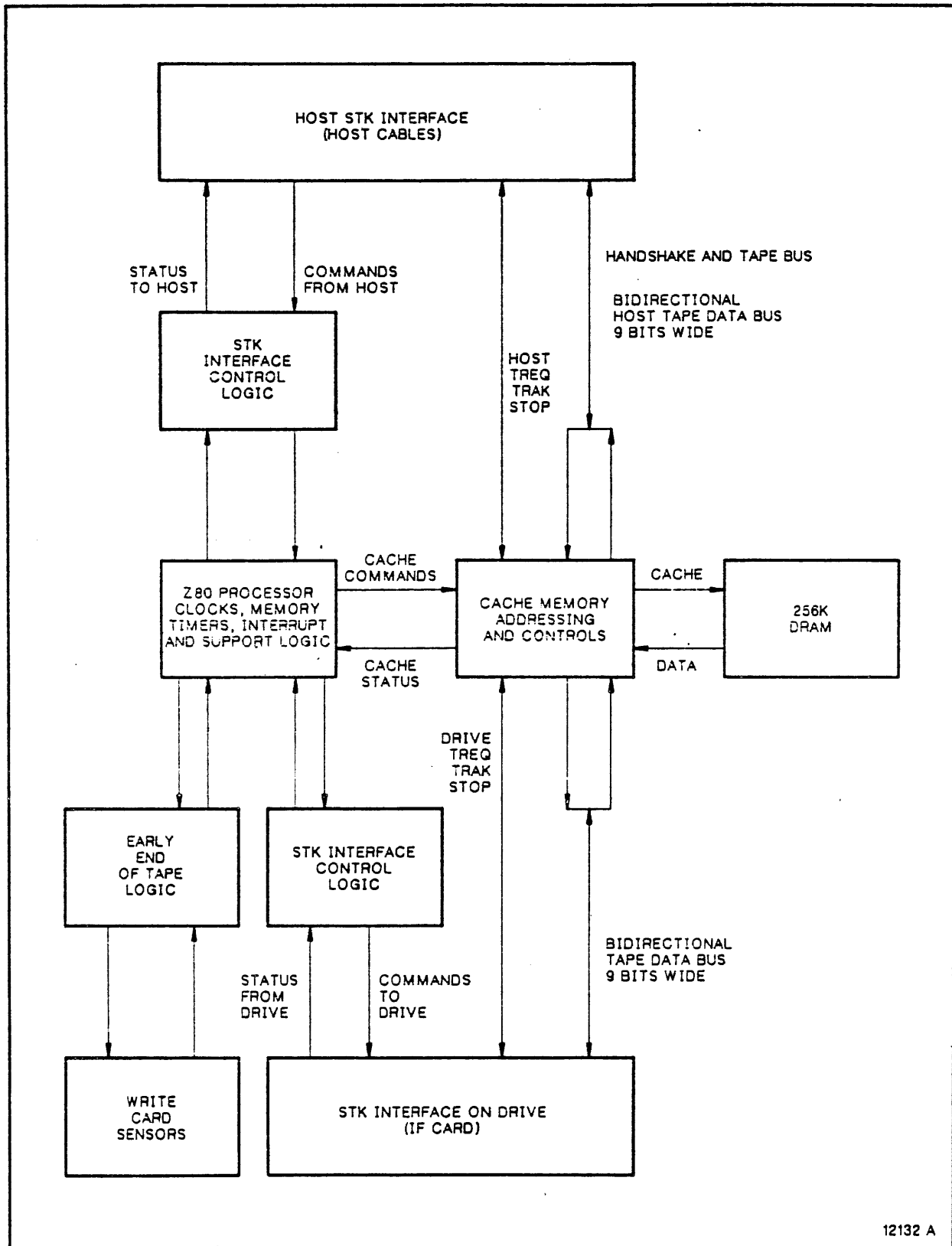
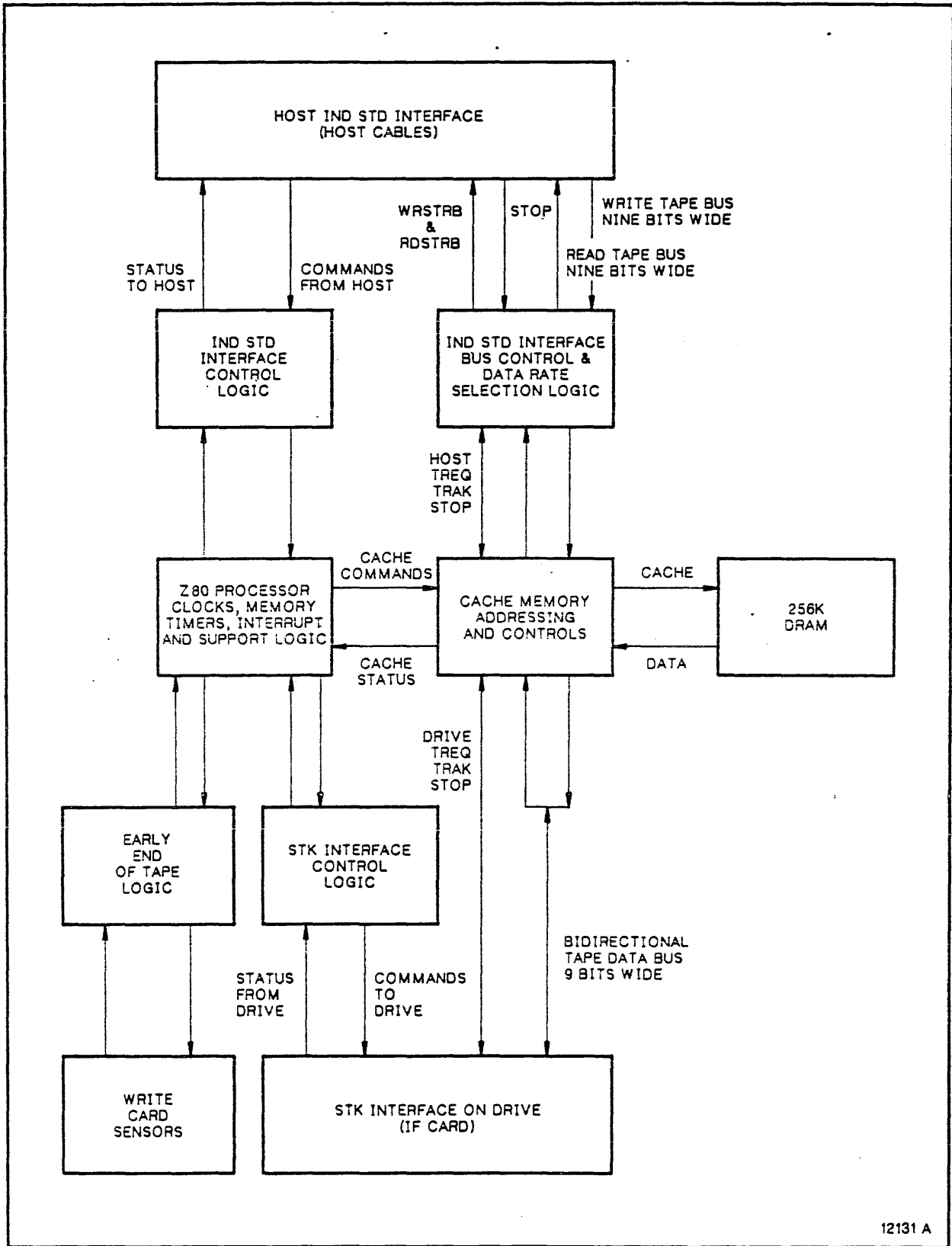


Figure 8-9. CB Card Block Diagram



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Figure 8-10. CP Card Block Diagram



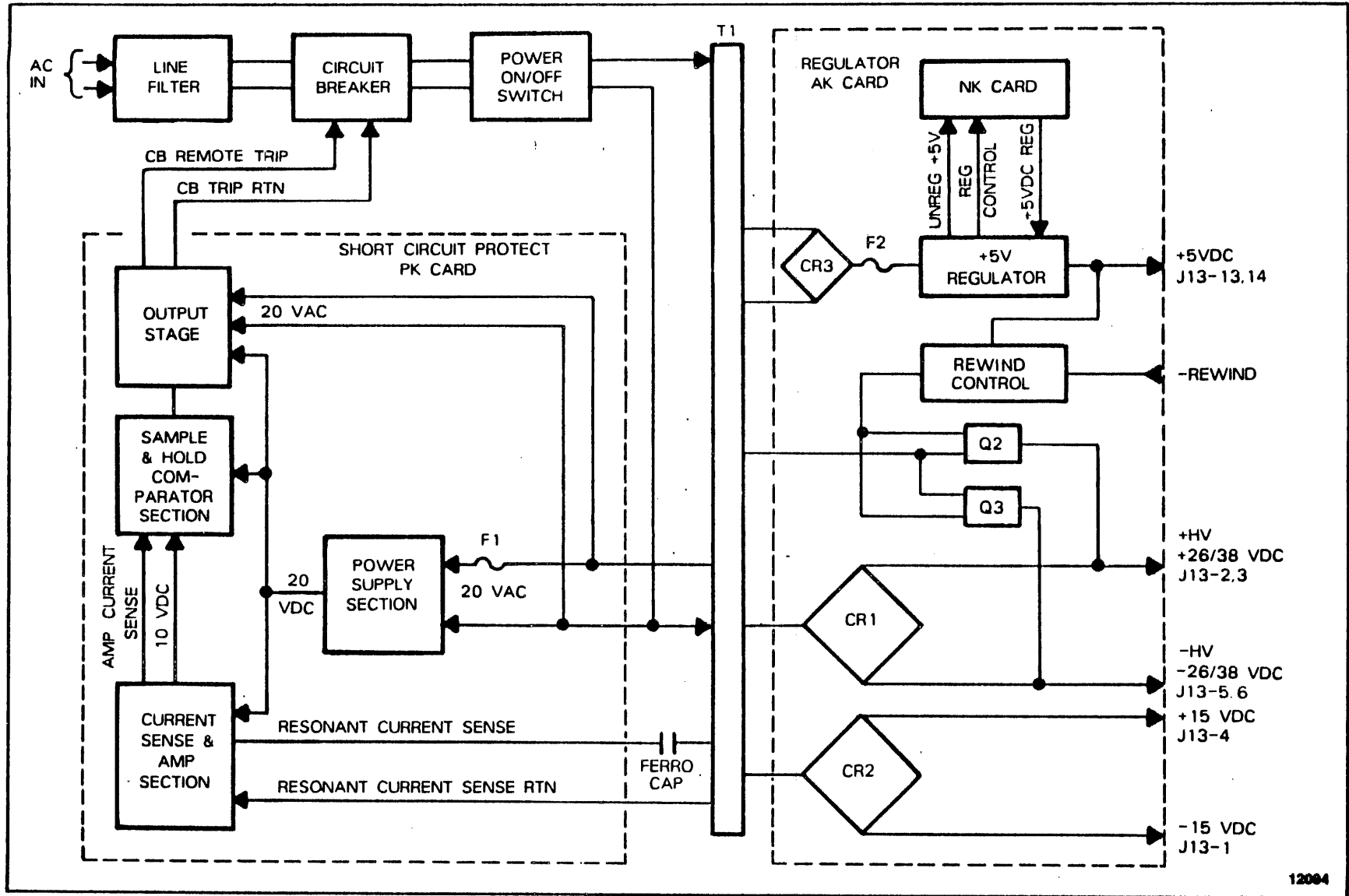


Figure 8-11. Power System Block Diagram

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21/22 IND STD FCD

2925 SCSI FCD

# CHAPTER 9

## MAINTENANCE

### 9.1 INTRODUCTION

This chapter provides instructions for the performance of maintenance procedures. Some of these procedures must be performed quarterly to ensure proper operation and at such times the MTS does not perform according to specifications. Other procedures should be performed only after parts replacements, or if the scheduled maintenance so indicates, as explained in the text. Should there be a defective part, Chapter 10 provides instructions for changing field replaceable parts. Operating procedures for maintenance programs are described in Chapter 11.

### 9.2 QUARTERLY PREVENTIVE MAINTENANCE CHECKLIST

The following is a checklist of the routine preventive maintenance to be performed quarterly by trained personnel.

1. With power off, check the file reel hub for free operation. Thoroughly clean as necessary with Hub and Transport Cleaner Fluid.
2. Remove the tape cleaner block. (Refer to Chapter 10 for removal procedures.) Thoroughly clean the block with Hub and Transport Cleaner Fluid. Inspect the cleaner block blade for damage in the form of scratches or nicks and replace the block if it is damaged.
3. With power on, ensure that the cooling fans are operating.
4. Check the power supply output levels. (Refer to paragraph 9.3.)
5. Check the file protect mechanism for proper operation using a work tape, both with and without a write enable ring installed. The Write Protect indicator light should be on with ring removed, and off with ring installed.
6. Check rewind for proper operation. Rewind time is about 2.5 minutes for 2400 feet of tape.
7. Check the read/write head for proper skew alignment, and adjust skew as necessary. (Refer to paragraph 9.5)
8. Check the read output amplitudes. (Refer to paragraph 9.7)

### 9.3 QUARTERLY POWER SUPPLY CHECK

The power supply output voltage levels are not adjustable. A failing voltage may be due to power supply or voltage regulator failure, or a defective circuit board. The tape may be loaded but should not be in motion except for checking the  $\pm 38$  Volts, when tape must be in rewind mode.

Voltage test points are on motherboard slot A1. Use pin B01 at slot A3 for ground.

Test Point	Voltage
A01	+5.1 ( $\pm 0.25$ ) Maximum ripple: 100 mV P-P
C03	+15 (+1.0, -1.5)
C01	-15 (+1.0, -1.5)
C05	+26 ( $\pm 4.0$ )
C17	-26 ( $\pm 4.0$ )
C05	+38 (32-42) In rewind only
C17	-38 (32-42) In rewind only

### 9.4 TAPE TRACKING AND SKEW ADJUSTMENT AFTER PARTS REPLACEMENT

Tape tracking and skew checks should be performed when any of the following components are replaced:

- Upper Swing Arm
- Lower Swing Arm
- Capstan
- Capstan Motor
- Read/Write Head
- Upper Tape Guide

An understanding of tape tracking and skew requirements is helpful in the performance of the capstan alignment (tape tracking) and read/write head alignment (skew) procedures: alignment of the capstan to the tape path assures that the tape does not take an angular path across the read/write head; alignment of the read/write head assures that the head is properly aligned with the tape. All tape tracking and skew alignment adjustments must be done with the MTS in 50 IPS mode.

Initial tape tracking adjustments are made visually to set coarse alignment and then a skew tape and oscilloscope are used for the final alignment to detect static and dynamic skew variations. Static skew, as shown in Figure 9-1, is the time from the peak of the bit used for the scope sync to the peak of any other bit. Dynamic skew, also shown in Figure 9-1, is the width of the variation or flutter of the bit not used as the scope sync. The two outside tracks (4 and 5) are used to check final alignment.

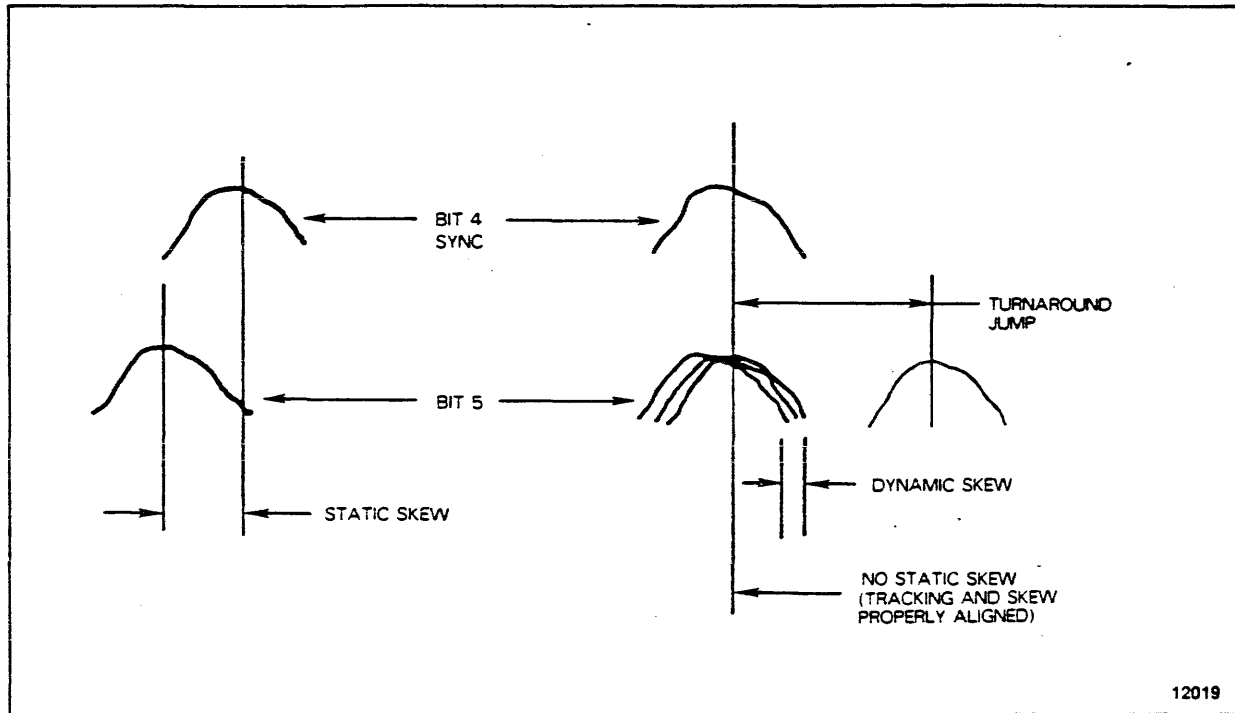


Figure 9-1. Static and Dynamic Skew and Turnaround Jump

### 9.4.1 Capstan Alignment (Tape Tracking)

The capstan motor is mounted with three spring-loaded screws. Adjusting the screws will influence the lateral position of the capstan wheel. The capstan wheel must be positioned so that the tape travels properly in the tape guide, as in the following procedure:

1. Open the threading cover and remove the outer flange from the upper tape guide.
2. Close the threading cover, mount and load a known good scratch tape, then open the threading cover to provide access for checks and adjustments.
3. Enter maintenance program 00 to move tape forward. Ensure that tape is flush with but not forced against the rear flange of the upper guide and is not riding over the front of the upper guide. If necessary, adjust capstan motor mounting screw 3. Refer to Table 9-1 and Figure 9-2.
4. Enter maintenance program 02 to perform the shoeshine routine (forward/backward tape motion). Ensure that tape is not

pushed against the back flange or hanging over the front of the tape guide in either forward or backward motion.

Table 9-1. Capstan Alignment Instructions

CONDITION	ADJUSTMENT
Tape tracks to front edge in both forward and backward	Turn screw 3 CW
Tape tracks to back edge in both forward and backward	Turn screw 3 CCW
Tape tracks to back in forward and tracks to front in backward	Turn screw 1 CW or turn screw 2 CCW
Tape tracks to front in forward and tracks to back in backward	Turn screw 1 CCW or turn screw 2 CW

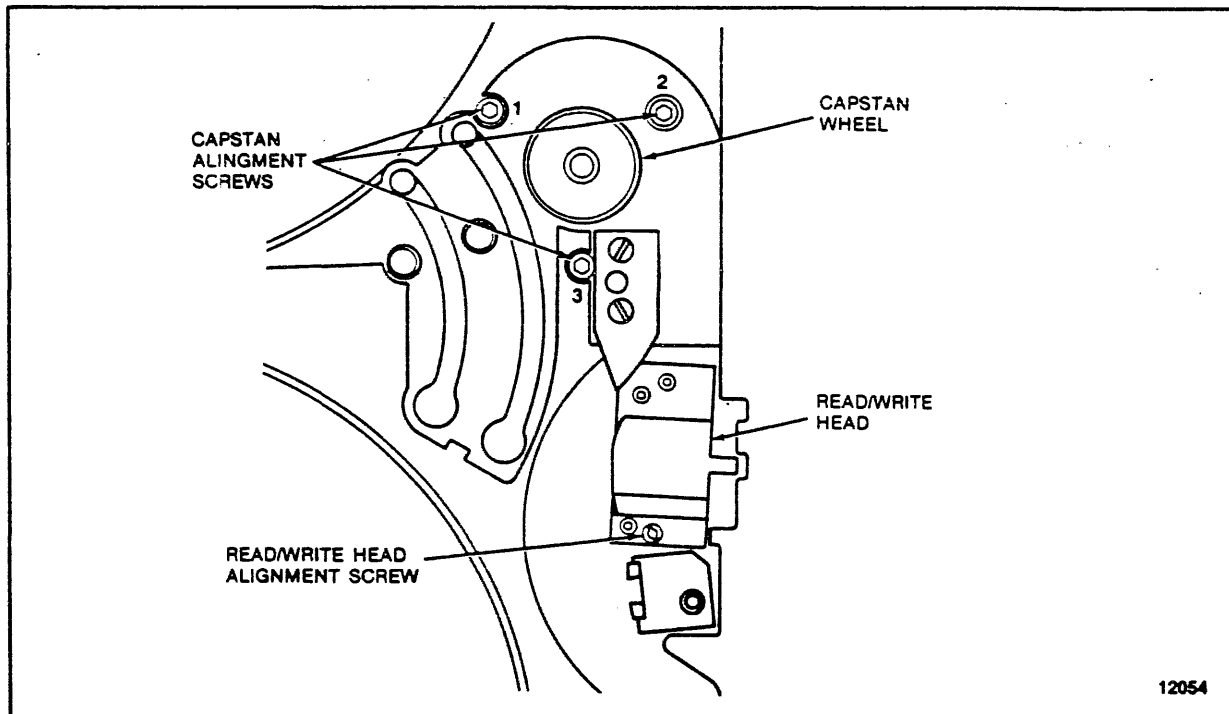


Figure 9-2. Capstan and Read/Write Head Alignment

If necessary, use instructions in Table 9-1 and Figure 9-2 to adjust tracking so that the tape travels in the same position on the guide in both forward and backward directions.

Ignore at this time any tape jump which may be present just as the capstan changes direction; do not attempt to adjust out the jump.

5. Check tape position on the capstan wheel. Ensure that tape tracks towards center of the capstan wheel and does not overhang the wheel on either side. If necessary, adjust motor mounting screw 3 as in step 3 above. If an adjustment was necessary, repeat step 4 above.
6. Unload and remove the scratch tape and reinstall the outer flange of the upper tape guide.

## 9.4.2 Head Skew Adjustment

The head skew must be adjusted so that all bits of a data byte will come under the R/W head within a specified time window. The adjustment also ensures that the head is not so skewed that it reads bits from more than one data byte at a time.

1. With power off, remove the card cage cover and disconnect the write head cable from the front of the WR card (slot A4).
2. With power on, mount and load a master skew tape (StorageTek PN 403802201, PN 403802202, or equivalent) without a write enable ring. Tape must meet the requirements of Storage Technology specifications. Ensure the File Protect indicator is illuminated at the completion of the load.

### CAUTION

Never do a high speed rewind on a master skew tape.

3. Connect a dual-trace oscilloscope channel 1 to bit 4 (TP 4) on the RD card (slot A6) and channel 2 to bit 5 (TP 5). (Refer to Figure 9-3) The scope settings should be as follows:

Sweep	5 microseconds/division
Trigger	Negative Slope
	Channel 1 Only
	Internal
	HF Reject
	Normal
Mode	Chopped
Channel 1	50 millivolts/division
Channel 2	50 millivolts/division

4. Enter maintenance program 00 to move tape forward. Adjust the read/write head alignment screw (Figure 9-2) until forward skew is less than 1 microsecond and as close as possible to 0.
5. Ensure that the the R/W head skew is not out of alignment by one or more bytes. Do this by monitoring all bits with scope channel 2 ( see Figure 9-3 for test points). The head is out of alignment when any bit shows a phase loss or a phase shift on the scope.
6. If the head is out of alignment, do Steps 7 and 8. If the head is properly aligned, go to step 9.
7. Move scope channel 2 up to bit 6 (TP 6) (refer to Figure 9-3). Adjust the head alignment screw to align bits 4 and 6. Move channel 2 to the next bits in the following order:
 

0, 1, 2, p, 3, 7

 If any bit is not aligned, again adjust the alignment screw. Continue until all bits have been checked and aligned.
8. Repeat Step 4
9. Move scope channel 2 to all other bits (7,3,p,2,1,0,6 - refer to Figure 9-3) and verify that none of the bits has a skew greater than  $\pm 2.5$  microseconds. If any bit exceeds this allowance, the head should be replaced and the entire tape tracking and skew adjustment must be repeated.
10. Enter maintenance program 01 to move tape backward. With scope channel 1 still on bit 4 (TP 4) and channel 2 on bit 5 (TP 5), adjust capstan motor mounting screw 1 or 2 very slightly until backward static skew is less than 1 microsecond and as close as possible to 0.
11. Enter maintenance program 00 to move tape forward. Ensure that forward static skew is still less than 1 and close to 0 microseconds. If necessary, readjust the read/write head alignment screw. (It may be necessary to perform steps 10 and 11 three or four times to ensure that forward and backward skew are negligible.)



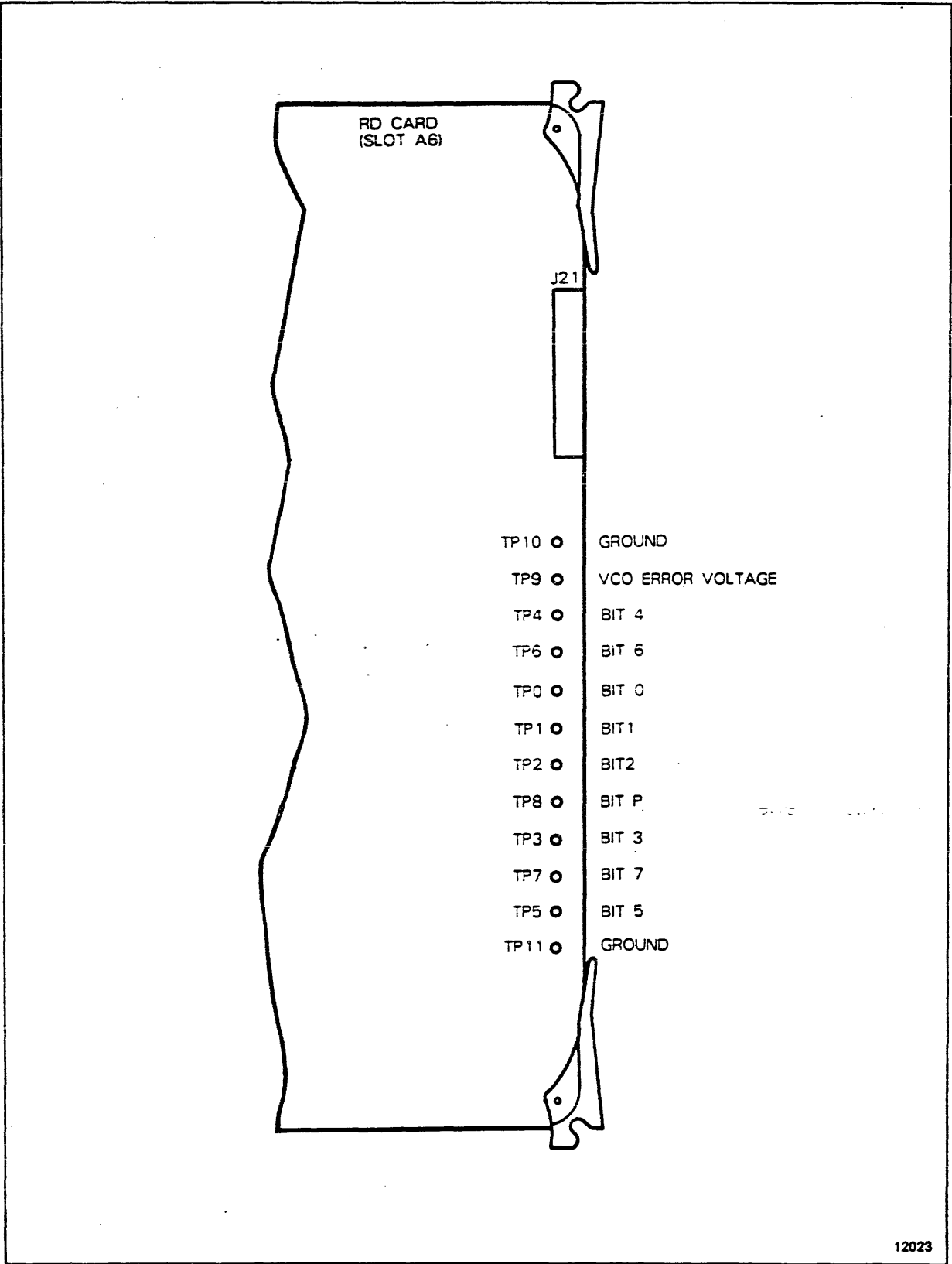


Figure 9-3. +Dif Analog Test Points

12. Enter maintenance program 02 to perform the shoeshine routine. Examine closely the upper tape guide and ensure that tape is not forced to the guide flanges. This can be best accomplished by removing the outer flange of the upper guide and ensuring that tape does not overhang the guide. Reinstall the flange when the check is completed.

13. If necessary, very slightly adjust capstan motor mounting screw 3. If this adjustment is made, return to step 10

Failure to achieve proper alignment may require reperforming this procedure or may indicate a defective component in the tape path, such as bent swing arm, a defective capstan, or a burred or nicked tape guide or flange. A bent swing arm is often characterized by excessive tape jump on the capstan as tape direction changes.

14. Measure the dynamic skew (timing jitter) using the following measurement technique:

a) Enter maintenance program 00 to move tape forward.

b) Sync scope on Bit 5 and measure the timing width of the scope trace at 0 Vac point (50% point of peak-to-peak transition),

c) sync scope on Bit 4 and measure the total time width (jitter) of Bit 5 scope trace at 0 Vac point,

d) The dynamic skew is equal to the measurement of Step c minus the measurement of step b. It must be equal to or less than 7.0 microseconds.

e) Enter maintenance program 01 to move tape backward and repeat Steps b through d to measure backward dynamic skew. It must be equal to or less than 7.0 microseconds.

15. If dynamic skew is not within specifications, check for defective tape path parts. If any parts must be replaced, repeat entire tape tracking and skew adjustment procedure.

16. When the tracking and skew requirements are met, unload and remove the master alignment tape. With power off, reconnect the cable to the WR card and reinstall the card cage cover.

17. Run all internal diagnostics.

## 9.5 QUARTERLY TAPE SKEW CHECKS

This procedure checks whether tape skew has remained within an allowable range. A greater skew tolerance than in the previous calibration procedure (paragraph 9.4.2) is allowed. If any of the

measurements below do not fall within specifications, the entire tape tracking and skew adjustment procedure (paragraph 9.4) must be performed.

1. With power off, remove the card cage cover and disconnect the write head cable from the front of the WR card (slot A4).
2. With power on, mount and load a master alignment tape without a write enable ring. Tape must meet the requirements of Storage Technology specifications. Ensure the File Protect indicator is illuminated at the completion of the load.

**CAUTION**

Never do a high speed rewind on a master alignment tape.

3. Connect a dual-trace oscilloscope channel 1 to bit 4 (TP 4) on the RD card (slot A6) and channel 2 to bit 5 (TP 5). The scope settings should be as follows:

Sweep	5 microseconds/division
Trigger	Negative Slope
	Channel 1 Only
	Internal
	HF Reject
	Normal
Mode	Chopped
Channel 1	50 millivolts/division
Channel 2	50 millivolts/division

4. Enter maintenance program 00 to move tape forward. Ensure forward skew is equal to or less than 4 microseconds.
5. Enter maintenance program 01 to move tape backward. With scope channel 1 still on bit 4 (TP 4) and channel 2 on bit 5 (TP 5), ensure that backward static skew is equal to or less than 4 microseconds.
6. Measure the dynamic skew (timing jitter) using the following measurement technique:
  - a) Enter maintenance program 00 to move tape forward.
  - b) Sync scope on Bit 5 and measure the timing width of the scope trace at 0 Vac point (50% point of peak-to-peak transition),
  - c) sync scope on Bit 4 and measure the total time width (jitter) of Bit 5 scope trace at 0 Vac point,

- d) The dynamic skew is equal to the measurement of Step c minus the measurement of Step b. It must be equal or less than 7.0 microseconds.
- e) Enter maintenance program 01 to move tape backward and repeat Steps b through d to measure backward dynamic skew. It must be equal to or less than 7.0 microseconds.

## 9.6 BIT POSITION CHECK AFTER PART REPLACEMENT

This check is required only if a component in the tape path was replaced, including the R/W head, and the subsequent tape tracking and skew adjustment performed. This procedure is not required for scheduled maintenance.

In the rare occasions when the shimmed skew block is replaced, it is the most likely reason for bit position problems.

1. Load a reel of blank tape with a write enable ring installed.
2. Enter maintenance program 0F, select 1600 bpi density at BOT, and write all ONEs on all tracks for about 10 seconds.
3. Use tape developer to develop two feet of the recorded tape.
4. Use a magnifier (jeweler's loupe) with a reticle scale to inspect the developed tape. The distance from the edge of tape to the edge of the outside track (physical track 1, bit 5) should be  $0.007 \pm 0.003$  inch ( $0.178 \pm 0.076$  mm) (Refer to Figure 9-4).
5. If the outside track does not meet this specification, recheck the capstan alignment.

### CAUTION

Cut the developed tape from the reel and place a new BOT marker on the tape. Do not reuse the developed part of the tape as damage to the read/write head could result.

## 9.7 QUARTERLY READ AMPLITUDE CHECKS

All amplitude checks must be performed at both 50 IPS and 100 IPS modes. The procedure below gives values for 50 IPS mode checks. Amplitude values at 100 IPS mode must be within 35% of amplitudes at 50 IPS mode.

The read amplitude measurements should be made only after all

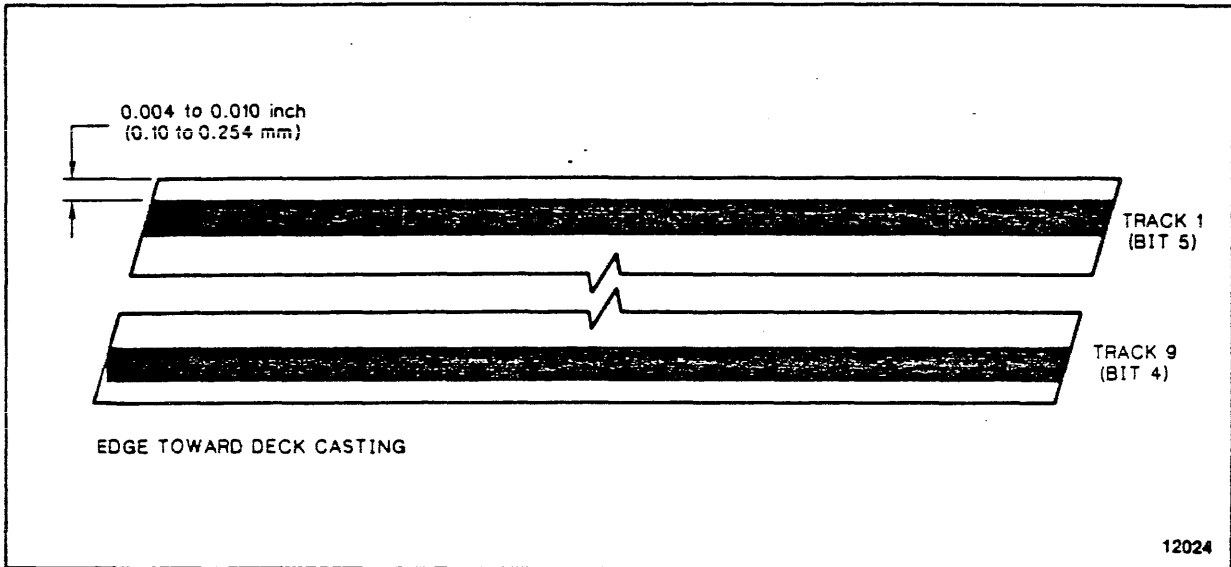


Figure 9-4. Bit Position Check

other measurements, alignments, and checks have been performed.

The amplitude measurements are made on the RD card at the +Dif Analog test points (Figure 9-3). Use an oscilloscope to measure each bit from peak to valley. Ground the scope at one of the two ground test points available on the card.

1. Load a master output tape with a write enable ring installed.
2. While positioned at BOT, select 1600 bpi density with the operator panel Density Select switch. Enter maintenance program 0F to write all-ONES on all tracks. (There should be an X in the display.) The signal amplitude of each bit while writing should be 0.7 to 3.0 volts.
3. Enter maintenance program 00 to perform a read forward operation. The signal amplitude of each bit should be within 10% of the signal amplitude measured in step 2.
4. After repositioning tape to BOT, select 6250 bpi density.

Enter maintenance program 0F and write a high/low frequency pattern on all tracks. The signal amplitude of each bit while writing should be 0.6 to 3.0 volts.

In 6250 bpi (GCR), Program 0F writes a pattern of all ONEs and then 1/3 all ONEs. The amplitude must be checked on the the all ONEs pattern.

5. Alternately enter maintenance programs 00 and 01 to perform three read passes. On the third read pass (forward), the signal amplitude of each bit should be 85% or greater of the signal amplitude measured in step 5.
6. Enter maintenance program 01 to perform a read backward operation. The signal amplitude of each bit should be within 20% of the signal amplitudes measured in step 6.

SEPARATOR SET PN 83464

THIS SEPARATOR SET CONTAINS 19  
TABS TOTAL IN THE FOLLOWING  
ORDER:

MAINTENANCE MANUAL

1. INTRODUCTION
  2. OPERATION
  3. INSTALLATION
  4. STORAGETEK INTERFACE
  5. INDUSTRY INTERFACE
  6. SCSI INTERFACE
  7. VS INTERFACE
  8. FUNCTIONAL DESCRIPTION
  9. MAINTENANCE
  10. REMOVAL/REPLACEMENT
  11. DIAGNOSTICS
- APPENDICES

IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD

# CHAPTER 10

## REMOVAL AND REPLACEMENT

### 10.1 INTRODUCTION

This chapter provides removal and replacement procedures for Field Replacement Units (FRUs). The procedures are arranged by location and/or function under the following major headings:

1. Tape Path
2. Swing Arm Assemblies
3. Capstan, Reels, and Blower
4. Circuit Cards
5. Power Supply and Fans

To prevent safety hazards and damage to the Magnetic Tape Subsystem (MTS), turn off the main circuit breaker located behind the right front cover before performing any replacement procedure. Certain procedures specify disconnecting the main power cord as well.

Removal of components may require access to rear of MTS casting. To access vertical models, release deck lock shown in Figure 10-1.

#### 10.1.1 Fuses

Four fuses are used in the MTS; their locations and sizes are:

PK Card	1 amp slow blow
AK Card	20 amp fast blow
Retractor Motor (inline)	3/4 amp slow blow
Vacuum Blower (inline)	4 amp slow blow

#### 10.1.2 Torx Screws

The majority of the screws used in the assembly of the MTS are #6



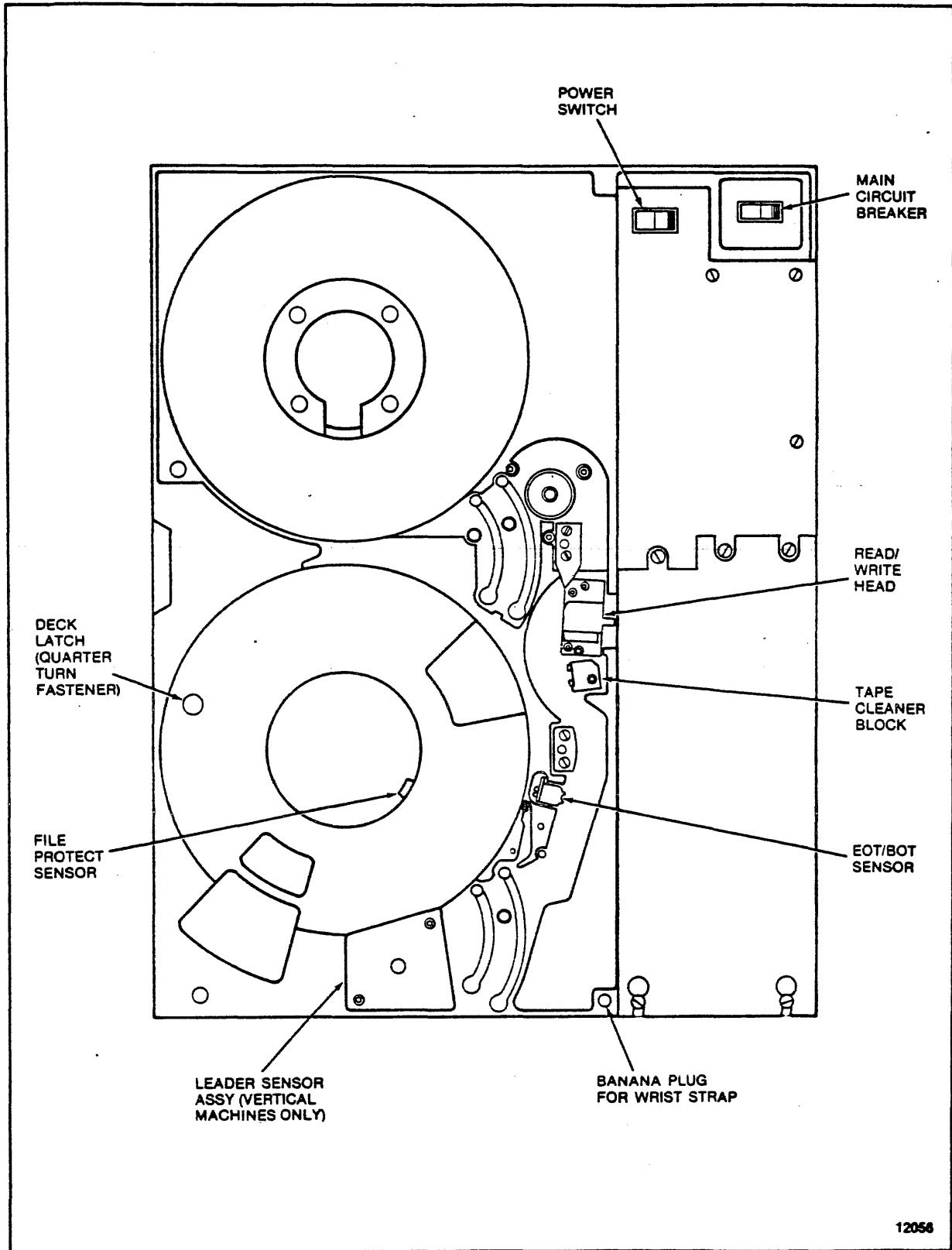


Figure 10-1. 2920 MTS Deck (Front)

and #10 Torx<sup>1</sup> thread-forming screws. Remove and reinstall these screws by using only the 2920 tool set (PN 404192401) containing the T15, T20, and T25 Torx screwdriver.

**CAUTION**

The screw threads must be clean when Torx screws are reinstalled in the aluminum deck casting. Start the screw by hand; do not overtighten.

## 10.2 TAPE PATH

The locations of the FRUs detailed in this section are shown in Figure 10-1.

**CAUTION**

When working on the tape path, always assure that the machine reel cover is in place before closing the tape path door.

### 10.2.1 EOT/BOT Sensor Replacement

1. Switch off the main circuit breaker.
2. Remove the EOT/BOT sensor mounting screw and pull the EOT/BOT assembly from the front of the deck casting. It may be necessary to use a pair of longnose pliers to remove the assembly.
3. Use the original mounting hardware to install the replacement EOT/BOT assembly. Tighten the mounting screw firmly, but do not overtighten.
4. Power up the MTS, load a work tape, and check that BOT is properly detected.
5. Enter maintenance program 00 to run the tape forward. Check that EOT is properly detected. If a machine check occurs, refer to Fault Code Dictionary PN 97712 or 87004.

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<sup>1</sup> Trademark of the Camcar Division of Textron Inc.

## 10.2.2 Leader Sensor Replacement

1. Switch off the main circuit breaker.
2. Remove the tie-wrap that secures the leader sensor cable.
3. Disconnect J28 from the leader sensor.
4. Remove the two leader sensor housing mounting screws. Remove the sensor housing by pulling J28 through the front of the deck. Be careful not to break the connector.
5. Remove the plastic sensor from housing. Install new sensor with manufacturer's decal visible. Do not overtighten.
6. Reinstall the leader sensor housing using the original mounting hardware. Reconnect J28.
7. Power up the MTS and run all internal diagnostics (refer to Chapter 11).

## 10.2.3 Tape Cleaner Block Replacement

1. Switch off the main circuit breaker.

**WARNING**

Take care when handling the tape cleaner block because the blade is sharp.

2. Remove the cleaner block mounting screw. Remove the block from the deck casting.
3. When replacing the tape cleaner block, make sure that the alignment pin in the deck is aligned with the hole in the cleaner block and that the cleaner block is seated against the casting before tightening the mounting screw. Tighten the screw firmly, but do not overtighten.
4. Power up the MTS and load a work tape.
5. Enter maintenance program 00 to run the tape forward. Check to see that the tape very slightly contacts the blade and screen of the cleaner block.

## 10.2.4 File Protect Sensor Replacement

1. Switch off the main circuit breaker.

### CAUTION

There may be shims between the file protect sensor and the deck casting that may drop out as the following step is performed.

2. Disconnect J27 from the file protect sensor. Remove the screw that secures the file protect assembly to the back of the deck casting.
3. Install the replacement file protect sensor over the locating pin and install the sensor mounting screw. Reinstall the shims, if any, over the screw. Secure the mounting screw, do not overtighten. Reconnect J27.
4. Power up the MTS and load a work tape with a write enable ring installed. Check that the file protect indicator turns off.
5. Unload the tape, remove the ring, and reload the tape. Check that the file protect indicator is illuminated.

## 10.2.5 Read/Write Head Replacement

1. Switch off the main circuit breaker.
2. Remove the three screws that secure the thread door, taking care not to lose the springs.
3. Remove the filler block over the read/write head cables (refer to Figure 10-2).
4. Loosen the three screws that secure the card cage cover to the card cage; remove the cover.
5. Disconnect the read cable from the RD card and the write cable from the WR card.
6. Remove the three socket head screws that secure the read/write head assembly to the skew block. Remove the head assembly. Do not remove the baseplate from the read/write head.
7. Mount the replacement read/write head on the skew block. Make sure that the pins are aligned. Firmly seat the read/write head against the skew block before inserting the retaining screws.

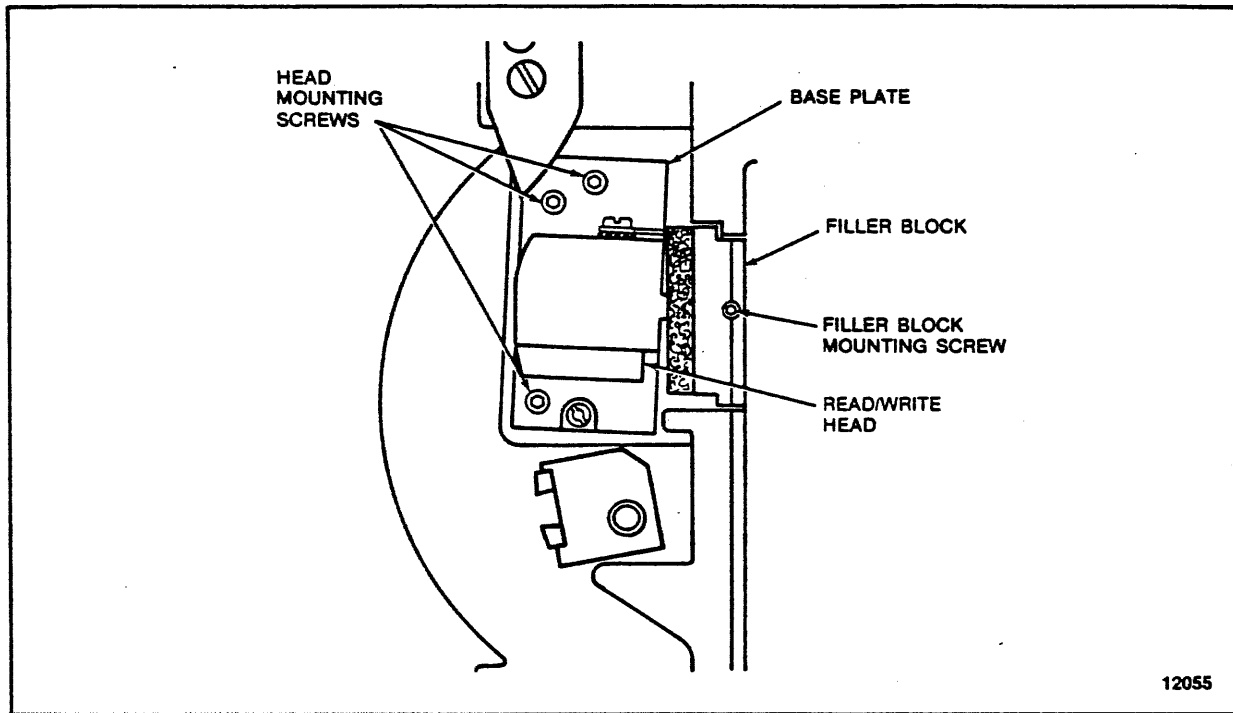


Figure 10-2. Read/Write Head

**CAUTION**

Do not tap or pound on the read/write head assembly: permanent damage can occur.

8. Reconnect the read and write cables.
9. Reinstall the filler block. Make sure that the filler block is clamped over the read/write head cable insulation and does not pinch any wires that may be unsheathed in this area.
10. Remove the protective covering from the replacement read/write head. (Use this covering to protect the tape-contacting area of the original read/write head.) Clean the replacement head with approved Hub and Transport Cleaner.
11. Reinstall the thread door. Operate the door to be sure that it does not bind when it is opened and closed. Binds can cause the door to be improperly seated, resulting in vacuum leaks that could affect tape threading.

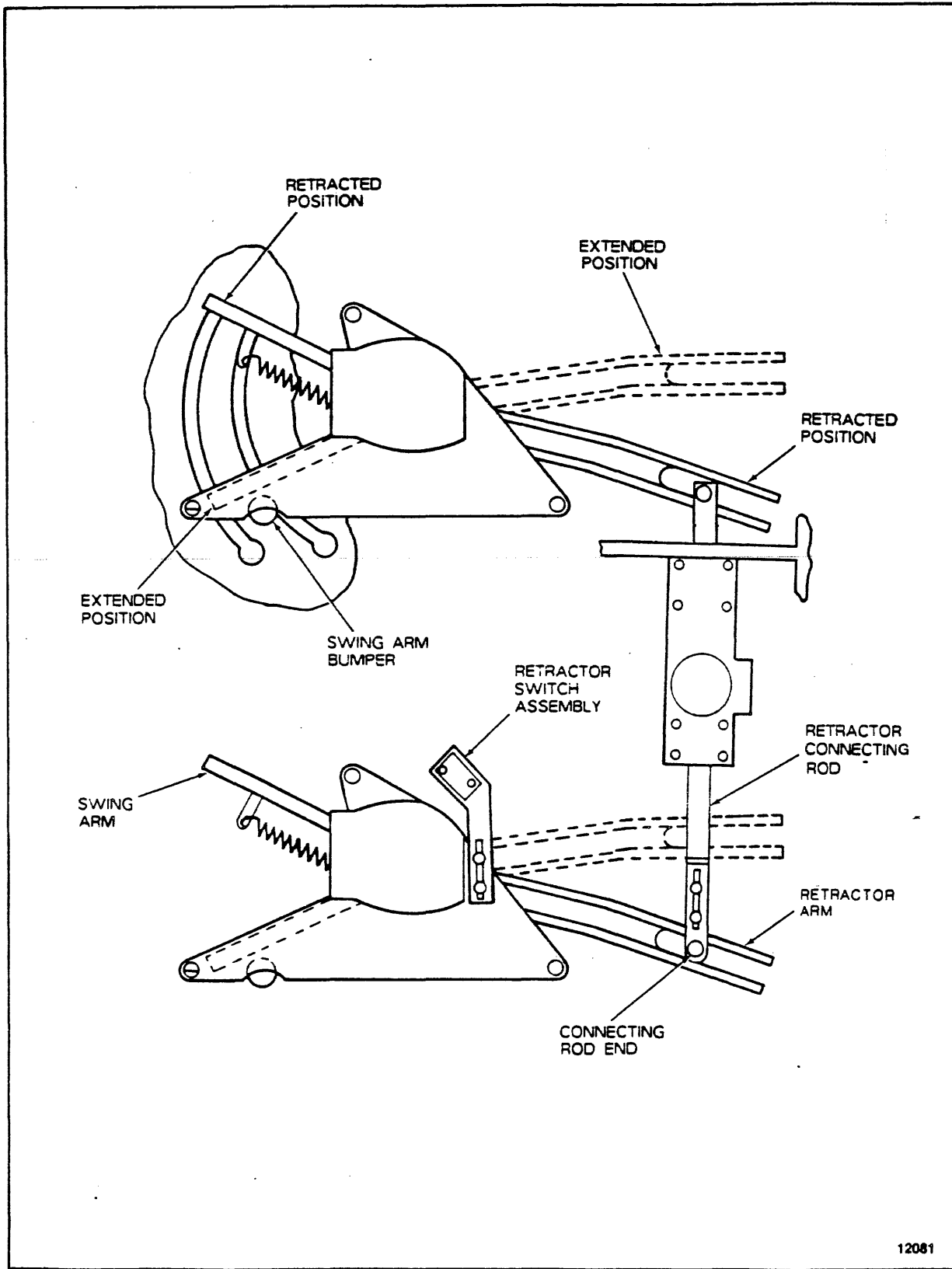
12. Perform the tape tracking and skew procedure and the read amplitude checks (refer to Chapter 9).

## 10.3 SWING ARM ASSEMBLIES

The procedures for replacing the swing arm assemblies are given in the following paragraphs.

### 10.3.1 Lower Swing Arm Assembly Replacement

1. Switch off the main circuit breaker.
2. Disconnect J24 from the lower swing arm tach assembly, J34 from the retractor switch assembly, and J17 from the retractor gear motor.
3. Push up on the bottom of the retractor connecting rod until the swing arms are in the extended position (refer to Figure 10-3).
4. If the retractor arm has a loop end, remove the connecting rod end. If the retractor arm has a slot end, loosen the attachment screw.
5. Unhook the lower swing arm tension spring from the spring post on the deck casting.
6. Remove the three screws that secure the swing arm pivot plate to the deck casting. Remove the lower swing arm assembly, guiding the rollers through the holes in the deck.
7. Remove the tension spring from the removed swing arm and install the tension spring on the replacement swing arm, making certain that the open side of the hook faces out from the swing arm.
8. Mount the replacement swing arm assembly in position and secure it with the original hardware.
9. Reinstall the connecting rod end if it was removed earlier, but do not tighten the attachment screw at this time.
10. Check the retractor switch bracket to see if it has two holes or a slot where it attaches to the pivot plate. If it has the holes, no adjustment is necessary. If there is a slot, then push the connecting rod up approximately 1/4-in. (0.64 cm) beyond the point where the swing arms contact the swing arm bumpers. Loosen the two screws that hold the retractor switch bracket to the swing arm pivot plate. Move the switch assembly until the retractor activates the switch. Tighten the two screws.



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Figure 10-3. Swing Arm Assemblies

11. Reconnect the tension spring to the spring post.
12. Loosen the stop collar and the connecting rod end if not done.
13. Push the connecting rod down until there is light contact between the outside roller (closest to the capstan wheel) on the upper swing arm and the recessed area at the top of the slot in the deck, or until the roller pin lightly contacts the deck.
14. Push down on the connecting rod end until the lower swing arm pins lightly contact the upper ends of the slots in the deck. Tighten the screw securing the connecting rod end.
15. Reconnect J24 to the tach assembly and J34 to the retractor switch assembly.
16. Power up the MTS. There will be a machine check indication because the retractor motor is still unplugged (at J17). Press RESET on the operator panel.
17. On the diagnostic keypad, press <ENTER PROBE> <6061> <ENTER>. The display should show a two-digit hex character. Push up on the connecting rod until the swing arms are in the extended position. Move the swing arms gently through their arc. Check to see that the display value changes as the arms move out of their bottom position, again just below the fixed roller, and again near the top of their arc.

**CAUTION**

To prevent damage to the retractor motor, do not proceed if this test fails.

18. Switch off the main circuit breaker.
19. Reconnect J17 to the retractor gear motor.
20. Power up the MTS. The power-up diagnostics will cycle the swing arms. Run several 1F diagnostics <ENTER DIAG> <1F> <ENTER>. This will allow the swing arms to find their natural stopping point.
21. The outer roller of the upper swing arm should stop within .100 inch from the recess in the deck. If it does not stop within this range then readjust by making small changes in the position of the connecting rod end.
22. With the swing arms in their retracted position run 1F diagnostics, insert a .02 to .03 inch shim between the stop



collar and the deck casting, and tighten the stop collar.

23. Push down on the connecting rod until the stop collar contacts the deck. In this position neither the upper or the lower swing arms should contact the deck.
24. Run 1F diagnostics again. When the swing arms stop in their retracted position the stop collar should not contact the deck. If the stop collar does contact the deck, readjust starting with step 12.
25. Perform the tape tracking and skew procedure (refer to Chapter 9).
26. Run all internal diagnostics (refer to Chapter 11).

### 10.3.2 Lower Swing Arm Tach Assembly Replacement

1. Switch off the main circuit breaker.
2. Disconnect J24 from the sensor assembly.
3. Remove the plastic snap-off cover over the sensor assembly.
4. The tach disc is secured to the swing arm shaft by a screw and two washers. The larger washer has a small hole that keys onto the dowel pin in the shaft. Remove the screw and washers. (On a few older machines, the tach disc is secured to the shaft by two retaining rings, a spring washer, and a flat washer.)
5. Remove the four socket-head screws that secure the sensor assembly to the swing arm pivot plate. Remove the tach assembly.
6. Install the replacement tach assembly with the hardware removed in step 5. The two ICs on the tach card should be located on the left. Align the small hole in the tach disc with the dowel pin on the swing arm shaft. Install the large washer, aligning the small hole in the washer with the dowel pin of the shaft. Install the small washer and secure it with the screw.

#### CAUTION

Make sure that the hole in the tach disc is properly aligned before tightening the screw. Permanent damage to the disc will occur if it is not properly aligned before tightening.

7. Reinstall the plastic cover over the sensor assembly.
8. Reconnect J24 to the sensor assembly.
9. Power up the MTS. If there is a failure of the tach assembly, the power-up diagnostics should display a fault code in the LED display (refer to Fault Code Dictionary PN 97712 or 87004). Run all internal diagnostics (refer to Chapter 11).
10. An additional check of the swing arm tach assembly can be made using the LED display. To perform this check, move the swing arms to their fully extended (downward) position. To do this, enter maintenance program 1F. When the swing arms reach the bottom of their travel, press RESET. You may have to do this several times to stop the arms in the proper position. On the diagnostic keypad, press <ENTER PROBE> <6061> <ENTER>. The LED display should display a two-digit hex character. The movement of the swing arms gently through their swing arc should cause a change in the units position of the display when each arm is at the top, at the bottom, and just below the fixed roller post position of the arc. Do not allow the arms to slip free and drop to the bottom under spring tension. This can damage the arms by changing the alignment.

### 10.3.3 Upper Swing Arm Assembly Replacement

1. Switch off the main circuit breaker.
2. Disconnect J14 from the file reel motor, J17 from the retractor motor, J18 from the vacuum blower motor, and J23 from the upper swing arm tach.
3. Remove the four screws that secure the vacuum blower and adapter assembly to the deck casting. Remove the blower and adapter assembly.
4. Remove the seal around the capstan motor. Remove all of the screws that secure the rear plenum cover to the deck casting. Remove the plenum cover.
5. Push up on the bottom of the connecting rod in order to place the swing arms in the extended position (refer to Figure 10-3).
6. Unhook the upper swing arm tension spring from the spring post on the deck.
7. Remove the three screws that secure the swing arm pivot plate to the deck casting. Remove the upper swing arm assembly, guiding the rollers through the holes in the deck.

8. Remove the tension spring from the removed swing arm and install the tension spring on the replacement swing arm, making certain that the open side of the hook faces out from the swing arm.
9. Mount the new swing arm assembly in position and secure it with the hardware removed in step 7.
10. Reconnect the tension spring to the spring post.
11. Loosen the stop collar and the connecting rod end.
12. Push the connecting rod down until there is light contact between the outside roller (closest to the capstan wheel) on the upper swing arm and the recessed area at the top of the slot in the deck, or until the roller pin lightly contacts the deck.
13. Push down on the connecting rod end until the lower swing arm pins lightly contact the upper ends of the slots in the deck. Tighten the screw securing the connecting rod end.
14. Reconnect J23 to the upper swing arm tach assembly, and J18 to the vacuum blower motor.
15. Power up the MTS. There will be a machine check indication because the retractor motor is still unplugged (J17). Press RESET on the operator panel.
16. On the diagnostic keypad, press <ENTER PROBE> <6061> <ENTER>. The display should show a two-digit hex character. Push up on the connecting rod until the swing arms are in the extended position. Move the swing arms gently up through their arc. Check to see that the display value changes as the arms move out of their bottom position, again just below the fixed roller, and again near the top of their arc.

**CAUTION**

To prevent damage to the retractor motor, do not proceed if this test fails.

17. Switch off the main circuit breaker.
18. Reconnect J17 to the retractor gear motor.
19. Power up the MTS. The power-up diagnostics will cycle the swing arms. Run several 1F diagnostics <ENTER DIAG> <1F> <ENTER>. This will allow the swing arms to find their natural stopping point.

20. The outer roller of the upper swing arm should stop within .100 inch from the recess in the deck. If it does not stop within this range then readjust by making small changes in the position of the connecting rod end.
21. With the swing arms in their retracted position run 1F diagnostics, insert a .02 to .03 inch shim between the stop collar and the deck casting, and tighten the stop collar.
22. Push down on the connecting rod until the stop collar contacts the deck. In this position neither the upper or the lower swing arms should contact the deck.
23. Run 1F diagnostics again. When the swing arms stop in their retracted position the stop collar should not contact the deck. If the stop collar does contact the deck, readjust starting with step 11.
24. Power down the MTS. Clean and install the vacuum plenum cover and capstan seal. Make sure the seal is properly pressed against the plenum cover. Check the alignment of all cables emerging from the vacuum plenum in their respective slots before tightening the plenum cover screws.
25. Reinstall the vacuum blower and adapter assembly using the hardware removed in step 5.
26. Reconnect J18 to the vacuum blower, and J14 to the file motor.
27. Power up the MTS and perform the tape tracking and skew procedure (refer to Chapter 9).
28. Run all internal diagnostics (refer to Chapter 11).

#### 10.3.4 Upper Swing Arm Tach Assembly Replacement

1. Switch off the main circuit breaker.
2. Disconnect J14 from the file reel motor, J17 from the retractor motor, J18 from the vacuum blower motor, and J23 from the upper swing arm tach.
3. Remove the four screws that secure the vacuum blower and adapter assembly to the deck casting. Remove the blower and adapter assembly.
4. Remove the seal around the capstan motor. Remove all the screws that secure the vacuum plenum cover to the deck casting. Remove the plenum cover.
5. Remove the plastic snap-off cover over the sensor assembly.

6. The tach disc is secured to the swing arm shaft by a screw and two washers. The larger washer has a small hole that keys onto the dowel pin in the shaft. Remove the screw and washers. (On a few older units, the tach disc is secured to the shaft by two retaining rings, a spring washer, and a flat washer.)
7. Remove the four socket-head screws that secure the tach assembly to the swing arm pivot plate.
8. Install the replacement tach assembly with the hardware removed in step 8. The two ICs on the tach card should be located on the left. Align the small hole in the tach disc with the dowel pin on the shaft. Install the large washer, aligning the small hole in the washer with the dowel pin of the shaft. Install the small washer and secure it with the screw.

**CAUTION**

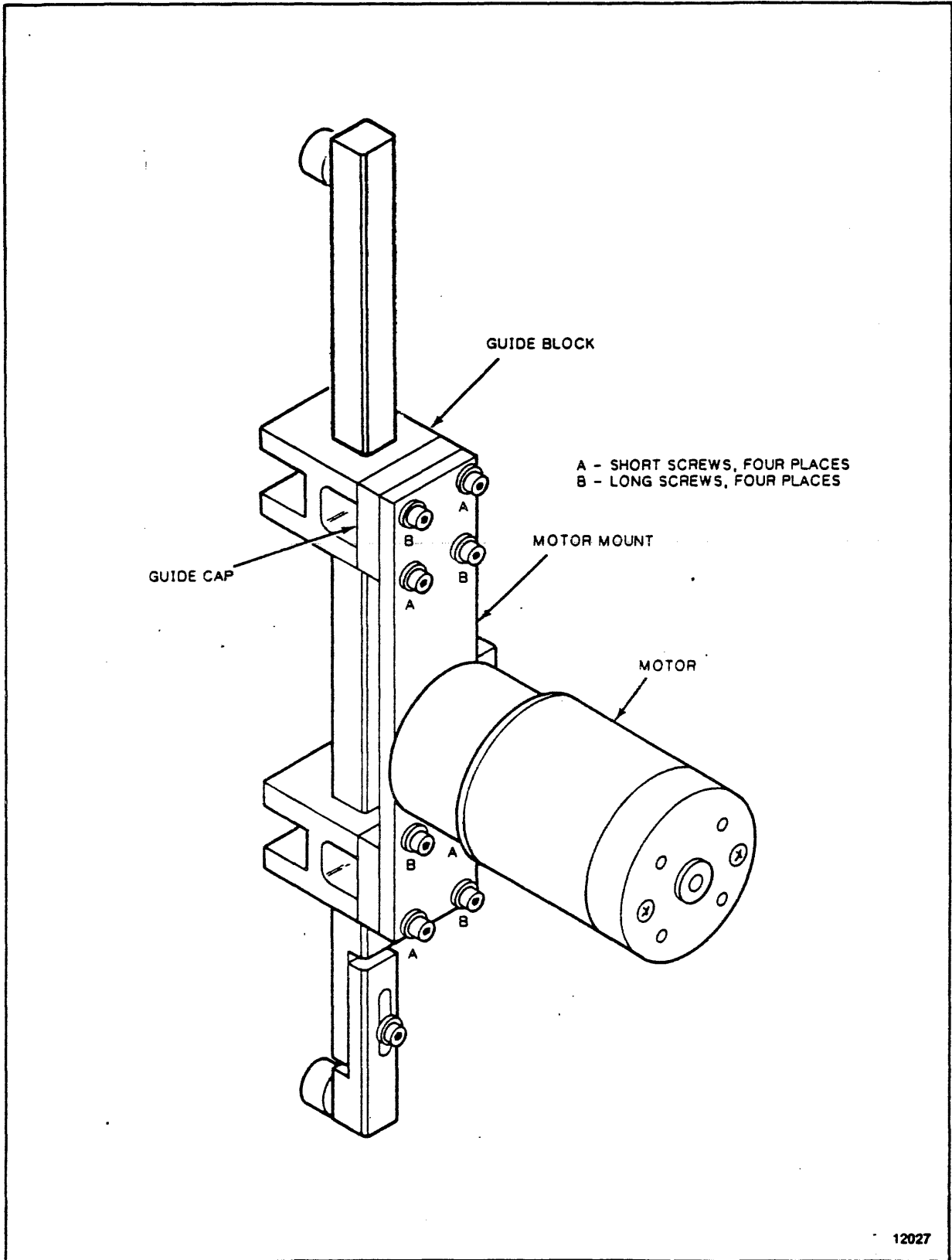
Make sure that the hole in the tach disc is properly aligned before tightening the screw. Permanent damage to the disc will occur if it is not properly aligned before tightening.

9. Reinstall the plastic cover over the sensor assembly.
10. Reconnect J23 to the tachometer.
11. Power up the MTS. If there is a failure of the tach assembly, the power-on diagnostics should display a fault code (refer to Fault Code Dictionary PN 97712 or 87004). For a further check of the tach assembly, refer to step 10 of the lower swing arm tach assembly replacement procedure (refer to Chapter 9).
12. Power down the MTS. Disconnect J23 from the tach. Clean and install the vacuum plenum cover and capstan seal, ensuring that the seal is properly pressed against the plenum cover. Check the alignment of all cables emerging from the vacuum plenum in their respective slots before tightening the plenum cover screws.
13. Install the vacuum blower and adapter assembly using the hardware removed in step 3.
14. Reconnect J14 to the file reel motor, J17 to the retractor motor, J18 to the vacuum blower motor, and J23 to the upper swing arm tach.
15. Power up the MTS and run all internal diagnostics (refer to Chapter 11).

### 10.3.5 Retractor Assembly Replacement

1. Switch off the main circuit breaker.
2. Disconnect J17 from the retractor motor.
3. Push upward on the bottom of the connecting rod to position the swing arms in the extended position (refer to Figure 10-3).
4. Remove the four socket-head screws (located at B in Figure 10-4) that secure the retractor assembly to the casting.
5. Remove stop collar clamp from top of connecting rod (Figure 10-4), and slide the entire assembly out of the hole in the casting.
6. On new retractor assembly, gently push the connecting rod all the way up.
7. Mount the new retractor assembly in reverse order of removal and remount the stop collar clamp but do not tighten.
8. Loosen the connecting rod end screw.
9. Push down on the top of the connecting rod until the upper swing arm rollers are very lightly contacting the end of the slots in the deck casting. Position the stop collar flat against the deck and firmly tighten the screw.
10. Push down on the connecting rod end until the lower swing arm rollers are very lightly contacting the end of the slots in the deck casting. Tighten the connecting rod end.
11. Power up the MTS. There will be a machine check indication because the retractor motor is still unplugged (J17). Press RESET on the operator panel.
12. On the diagnostic keypad, press <ENTER PROBE> <6061> <ENTER>. The display should show a two-digit hex character. Move the swing arms gently through their arc. Check to see that the display value changes as:
  - a) The arms move out of their bottom position;
  - b) The arms are just below the fixed roller;
  - c) The arms are near the top of their arc.

Now pull the connecting rod down until the stop collar



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Figure 10-4. Retractor Assembly

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contacts the deck. Check to see that there is a gap between the swing arm pins and the end of the slots that should have been created by the tension springs pulling down on the swing arms. As a check, this gap should measure between 0.03 in. (0.08 cm) and 0.08 in. (0.20 cm) at the outside pin. This can be measured on the front of the deck by placing a steel rule by the roller pin and moving the pin until it contacts. If the gap is incorrect, go back to step 11. Check the display panel and see if the display changes as you move the arms through the distance of the gap. If the display changes, follow the procedure in the following paragraph. Otherwise, go to step 16.

If the display changes within the range of the gap described above, loosen the three screws holding the pivot plate to the deck of the assembly that causes the display to change. From the back of the deck, rotate the plate counterclockwise as far as it will go, then tighten the screws. Check the display again as described above.

**CAUTION**

To prevent damage to the retractor motor, do not proceed if this test fails.

13. Switch off the main circuit breaker.
14. Reconnect J17 to the retractor motor.
15. Power up the MTS. The power-on diagnostics will cycle the arms and check for proper operation of the arms during this procedure. You can cause additional cycling of the arms by entering diagnostic routine 1F. The LED display should indicate four dashes for proper operation. A fault code indicates failure and should be investigated before proceeding (refer to Fault Code Dictionary PN 97712 or 87004).
16. Run all internal diagnostics (refer to Chapter 11).

## 10.4 CAPSTAN, REELS, AND BLOWER

Procedures for replacing the capstan motor, file reel hub, file and machine reel motors, and vacuum blower are given in the following paragraphs.



## 10.4.1 Capstan Motor Replacement

1. Switch off the main circuit breaker.
2. Disconnect J14 from the file reel motor, J17 from the retractor motor, J18 from the vacuum blower motor, and J23 from the upper swing arm tach.
3. Disconnect J16 from the capstan motor.
4. Remove the four screws that secure the vacuum blower adapter to the deck casting. Remove the blower and adapter assembly.
5. Remove the seal from around the capstan motor. Remove all the screws that secure the vacuum plenum cover to the deck casting. Remove the plenum cover.
6. At the front of the deck casting, remove the screw that secures the capstan wheel to the motor shaft. Remove the capstan wheel.
7. Each of the three capstan motor mounting screws retains a spring between the capstan motor and the deck casting. These springs are required during reassembly and are critical to proper operation.

Equally loosen the three screws that secure the capstan motor to the deck casting while supporting the capstan motor from the rear, but do not pull the screws from the casting until you can remove the springs from the rear. Remove the springs and store them safely for reassembly.

8. Reassemble all components in reverse order of disassembly. Position the capstan motor with the tach cable to the left (as viewed from the rear) and route the cable through the groove in the casting directly below the motor.

Insert the three capstan motor mounting screws through the front of the casting and slide the springs on the exposed threaded portions of the screws from the rear.

9. With the springs properly placed on the screws, install the motor and moderately tighten the screws. Tighten screws alternately and equally to prevent stripping.
10. Back off each mounting screw by one complete turn.
11. Clean and replace the plenum cover. Ensure that all cables emerging from the vacuum plenum are located properly in their respective slots in the deck casting before tightening the plenum cover retaining screws. Replace the seal around the capstan motor, ensuring that the wide flange is pressed against the plenum cover.

12. Reinstall the vacuum blower and adapter assembly.
13. Reconnect J14 to the file reel motor, J16 to the capstan motor, J17 to the retractor motor, J18 to the vacuum blower motor, and J23 to the upper swing arm tach.
14. Perform the tape tracking and skew procedure (refer to Chapter 9).

#### 10.4.2 File Reel Hub Replacement

1. Remove the three socket-head screws that secure the hub cover to the hub assembly. Remove the hub cover.
2. Remove the three socket-head screws that secure the hub assembly to the clamp collar. Slide the hub off the reel motor shaft.
3. Slide the replacement file reel hub assembly onto the reel motor shaft. Align the screw holes in the hub with the holes in the clamp collar. Insert the mounting screws and tighten securely.
4. Reinstall the hub cover. Do not overtighten the screws. Overtightening can damage the hub cover.
5. Power up the MTS and load a scratch tape. Enter maintenance program 00 to run the tape forward. Check that the tape does not contact either flange of the reel. Perform the same check using maintenance program 01 to run the tape backward.

If necessary, use the clamp collar to reposition the hub until the tape wraps on the reel without contacting the reel flanges.

6. Check the alignment and operation of the file protect sensor. To check for proper operation of file protect, load a scratch tape with a write enable ring installed and check that the file protect indicator turns off. Unload the tape, remove the ring, reload the tape, and check that the file protect indicator is illuminated.

#### 10.4.3 File Reel Motor Replacement

1. Switch off the main circuit breaker.
2. Disconnect J14 from the file reel motor.
3. Remove the three socket-head screws in the hub cover. Remove the hub cover by opening the hub latch and pulling off the cover with a slight counterclockwise twist to clear the hub latch.

4. Remove the three screws that secure the hub assembly to the clamp collar and remove the hub assembly.
5. Remove wire tie from rear of motor
6. Remove the four screws that secure the reel motor to the deck casting and remove the motor.
7. Reassemble in reverse order. The outer edge of the clamp collar should be positioned 0.816 in.  $\pm 0.002$  in. (2.07  $\pm 0.005$  cm) from the front of the reel motor.
8. To check for proper alignment of the reel to the tape path, power up the MTS, mount and load a scratch tape, enter maintenance program 00, and run tape forward to EOT. Rewind while observing the tape as it wraps back on the file reel: the tape should not contact either flange of the reel. If necessary, use the clamp collar to reposition the hub until the tape wraps on the reel without contacting the reel flanges.
9. Check the alignment and operation of the file protect sensor. To check for proper operation of file protect, load a scratch tape with a write enable ring installed and check that the file protect indicator turns off. Unload the tape, remove the ring, reload the tape, and check that the file protect indicator is illuminated.

#### 10.4.4 Machine Reel Motor Replacement

1. Switch off the main circuit breaker.
2. Disconnect J15 from the reel motor.
3. Remove the machine reel cover.
4. Remove the three screws that secure the machine reel hub cap to the hub and remove the cap and outer flange.
5. Remove the three screws that secure the hub assembly to the clamp collar and remove the hub assembly.
6. From the front of the deck casting, remove the four screws that secure the machine reel motor to the deck casting. Remove the motor.
7. Install the replacement reel motor. The outer edge of the clamp collar should be positioned 0.642  $\pm 0.005$  in. (1.63  $\pm 0.013$  cm) from the front of the reel motor.

8. Reassemble all components in reverse order. Ensure that the rim of the outer flange is positioned outwards.
9. Power up the MTS and load a scratch tape. Enter maintenance program 00 to run the tape forward. Check for proper alignment of the reel to the tape path. The tape should not contact either flange of the reel as it wraps on the machine reel. You may remove the column door and the machine reel cover once the tape has been loaded to observe the machine reel area.

If necessary, use the clamp collar to reposition the hub on the motor shaft until the tape wraps on the reel without contacting the reel flanges.

### 10.4.5 Vacuum Blower Replacement

1. Switch off the main circuit breaker.
2. Disconnect J18 from the vacuum blower.
3. Remove the four screws that secure the vacuum blower to the vacuum blower adapter. Remove the blower.
4. Remove the blower mounting plate from the blower and install the plate on the replacement blower.
5. Reassemble in reverse order. When installing the four screws, make sure that the threads of all the screws are caught before completely tightening any one screw. Reconnect J18 and check the subsystem by performing at least 10 tape load operations.

## 10.5 CIRCUIT CARDS

The procedures for replacing circuit cards are given in the following paragraphs.

### 10.5.1 Card Cage Circuit Cards Replacement

1. Switch off the main circuit breaker.
2. Loosen the four screws that secure the card cage cover and remove the cover.
3. Put on a wrist strap and plug its banana clip into the receptacle on the deck casting (refer to Figure 10-1).
4. If you are removing the WR card, disconnect the card's front edge connector. If you are removing the RD card, disconnect

front edge connectors from both the WR and RD cards. Remove the circuit card by pulling on the ends of the tabs at the top and bottom of the card.

**CAUTION**

When replacing the RD card, ensure components on the card do not rub against inside of the card cage, as this may damage the card.

5. Insert the replacement card. Make sure that the tab ends are locked in the mating slots of the card cage.
6. Power on the MTS and run all internal diagnostics to ensure proper operation (refer to Chapter 11).

### 10.5.2 Front Operator Panel Replacement

1. Switch off the main circuit breaker and disconnect the main power cord.
2. Remove the four screws that secure the front panel assembly to the deck casting.
3. Remove the electrical connectors from the back of the card, and remove the ground cable from the lug on the deck casting. Note the orientation of the connectors for proper reassembly.
4. Reassemble in reverse order.
5. Power up the MTS and run maintenance program 08, the Keyboard/LED Test. Each depressed key displays its ASCII code. The RESET key terminates the test.

### 10.5.3 AK Card Replacement

1. Switch off the main circuit breaker and disconnect the main power cord.
2. Remove J11, J12, and J13 from the AK card. The connectors are keyed and labeled.
3. Remove the seven screws that secure the AK card to the capacitor bank. Do not drop the screws into the fans or card cage. You may have to hold the standoffs behind the AK card with a 5/16-in. open-end wrench when loosening the screws. Remove the card.
4. When reassembling the AK card to the capacitor bank, start

all screws before completely tightening any one screw. As the screws make electrical contact, make sure they are tightened securely.

5. Reconnect all three electrical connectors (J11, J12, and J13).
6. Power up the MTS and check all power supply output voltages (refer to Chapter 9).
7. Run all internal diagnostics to ensure proper operation (refer to Chapter 11).

#### 10.5.4 PK Card Replacement

1. Switch off the main circuit breaker and disconnect the main power cord.
2. Remove the clear plastic safety cover from the PK card standoffs.
3. Remove the insulator boot and the wire from the ferro capacitor.
4. Remove the wires connected to the top edge of the PK card. Note the wire numbers are relative to the terminal post positions.
5. Pull the card away from the transformer. Pull the wire that was attached to the ferro cap through the sense coil on the PK card.
6. Reassemble in reverse order.
7. Power up the MTS and check all power supply output voltages (refer to Chapter 9).
8. Run all internal diagnostics to ensure proper operation (refer to Chapter 11).

#### 10.5.5 Motherboard Replacement

1. Switch off the main circuit breaker and disconnect the main power cord.
2. Loosen the four screws that secure the card cage cover and remove the cover.
3. Unlatch all circuit cards in the card cage and slide the cards forward. It is not necessary to slide the cards completely out of the cage.

4. Remove all electrical connectors from the motherboard.
5. Disconnect the four wires from the solid state relay. The wires are marked to show the relay connections.
6. Release motherboard harness from the two plastic cable clamps.
7. Remove the eight nuts and washers that secure the motherboard to the card cage.
8. Reassemble in reverse order. Insert the circuit cards in the motherboard connectors before tightening the eight motherboard mounting screws to ensure proper alignment.
9. Power up the MTS and run all internal diagnostics to ensure proper operation (refer to Chapter 11).

## 10.6 POWER SUPPLY AND FANS

The procedures for replacing the power supply components and cooling fan are given in the following paragraphs.

### 10.6.1 Regulator Assembly Replacement

1. Switch off the main circuit breaker and disconnect the main power cord.
2. Disconnect the ground strap located on the left side (as viewed from rear) of the rectifier assembly.
3. Remove the AK card from the regulator assembly. (See Step 10.5.3, AK card replacement.)
4. Loosen the three remaining screws that secure the rectifier assembly to the deck casting. Slide the rectifier assembly to the right to clear the screw heads and pull it to the rear of the MTS.
5. Reassemble in reverse order.
6. Power up the MTS and check all power supply output voltages (refer to Chapter 9).
7. Run all internal diagnostics to ensure proper operation (refer to Chapter 11).

## 10.6.2 Transformer Replacement

1. Switch off the main circuit breaker and disconnect the main power cord.
2. Remove the PK card. Refer to paragraph 10.5.4 for the procedure.
3. Remove and mark the remaining wire from the ferro capacitor.
4. Disconnect J12 from the AK card.
5. Disconnect J31 located beneath the power transformer.
6. Loosen all four screws that secure the transformer brackets to the deck casting. Remove the two screws on the right side. (on older machines, it may be necessary to remove all four screws).
7. Slide the transformer to the right and off the two remaining screws. Use caution: the transformer weighs 25 pounds (11.4 kg).
8. Transfer the insulated stand-offs from the removed transformer to the replacement transformer.
9. Reassemble in reverse order.
10. Power up the MTS and check all power supply output voltages (refer to Chapter 9).
11. Run all internal diagnostics to ensure proper operation (refer to Chapter 11).

## 10.6.3 Main Circuit Breaker Replacement

1. Switch off the main circuit breaker and disconnect the main power cord.
2. The circuit breaker is snapped into its receptacle from the front of the deck. Recessed areas are formed on either side of the breaker to allow removal with a screwdriver blade.
3. Note the locations of the electrical connections before disconnecting them. Prevent wires from falling into the deck casting recess. Disconnect the wires and remove the circuit breaker.
4. Reassemble in reverse order.



## 10.6.4 Cooling Fan Replacement

1. Switch off the main circuit breaker and disconnect the main power cord.
2. Disconnect J31 located near the card cage.
3. Remove the ground wire from the fan assembly.
4. Remove the screw that secures the fan assembly to the card cage.
5. Slide the fan assembly back to free the locking tabs at the forward end of the fan assembly; then slide the assembly forward and out from under the securing screw. Finally, pivot the assembly to the left to clear the card cage and the motherboard.
6. An individual fan may be replaced by removing it from the mounting plate. Check the airflow direction as indicated on the side of the fan before installation. Air flow should be upward. Remove the fan guard and attach it to the replacement fan.
7. Reassemble in reverse order.
8. Power up the MTS and check the fans for proper operation.

## 10.7 CABLE HARNESS REPLACEMENT

The procedures for replacing the power cable harness, the AC cable harness, the motor cable harness, and the sensor cable harness are given in the following paragraphs.

### NOTE

Unit must be unplugged from the voltage source when removing or replacing cable harnesses.

### 10.7.1 Cable Harness, Power

1. Disconnect J13, J8, J4, and J5 connectors.
2. Remove the cable from the clamps at the side of the card cage and motherboard.
3. Reinstall the cable assembly in reverse order.

## 10.7.2 Cable Harness, AC

1. Remove the regulator assembly per paragraph 10.6.1. Document the wire connections from the AC cable harness as assemblies are disconnected. Observe the wire routing.
2. Remove the operator panel from the front of the deck and disconnect the wires from the power switch, main circuit breaker, and line filter.
3. Disconnect the AC harness where it attaches to the PK card.
4. Reinstall the harness in reverse order.

## 10.7.3 Cable Harness, Motor

1. Unplug connectors J17, J18, J14, J15, J16, and J1. Remove the harness clamps, if any.
2. Remove the blower assembly to gain access to and to remove the harness. Observe how the harness is routed to assure connectors terminate at the proper places.
3. Reverse the procedure to reinstall the replacement harness. Reattach the cable ties in the proper locations.

## 10.7.4 Cable Harness, Sensor

1. Unplug connectors J22, J23, J24, J27, J28, J34, J3, J9, and single fast-on lugs to the door interlock switch. Remove the two screws from J30 connector (EOT/BOT assembly). Notice that pin 1 of J30 is toward the top.

### NOTE

J28 is not connected if the MTS is used in the horizontal mount configuration.

2. Cut the appropriate cable ties to free up the harness. Observe the harness routing to assure the replacement harness does not interfere with moving parts.
3. Replace the harness in reverse order. Replace the cable ties previously removed.

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SEPARATOR SET PN 83464

THIS SEPARATOR SET CONTAINS 19  
TABS TOTAL IN THE FOLLOWING  
ORDER:

MAINTENANCE MANUAL

1. INTRODUCTION
  2. OPERATION
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- APPENDICES

IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD

# CHAPTER 11

## DIAGNOSTIC/MAINTENANCE PROGRAMS

### 11.1 INTRODUCTION

The 2920 Magnetic Tape Subsystem (MTS) diagnostic programs are capable of detecting fault conditions in the tape subsystem and isolating failures within a specific number of field replaceable units (FRUs). The programs, which consist of internal diagnostic programs and maintenance programs, reside in the Diagnostic PROM.

An optional set of diagnostics, external programs, are released on floppy diskettes and run from a Storage Technology Corporation Model 3910 Detached Diagnostic Device via the standard 1900 interface. The external routine library provides complete 2920 interface verification and limited online exercising. The 1900 Diagnostic Monitor, under which the external diagnostic routines are run, also provides a high-level, interpretive language with which to create online command sequences quickly. (Refer to the 3910 User's Guide For 1900 Diagnostics Manual, PN 9613.) An ANSI Fortran (X3.9-1966) source code equivalent of the 1900 Diagnostic Monitor and routine library is also available for installation. This option allows testing of the entire interface from the host system to the 2920 MTS. (Refer to the 1900 Fortran Monitor Manual, PN 9646.)

Some of the information in the rest of this chapter is unique to 50 IPS, 100 IPS, StorageTek Standard Interface, or Industry Standard Interface. This is indicated in the text or tables where applicable.

#### 11.1.1 Test Initiation

The internal diagnostic package provides several options in the execution of diagnostic library routines. The following panel key sequences are used to implement these options:

Complete internal package:	<ENTER DIAG>,10,<ENTER>
Individual test:	<ENTER DIAG>,id,<ENTER>
Test run modification:	<ENTER DIAG>, n,<ENTER>
Continue:	n = 5
Loop:	6
Bypass Error:	7

Note that the test run modification entry is to be followed by the individual test entry to which that option is applied. Options can be combined but cannot be applied to any other Section 0 routine (maintenance routines).

## 11.1.2 Status Buffers

In many cases the fault code dictionary refers to the status buffers A, B, or C. Access to any of the 16 bytes contained in each buffer is obtained via the maintenance routine of matching ID (e.g., <ENTER DIAG>,B,<ENTER>). Once entered, the 16 buffer bytes can be scrolled by repeatedly pressing <ENTER>. Pressing <ENTER> displays the buffer ID and index (B1,B2...); releasing <ENTER> displays the contents. The index is presented in hexadecimal notation (as is all data displayed) and wraps around upon reaching the last entry (...BE,BF,B0,B1...).

## 11.2 SECTION 0 - MAINTENANCE ROUTINES

The maintenance routines have several functions. They are not in themselves intended to isolate hardware malfunctions, but they permit the operator do any of the following:

- Exercise the machine in basic motion operating modes,
- Select operating options for diagnostic routines,
- Manually do some independent tests from the operator panel,
- Retrieve status from memory registers for display on panel.

These functions are tabulated in Table 11-1.

The maintenance routines are initiated by entering the routine ID number at the diagnostic keypad. Refer to Chapter 2 for descriptions of the diagnostic keypad. The routines are individually described below in the order of their routine number.

### 11.2.1 Forward Motion (00)

The Forward Motion routine initiates forward tape motion in read mode. If subsystem density is to be selected, it must be done while the tape is positioned at BOT and prior to the initiation of this routine. Tape motion halts when EOT is detected or when the Reset key is pressed.

### 11.2.2 Backward Motion (01)

The Backward Motion routine initiates backward tape motion in read mode. Subsystem density remains as indicated on the front panel. Tape motion halts when BOT is detected or when the Reset key is pressed.

Table 11-1. Maintenance Routines

ROUTINE TYPE	ROUTINE NAME	ROUTINE ID
Motion Routines	Forward Motion	00
	Backward Motion	01
	Shoeshine Motion	02
	Start/Stop Motion	03
	Maintenance Write	0E
	Maintenance Write	0F
Diagnostics Runtime Options	Speed Select Option	04
	Continue Option	05
	Loop Option	06
	Bypass Error Option	07
Manual Operating Tests	Keyboard/LED Driver	08
	Reel/Capstan Driver	09
Status Display	Status A Display	0A
	Status B Display	0B
	Status C Display	0C

### 11.2.3 Shoeshine Motion (02)

The Shoeshine Motion routine performs a continuously alternating forward/backward motion with the motion duration selectable at the front panel. This routine halts when EOT is detected in the forward direction, BOT is detected in the backward direction, or when the Reset key is pressed. The least significant display digit indicates the operating rate and direction as follows (pressing <ENTER> selects the next rate):

Forward motion time	Display Contents
2 sec	(@2 1)
1 sec	(@2 2)
500 ms	(@2 3)
250 ms	(@2 4)

### 11.2.4 Start/Stop Motion (03)

The Start/Stop Motion routine performs a start/stop-type motion with the start/stop rate and direction selectable at the front panel. This routine halts when EOT is detected in the forward direction, BOT is detected in the backward direction, or when the Reset key is pressed. The least significant display digit indicates the operating rate and direction as follows (pressing

<ENTER> selects the next rate):

Motion/Stop Time (each)	Least Sig Digit of Display	
	Forward	Backward
500 ms	(1)	(5)
250 ms	(2)	(6)
125 ms	(3)	(7)
63 ms	(4)	(8)

### 11.2.5 Speed Select Option (04)

This routine toggles the internal speed selection circuitry. If the subsystem was in the 50 IPS mode before the command was issued, the display will indicate the new mode of 100 IPS (@4 H) for approximately one half second before the display returns to idle (----). If the subsystem was in the 100 IPS mode before the command was issued, the display will indicate the new mode of 50 IPS (@4 L).

Speed mode change will occur whether or not tape is loaded. If the tape is loaded, the arm positions will change to the reference position appropriate to the newly selected mode.

### 11.2.6 Continue Option (05)

The Continue Option routine sets the Continue option for a subsequent diagnostic run request. This modifies the monitor's handling of diagnostic termination, allowing execution to continue with the next entry in the internal test library rather than to the normal return-to-idle response (----). Execution terminates for any one of the following conditions:

1. An error is detected (unless Bypass Error option is set).
2. The end of the internal test library is detected (unless the Loop option is set).
3. The Reset key is pressed.

### 11.2.7 Loop Option (06)

The Loop Option routine sets the Loop option for a subsequent diagnostic run request (see Test 05 if used with the Continue option). If the Continue option is not set, the Loop option will result in the repeated execution of the subsequently requested diagnostic routine. Execution terminates for any one of the following conditions:

1. An error is detected (unless Bypass Error option is set.)



2. The Reset key is pressed.

### 11.2.8 Bypass Error Option (07)

The Bypass Error Option routine sets the Bypass Error option for a subsequent test run request. This option is only valid if issued with a Continue or Loop Option (Tests 05 and 06).

### 11.2.9 Keyboard/LED Driver (08)

The Keyboard/LED Driver routine samples the keyboard input (ASCII data) and copies the data to all four digits of the display. Pressing the Reset key terminates the routine; holding the key down causes every other LED on the front panel to illuminate. When the key is released, these LEDs extinguish and the remaining LEDs illuminate. This permits the operator to verify independent functioning of all panel indicators.

### 11.2.10 Reel/Capstan Driver (09)

The Reel/Capstan Driver routine drives the reels and capstan in various modes selectable at the front panel. The mode number is displayed as the least significant digit on the panel display. Initially, Mode 0, all servos are nulled. Each time <ENTER> is pressed, the mode number seen in the display is bumped and the appropriate motion occurs as defined below:

Mode 0: Servo drivers nulled

- 1: Capstan forward, uP control (approx 25 ips), low gain
- 2: Capstan forward, uP control (approx 25 ips), high gain
- 3: Capstan forward, velocity control (50 ips), high gain
  
- 4: Capstan backward, uP control (approx 25 ips), low gain
- 5: Capstan backward, uP control (approx 25 ips), high gain
- 6: Capstan backward, velocity control (50 ips), high gain
  
- 7: Machine reel forward, thread mode
- 8: Machine reel backward, thread mode
- 9: Machine reel forward, current mode
- A: Machine reel backward, current mode
  
- B: File reel forward, thread mode
- C: File reel backward, thread mode
- D: File reel forward, current mode
- E: File reel backward, current mode

The routine repeats this sequence upon reaching the last entry.

Pressing the Reset key terminates the routine.

### 11.2.11 Status A Display (0A)

The Status A Display routine allows the display of the 16 bytes in status area A. While <ENTER> is pressed, the index to the status bytes (A0,A1,...) is displayed in the first two display digits; when released, the content of that location is displayed in the last two digits. Upon reaching the last byte, the sequence is repeated (...AE,AF,A0,A1,...). The panel is returned to idle by pressing the Reset key or <CLEAR>.

The last location examined is remembered, and can be accessed using <DISP ADDR> or <ENTER PROBE> without an address entry.

### 11.2.12 Status B Display (0B)

The Status B Display routine displays the contents of the status area B (see Test 0A).

### 11.2.13 Status C Display (0C)

The Status C Display routine displays the contents of status area C (see Test 0A).

### 11.2.14 Maintenance Write (0E)

This Maintenance Write routine erases all tracks and writes one track as selected at the front panel. Initially all tracks are erased by setting all diagnostic dead track bits, thereby disallowing write trigger transitions (an X is displayed in the least significant display digit). <ENTER> may then be used to select the writing of one track only and the track number (0-7,P) is displayed. The track selections repeat upon reaching track P. Pressing the Reset key terminates the routine.

Note that the density in which the tape is to be written must be selected at BOT (use the Density key) prior to initiating this routine. If PE density is selected, the track written will contain the all-ONEs frequency appropriate for PE density. If GCR is selected, two frequencies will be written: the higher frequency representing the all-ONEs data rate, and the lower representing the minimum frequency allowed in GCR recording (one-third the all-ONEs rate). This feature is provided for dynamic range measurement of the read channel.

## 11.2.15 Maintenance Write (OF)

This Maintenance Write routine writes in all tracks or allows the selection of one track to be erased. Initially all tracks are written by resetting all diagnostic dead track bits, thereby allowing write trigger transitions (an X is displayed in the least significant display digit). <ENTER> may then be used to select the erasure of one track only and the track number (0-7,P) is displayed. The track selections repeat upon reaching track P. Pressing the Reset key terminates the routine.

## 11.3 INTERNAL DIAGNOSTICS

The internal diagnostics are a set of routines (Table 11-2), each executable by specifying a program ID at the diagnostic keypad. The internal diagnostics are arranged numerically so that if they are run in sequence, they will test the subsystem from the microprocessor and RAM outward to the drive. These routines are divided into four sections: power-up, formatter, transport, and read/write tests.

### 11.3.1 Section 1 - Power-Up Tests

The power-up tests are automatically executed whenever power is applied to the subsystem or they can be run individually from the diagnostic keypad by entering the test ID number when the panel is idle. These routines ensure basic operation of the microprocessor and control logic of the subsystem which includes the testing of memory (RAM and PROM checksum), counter/timers, interrupt hardware, stuck keyboard conditions, servo control register loop back, status from the data path and write cards, and swing-arm motions. Errors that occur during power-up will display a three-digit hexadecimal fault code and flash a machine check indication. This condition will prevent further subsystem operation until the Reset key is pressed. Errors that occur following the manual initiation of an internal diagnostic test will also display a fault code but will not flash a machine check indication or prevent placing the subsystem online.

Table 11-2. Internal Diagnostics  
(Sheet 1 of 2)

TEST TYPE	TEST NAME	TEST ID	
Section 1 - Power-up	Test Package Initiator	10	
	Memory/PROM Checksum	12	
	IF Test 1	13	
	IF Test 2	14	
	Keyboard Status	15	
	Cache/IF Interface Test	16	
	Cache Internal Test	17	
	Servo-LSI Register Loop	18	
	Data Path Status	1B	
	Write Card Status	1D	
	Release/Retract Swing Arms	1F	
	Section 2 - Formatter	PE Basic LWR	22
		PE LWR Velocity	23
		GCR Basic LWR	24
GCR LWR Velocity		25	
PE LWR, One Track Dead		26	
GCR LWR, One Track Dead		27	
PE LWR, Two Tracks Dead		28	
GCR LWR, Two Tracks Dead		29	
PE Basic LWR, 100 IPS		2C	
GCR Basic LWR, 100 IPS		2E	
Section 3 - Transport	Unload/Load	32	
	Drive Basic Motion, 50 IPS	34	
	Drive Basic Motion, 100 IPS	35	
	Drive Rewind	36	
Section 4 - Read/Write, 50 IPS	PE Amplitude Sensor	42	
	GCR Amplitude Sensor	43	
	PE Write Records	48	
	PE Read Forward	49	
	PE Read Backward	4A	
	PE Positioning	4B	
	GCR Write Records	4C	
	GCR Read Forward	4D	
	GCR Read Backward	4E	
	GCR Positioning	4F	

**Table 11-2. Internal Diagnostics  
(Sheet 2 of 2)**

TEST TYPE	TEST NAME	TEST ID
Section 5 - Read/Write, 100 IPS	PE Amplitude Sensor	52
	GCR Amplitude Sensor	53
	PE Write Records	58
	PE Read Forward	59
	PE Read Backward	5A
	PE Positioning	5B
	GCR Write Records	5C
	GCR Read Forward	5D
	GCR Read Backward	5E
	GCR Positioning	5F
Section 6 - Cache	Cache Buffer Extended Memory Test	62
	Early EOT Test	64

#### 11.3.1.1 TEST PACKAGE INITIATOR (10)

The Test Package Initiator routine sets the Continue option and returns the subsystem to the monitor. Testing begins with Test 12 and continues until its completion or an error is detected.

#### 11.3.1.2 MEMORY/PROM CHECKSUM (12)

The Memory/PROM Checksum test checks all of memory (RAM and PROM). RAM is tested (both the diagnostic loop write-to-read buffer and functional memory) for its ability to write, read, write complement, and read with a demanding Z80 instruction sequence. The PROMs are read and the checksums verified.

#### 11.3.1.3 IF TEST 1 (13)

The testing performed by this routine depends in the type of interface card installed; StorageTek or Industry Standards. The tests are described in the following paragraphs.

##### 11.3.1.3.1 Routine 13 for StorageTek Interface Card

This routine checks all three counters (8253) for their down-count ability through the entire 16-bit count range. A

terminal count pulse is expected at the interrupt controller (8259) for each counter in a fixed sequence following a fixed delay.

#### 11.3.1.3.2 Routine 13 for Industry Standard Interface Card

This routine checks counter functions and interrupts generation of the MK3801 by preloading the three counters with independent values and ensuring a similar sequence of interrupts.

#### 11.3.1.4 IF TEST 2 (14)

The testing performed by this routine depends in the type of interface card installed; StorageTek or Industry Standards. The tests are described in the following paragraphs.

##### 11.3.1.4.1 Routine 14 for StorageTek Interface Card

This routine checks that all counter-related interrupts are functional. Counters 0, 1, and 2 are set for delays of 200, 400, and 600 microseconds, respectively. When the interrupts are received by the handler, a bit corresponding to the one received is set in a processor register, allowing verification of the sequence of interrupts received.

##### 11.3.1.4.2 Routine 14 for Industry Standard Interface Card

This routine checks the read/write memory registers for independent functions. These registers are located in memory addresses INSTATA, INSTAB, INSTATC, INTCLR and DIAGSTAT.

#### 11.3.1.5 KEYBOARD STATUS (15)

This Keyboard Status test ensures that there are no stuck-active conditions in the keyboard control and status registers. All row selects (0 through 4) are individually activated and status KBDATA is read to check the column-depressed response. An error will be displayed if more than one key is indicated as being active.

#### 11.3.1.6 CACHE/IF CARD COMMUNICATIONS (16)

This routine tests the command, status and data lines between the IF card and the Cache Buffer card. The Cache card sends a DMS followed by a NOP to the IF card. The IF card sets up the status lines as specified in the 2920 Product Specification. The cache card continues sending NOPs to the IF card until all the status

lines are tested. The IF card then goes into the command wrap phase, wrapping the command lines from the cache card back to the DTR. After all of the command lines have been tested, the cache card initiates the IF card's Write No Motion and Read No Motion tests.

#### 11.3.1.7 CACHE CARD INTERNAL TEST (17)

The Cache Card Internal routine tests the data path, timer and the memory on the Cache Card. The test starts by testing the Cache Card's microprocessor scratch memory, then the PROMs are read and their check-sums verified. The test then verifies that the Cache Buffer's timer times out in the requested time. Next the Cache memory is written and verified, including the stop and parity bits. The memory test pattern is then reversed to test all bits in both high and low polarity. (Cache memory is also tested in routine 62.) After this memory is tested, the Early EOT counters are tested. (Early EOT is further tested in routine 64.) The CRC circuitry is tested last by writing test patterns to cache memory and reading them back while checking correct CRC status. The CRC is further tested by altering one byte in the test pattern, thus forcing a CRC error when the test pattern is read back.

#### 11.3.1.8 SERVO-LSI REGISTER LOOP (18)

The Servo-LSI Register Loop routine tests the loopable paths through the XRS and XCS chips including the capstan position counter PCREAD, capstan velocity register VR, and both swing arm position counters READMPOS, READFPOS. All registers are loaded with walking ONEs and ZEROS such that independent functioning of these addresses can be verified.

#### 11.3.1.9 DATA PATH STATUS (1B)

The Data Path Status routine checks that proper status is seen from the data path card following resets in both PE and GCR modes. Status is examined in DP card Registers DTREG through AMPSREG.

#### 11.3.1.10 WRITE CARD STATUS (1D)

The Write Card Status routine enables each sensor individually and when the associated control lines are disabled, the following conditions are expected in the sensor status register (SENSORS):

1. EOT, BOT, and Leader Status must be off
2. File Protect must be asserted

3. Tape Present is a don't care (due to the possibility of tape in the thread path)

Also, Sensor Error must never be asserted as this indicates detection of an impossible combination by the WR write card (e.g., LED off but detector active).

This routine also ensures resetting write/erase currents. Write Current Active is tested by the first write test (42) in the diagnostic package.

#### 11.3.1.11 RELEASE/RETRACT SWING ARMS (1F)

The Release/Retract Swing Arms routine drives the swing arms to the extent of their travel. The swing arms are first driven to their extended position and then returned to retracted position. During the retract motion, proper phasing of the motion tachs is checked. A software count representing the distance travelled is expected to match that detected by the position counters of the SV servo card XRS chip. (If tape is detected in the thread path, all count compares are bypassed.)

### 11.3.2 Section 2 - Formatter Tests

The formatter tests ensure proper data path operation by simulating record writing in a loop write-to-read mode. No tape motion takes place in these tests; they may be executed in a tape loaded or unloaded state.

#### 11.3.2.1 PE BASIC LOOP WRITE-TO-READ, 50 IPS (22)

The PE Basic Loop Write-to-Read (LWR) routine is the initial test of the subsystem's PE loop write-to-read capability. This routine sets the subsystem to the PE mode and simulates records of selected data and byte counts.

The first six patterns (all-ONEs, all-ZEROs, AA-55, 55-AA, walking ZERO bit, and walking ONE bit) are written as short records (five to eight bytes). In each of these cases, data is retained in the read path for subsequent data comparison. These pattern and length combinations result in the transfer of 1128 bytes in 144 records.

The next eight records are written as long records (one to eight kilobytes). For these records, a 32-byte data pattern is repeated up to the desired length (based on time) and then STOP is asserted to the DP data path card. When the data path indicates completion, status is used to indicate data integrity. Approximately 36 kilobytes are transferred in the eight records.



These transfers involve the IF processor card, DP data path card, and RD read card. No errors are forced by this test so that the occurrence of an error will result in a fault code.

#### 11.3.2.2 PE LWR VELOCITY (23)

The PE LWR Velocity routine verifies the velocity error detection thresholds normally enabled during PE writes. A capstan tach will be approximately 20 tach periods in length. The velocity check circuitry counts the number of VCO pulses received from the RD card for each tach period. Four records will be used to simulate 50 IPS velocity errors of +12.5%, +5.6%, -8.2%, and -11.7%. Of these, the first and last records will exceed the 10% threshold and a Velocity Check is expected.

#### 11.3.2.3 GCR BASIC LOOP WRITE-TO-READ, 50 IPS (24)

The GCR Basic Loop Write-to-Read (LWR) routine is the initial test of the subsystem's GCR loop write-to-read ability. This routine sets the subsystem to GCR mode and simulates records of selected data and byte counts.

The first six patterns (all ONEs, all ZEROs, AA-55, 55-AA, walking ZERO bit, and walking ONE bit) are written as short records (one to six bytes). In each of these cases, data is retained in the read path for subsequent data comparison. These pattern and length combinations result in the transfer of 660 bytes in 120 records.

The next eight records are written as long records (one to eight bytes). For these records, a 32-byte data pattern is repeated up to the desired length (based on time) and then STOP is asserted to the data path card. When the data path indicates completion, status is used to indicate data integrity. Approximately 36 kilobytes are transferred in the eight records.

These transfers involve the IF processor card, DP data path card, and RD read card. No errors are forced by this by this test so that the occurrence of an error will result in a fault code.

#### 11.3.2.4 GCR LWR VELOCITY (25)

The GCR LWR Velocity routine verifies the velocity error detection thresholds normally enabled during GCR write operations. A capstan tach is diagnostically simulated during the writing of records approximately 20 tach periods in length. The velocity check circuitry counts the number of VCO pulses received from the RD card for each tach period. Four records will be used to simulate 50 IPS velocity errors of +12.5%, +5.6%, -8.2%, and -11.7%. Of these records, the first and last records will exceed

the 10% threshold and a Velocity Check is expected.

#### 11.3.2.5 PE LWR, ONE TRACK DEAD (26)

The PE LWR, One Track Dead routine tests the error detection and correction ability of the PE loop write-to-read function. Sixty-four short records and eight long records are written with a test track forced inactive. Track 0 is the initial test track, shifting up to track P with each successful completion of the 72 records.

The short records use the walking ZERO bit pattern with a length of six bytes. Corrected data is compared to the write buffer upon readback. For the short records, dead tracking is performed throughout from preamble through postamble. This procedure tests the hardware's ability to recognize a late ready track.

The long records are identical to those used in Test 22 with lengths from one to eight kilobytes. Dead tracking starts approximately halfway through the preamble ensuring "record latch" and testing early track ready indications.

Only correction status is expected for these single track-in-error situations.

#### 11.3.2.6 GCR LWR, ONE TRACK DEAD (27)

The GCR LWR, One Track Dead routine tests the error detection and correction ability of the GCR loop write-to-read function. Forty-eight short records and eight long records are written with a test track forced inactive. Track 0 is the initial test track, shifting up to track P with each successful completion of the 56 records.

The short records use the walking ZERO bit pattern with a length of eight bytes. Corrected data is compared to the write buffer upon readback. For the short records, dead tracking is performed throughout from preamble through postamble. This procedure tests the hardware's ability to recognize a late ready track.

The long records are identical to those used in Test 22 with lengths from one to eight kilobytes. Dead tracking starts approximately halfway through the preamble ensuring "record latch" and testing early track ready indications.

Only correction status is expected from the data path card (DP) for these single track-in-error situations.

#### 11.3.2.7 PE LWR, TWO TRACKS DEAD (28)

The PE LWR, Two Tracks Dead routine checks that two tracks in error are identified and that an uncorrectable record is flagged. The test procedure is as described for Test 26 except that the dead tracking is performed on all 36 permutations of two tracks from 0 and 1 to 7 and P. This procedure results in the transfer of 18,432 bytes in 2,403 short records and 1296 kilobytes in 288 long records.

This test expects the following status from the data path card: Uncorrectable, Partial Record, Multi-track Error, and End Data Check.

#### 11.3.2.8 GCR, LWR, TWO TRACKS DEAD (29)

This routine checks that two GCR tracks in error are identified and that data correction is performed. The test procedure is as described for test 27 except that the dead-tracking is performed on all 36 permutations of two tracks from 0 and 1 to 7 and p. This results in the transfer of 10,368 bytes in 1728 short records and 1296K bytes in 288 long records. This test expects Multi Track error status from the data path (DP) card.

#### 11.3.2.9 PE BASIC LWR, 100 IPS (2C)

This routine switches the subsystem to 100 IPS mode, then performs tests as in Routine 22.

#### 11.3.2.10 GCR BASIC LWR, 100 IPS (2E)

This routine switches the subsystem to 100 IPS mode, then performs tests as in Routine 24.

### 11.3.3 Section 3 - Transport Tests

Once the formatter has been checked, the diagnostic routines test the tape transport. The transport tests ensure proper servo operation, tape handling during a load operation, motion control, and high-speed rewind functions.

#### 11.3.3.1 UNLOAD/LOAD (32)

The Unload/Load routine tests the reel and capstan servos by cycling through an unload/load sequence. Testing takes place primarily during the load sequence as the unload phase is not guaranteed to occur. The capstan is cycled through a forward and backward ramp and the tach examined for phasing through a

complete revolution. The reel servos are driven in both current and voltage feedback modes and the proper response is expected of the pump up/down drive signals. The drive will complete the thread sequence and stop just after the swing arms are in servoing position.

Note that this routine interrupts the normal rewind-to-BOT procedure so that Test 34 can diagnose any ramp problems. This means that the sizing of the file reel and the initialization of the adaptive motion variables are not yet complete. These will occur upon completion of the next rewind, whether it be commanded offline from the panel, online from the interface, or a result of the continuation of this test package (Test 36).

#### 11.3.3.2 DRIVE BASIC MOTION, 50 IPS(34)

The Drive Basic Motion routine performs the first test of loaded drive motion in the diagnostic package. The drive's start/stop characteristics are analyzed by allowing the functional code to control motions with the normal interrupts (250 us capstan acceleration/deceleration; 1 ms capstan at velocity; 10 ms reel control). This routine monitors the result of the functional code control: that capstan position error limits are not exceeded during the ramps, that swing arm position feedback for the reel servo is within a certain range (isolating tape slip problems), and that capstan velocity is correct during sustained motion.

#### 11.3.3.3 DRIVE BASIC MOTION, 100 IPS (35)

This routine test for 100 IPS start/stop characteristics, analyzes characteristics of ramp error, instantaneous velocity error, and stop lock positioning.

#### 11.3.3.4 DRIVE REWIND (36)

The Drive Rewind routine tests the performance of the functional rewind task. Following a 125-foot forward motion (providing that EOT is not detected), a rewind is initiated. A ramp up to a minimum of 175 ips is expected. This only verifies that initial ramp up can be completed without excessive reel error but not that the nominal rewind speed of 220 ips can be attained.

### 11.3.4 Section 4 (50 IPS) and Section 5 (100 IPS) - R/W Tests

The Read/Write Tests check the subsystem read/write electronics. Data transfer from the data path card, read backward/forward operations, and tape positioning (PE and GCR) are verified by these tests.

#### 11.3.4.1 PE AMPLITUDE SENSOR (42=50 IPS, 52=100 IPS)

The PE Amplitude Sensor routine is the first test of the subsystem read/write electronics. Write Current Status is verified before any motion occurs (the drive must be write enabled). This routine checks amplitude sensor response by writing (in PE density) an all-ONES pattern on all tracks (using the Write ARA command). Verification of over 30 feet of tape will isolate bad tape as a failure mechanism. The individual functioning of all amp sensors is then tested by using the diagnostic dead-track control to write one-track-at-a-time and all-but-one-track combinations (nine times each). Finally, gross write-to-read feedthrough problems are detected by toggling write triggers with tape motion halted.

#### 11.3.4.2 GCR AMPLITUDE SENSOR (43=50 IPS, 53=100 IPS)

The GCR Amplitude Sensor routine is identical to that of Test 42 except that the subsystem is placed in GCR mode. This requires the generation of the proper write current levels by the WR write card and amp sensor threshold selection by the RD read card.

#### 11.3.4.3 PE WRITE RECORDS (48=50 IPS, 58=100 IPS)

The PE Write Records routine performs the first formatted PE write test of the test package. As the DP data path card has been verified by the loop write-to-read tests, this routine detects and isolates faults in the WR write card, RD read card, and read/write head. If any velocity errors occur, both the DP data path card and the SV servo card will be indicated.

256 records are written (16 groups separated by tape marks). Each record contains data representing its tape position. Any reject or machine check that occurs during the writing of a record will be displayed.

#### 11.3.4.4 PE READ FORWARD (49=50 IPS, 59=100 IPS)

The PE Read Forward routine isolates read failures associated with the RD read card and the read/write head since data transfer from the data path card has been tested with the loop write-to-read tests. Following a rewind, the records written by Test 48 are read forward and the data verified. Any reject or machine check that occurs during the writing of a record will be displayed.

#### 11.3.4.5 PE READ BACKWARD (4A=50 IPS, 5A=100 IPS)

The PE Read Backward routine verifies read backward operations using the tape formatted by Test 48. After positioning on the BOT side of the logical end-of-tape (two tape marks), the 256 records are read backward and the data verified. Any reject or machine check that occurs during the reading of a record will be displayed.

#### 11.3.4.6 PE POSITIONING (4B=50 IPS, 5B=100 IPS)

The PE Positioning routine tests the positioning commands (Forward Space File, Backward Space File, Backspace A Block, and Forward Space A Block). Various combinations of these commands are issued expecting the tape formatted by Test 48. Tape position is verified by the data read from the records.

#### 11.3.4.7 GCR WRITE RECORDS (4C=50 IPS, 5B=100 IPS)

The GCR Write Records routine performs the first formatted GCR write of the test package. Failures detected by this test are now limited to the WR write card, RD read card, and the read/write head.

256 records are written (16 groups separated by tape marks). Each record contains data representing its tape position. Any reject or machine check that occurs during the writing of a record will be displayed.

#### 11.3.4.8 GCR READ FORWARD (4D=50 IPS, 5D=100 IPS)

The GCR Read Forward routine isolates read failures associated with the RD read card and the read/write head since the data transfer from the data path has been tested by the loop write-to-read tests. Following a rewind, the records written by Test 4C are read forward and the data verified. Any reject or machine check that occurs during the writing of a record will be displayed at operator panel.

#### 11.3.4.9 GCR READ BACKWARD (4E=50 IPS, 5E=100 IPS)

The GCR Read Backward routine verifies read backward operations using the tape formatted by Test 4C. After positioning on the BOT side of the logical end-of-tape (two tape marks), the 256 records are read backward and the data verified. Any reject or machine check that occurs during the reading of a record will be displayed.

#### 11.3.4.10 GCR POSITIONING (4F=50 IPS, 5F=100 IPS)

The GCR Positioning routine tests the positioning commands (Forward Space File, Backward Space File, Backspace A Block, and Forward Space A Block). Various combinations of these commands are issued expecting the tape formatted by Test 4C. Position is verified by the data read from the records.

### 11.3.5 Section 6 - Cache Buffer Tests

The Cache Buffer Diagnostics perform the longer tests for the Cache Buffer card. Cache Memory and Early EOT circuitry are verified by these tests.

#### 11.3.5.1 CACHE BUFFER EXTENDED MEMORY TEST (62)

This routine tests the cache memory more extensively than Routine 17.

#### 11.3.5.2 EARLY EOT TEST (64)

The Early EOT routine lets tape move forward up to six revolutions, then backward for up to four revolutions. While this test is being performed, forward and backward capstan pulses are looked for. At the same time, forward and backward swing arm pulses are verified. (Routine 17 statically tested the Early EOT counters.)

## 11.4 EXTERNAL DIAGNOSTICS

The External Diagnostics are supplied on a floppy diskette with the standard 1900 diagnostic control monitor. The routine library consists of an interface verification test, an internal diagnostic initiator, and several online exerciser routines (PE and GCR).

Interface verification is performed by the internal manipulation of all status lines following invocation by the 3910 Detached Diagnostic Device. The interface test sets the subsystem in a diagnostic mode which allows the independent activation of each standard interface line. The 3910 verifies that all status line transitions occur. With satisfactory communication ensured, internal diagnostics can be initiated and the test results obtained. All subsystem fault isolation is performed by the internal diagnostics. The remaining online 3910 routines are not intended to isolate any fault conditions within the subsystem, but only to provide a figure of merit for subsystem performance.

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SEPARATOR SET PN 83464

THIS SEPARATOR SET CONTAINS 19  
TABS TOTAL IN THE FOLLOWING  
ORDER:

MAINTENANCE MANUAL

1. INTRODUCTION
2. OPERATION
3. INSTALLATION
4. STORAGETEK INTERFACE
5. INDUSTRY INTERFACE
6. SCSI INTERFACE
7. VS INTERFACE
8. FUNCTIONAL DESCRIPTION
9. MAINTENANCE
10. REMOVAL/REPLACEMENT
11. DIAGNOSTICS

APPENDICES

IPC

PN COMPATIBILITY

MMLL

21/22/25 STD & 25 IND STD FCD

21/22 IND STD FCD

2925 SCSI FCD

## APPENDIX A

### SPECIAL TEST EQUIPMENT, TOOLS, AND SUPPLIES

This appendix lists the special test equipment, special tools, and supplies required to maintain the MTS. The part numbers provided are Storage Technology part numbers unless otherwise specified.

ITEM	PART NUMBER	FUNCTION
Cleaning Kit includes:	6164	Tape path cleaning
Hub/Transport Cleaner Fluid	402626502	
Lint-free Cloth	6168	
Foam-Tipped Swabs	11698	
Diagnostic Floppy	4038428	2920/3910 External Diagnostic Package
Wrist Strap	24000027	Circuit card handling
Master Skew Tape (600 ft.)	403802201	Read/write head alignment
Master Skew Tape (1200 ft.)	403802202	Read/write head alignment
Master Output Tape	401202102	Read amplitude check
Tape Developer (Magna-See)	4583	Bit position check
Jeweler's Loupe (optional)	Bauch&Lomb 81-34-35	Bit position check
Torque Screwdriver		Screw removal
Torx T15 for #6 screws	403443401	
Torx T25 for #10 screws	403443501	
Torx T30 for 1/4" screws	403443601	
Torx key for #6 screws	403443701	

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# APPENDIX B

## DATA FORMATS

### B.1 INTRODUCTION

The MTS is capable of formatting and deformatting data in both PE and GCR recording modes. This appendix describes how each recording mode is formatted.

### B.2 PHASE ENCODED (PE) OPERATION (1600 BPI)

**ANSI Compatibility.** The MTS writes and reads half-inch magnetic tapes in phase-encoded recording mode as specified by ANSI x3.39-1973.

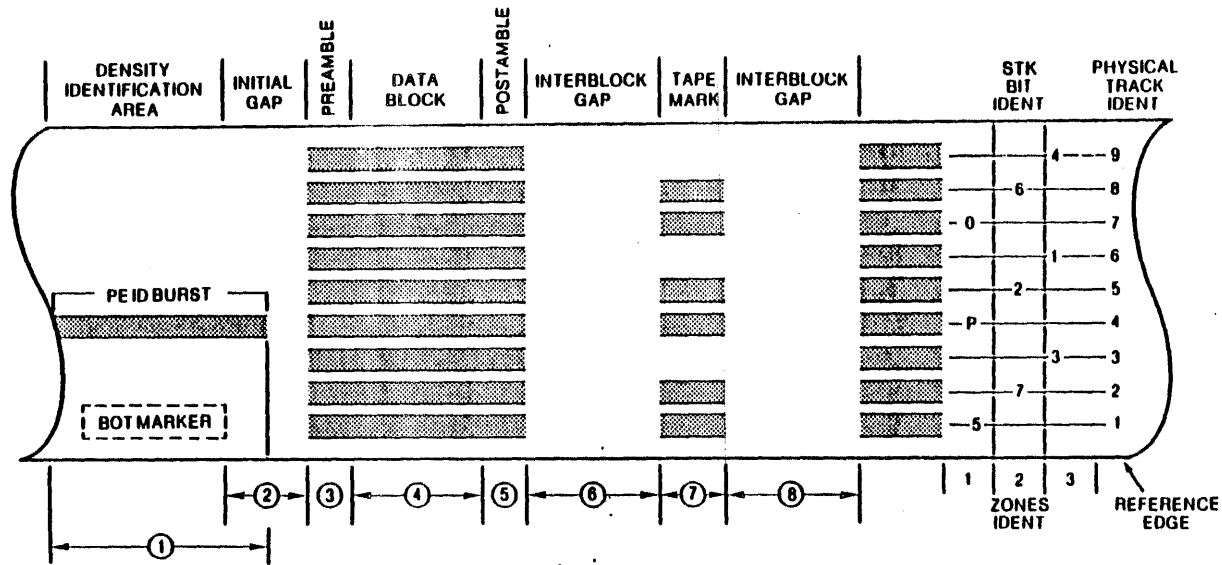
**Recorded Format.** The PE recorded format is as shown in Figure B-1. Recording density is 1600 bits per inch (nominal).

**Block Length.** The MTS does not control or limit the number of data characters within a block or record except to disallow the writing of data blocks containing no data characters. The USER has control over block size and may exceed the ANSI-specified maximum and minimum values. Minimum block size is one byte.

**Maximum Interblock Gap (IBG).** The USER may generate extended length IBGs by issuing multiple Erase Gap (ERG) commands. The USER should avoid generating gaps in excess of the ANSI-specified maximum of 25 feet (7.62 meters). When reading, detection of an erase section in excess of 25 feet causes Empty Tape Error to be set.

**End of Recording Area.** The USER must control or limit operations beyond the EOT marker (end of recording area).

**Tape Mark Block.** A tape mark will be read if sufficient characters in zone 2 with at least one track of zone 1 together with the erasure of zone 3 can be detected or zone 1 and erasure of zone 3.



- A. Tape is shown oxide side up.
- B. Areas shown without recording, including IBGs, are magnitized so that the rim end of the tape is a north-seeking pole.
- 1. Density Identification Area - PE recording is identified by an ID burst of recording at the BOT marker consisting of 1600 FCI on track 4 and erasure on all other tracks. This burst begins 1.7 inches minimum before the trailing edge of the BOT marker, continues past the trailing edge, ending at least 0.5 inch before the first block.
- 2. Initial Gap - The gap between the trailing edge of the BOT marker and the first recorded character is 3 inches minimum and 25 feet maximum.
- 3. Preamble - Preceding data in each block, a preamble is written consisting of 41 characters, of which the first 40 characters contain ZERO bits followed by a single character containing ONEs in all tracks.
- 4. Data Block - ANSI specifies this shall contain a minimum of 16 or a maximum of 2048 characters. Actual block length is under USER control.
- 5. Postamble - Following data in each block, a postamble is written consisting of 41 characters of which the first character contains ONEs in all tracks followed by 40 characters containing ZEROs in all tracks.
- 6. Tape Mark/Interblock Gap - The IBG immediately preceding a tape mark is 3.6 inches long nominal.
- 7. Tape Mark - The PE mark is written as 64 to 256 flux reversals at 3200 FCI in zone 2 (physical tracks 2,5,8) and zone 1 (physical tracks 1,4,7). Zone 3 (physical tracks 3,6,9) is DC erased.
- 8. Interblock Gaps - IBGs are 0.6 inch nominal, 0.5 inch minimum. Extended length IBGs may be generated by the USER.
- 9. End of Recording Area - The recording area starts at the leading edge of the EOT marker

12095

Figure B-1. PE Tape Format

### B.3 GROUP-CODED RECORDING (GCR) OPERATION (6250 BPI)

**ANSI Compatibility.** The MTS writes and reads half-inch magnetic tapes in group-coded recording mode as specified by ANSI x3.54-1976.

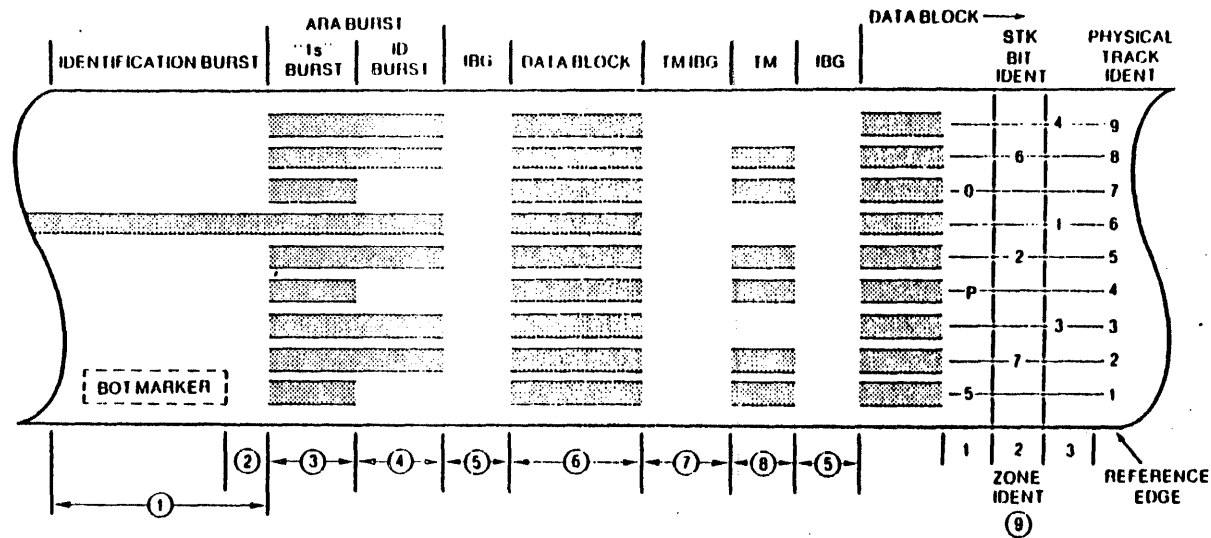
**Recorded Format.** The GCR recorded format is as shown in Figures B-2 and B-3. Recording density is 6250 bits per inch (nominal).

**Block Length.** The MTS does not control or limit the number of data characters within a block or record except to disallow the writing of data blocks containing no data characters. The USER has control over block size and may exceed the ANSI-specified maximum and minimum values. Minimum block size is one byte.

**Maximum Interblock Gap (IBG).** The USER may generate extended length IBGs by issuing multiple Erase Gap (ERG) commands. The USER should avoid generating gaps in excess of the ANSI-specified maximum of 15 feet. When reading, detection of an erase section in excess of 15 feet (4.572 meters) causes Empty Tape Error to be set.

**End of Recording Area.** The USER must control or limit operations beyond the EOT marker (end of recording area).

**Tape Mark Block.** A tape mark will be read if sufficient characters in zone 2 with at least one track of zone 1 together with the erasure of zone 3 can be detected or zone 1 and erasure of zone 3.



- A. Tape is shown oxide side up.
- B. Areas shown without recording, including IBG's are magnified so that the rim end at the tape is a north-seeking pole.
1. **Identification Burst** - The GCR method is identified by a burst of a recording at the BOT marker. The burst is in the PE frequency range (1600 BPI) on track 6 and erasure on all other tracks. The ID burst begins 1.7 inches minimum before the trailing edge of BOT and continues past the trailing edge of the BOT marker.
  2. **ARA Burst** - The ARA burst enables the capability of writing all tracks to be verified. It begins no sooner than 1.5 inches and no later than 4.3 inches as measured from the leading edge of the BOT marker.
  3. **ARA '1s' Burst** - Immediately following the ID burst there is an ARA Burst (all ONES in all tracks) which is separated from the ID Burst by an undefined gap. It ends sooner than 9.5 inches and no later than 11.5 inches as measured from the leading edge of the BOT marker.
  4. **ARA ID Burst** - Appended to the end of the ARA '1s' Burst is an ID character consisting of ONES in tracks 2,3,5,6,8, and 9 and erasure in tracks 1,4, and 7. This ID character is approximately 2 inches long. (At least a contiguous 1/4-inch section of this 2-inch long burst must be error-free in all tracks simultaneously). There is a normal IBG between the ARA ID character and the first data block.
  5. **Interblock Gaps** - IBGs are 0.285 inch minimum and 0.3 inch nominal. Extended length IBGs may be generated by the USER.
  6. **Data Block** - See GCR Data Block Format Illustration.
  7. **Tape Mark Interblock Gap** - The IBG immediately preceding a tape mark is 3.3 inches nominal.
  8. **Tape Mark** - The GCR tape mark is written as 250 to 400 flux reversals at 9042 FCI in zone 2 (physical tracks 2,5,8) and zone 1 (physical tracks 1,4,7). Zone 3 (physical tracks 3,6,9) is DC erased.
  9. **End of Recording Area** - The end of the recording area starts at the leading edge of the BOT marker.

12096

Figure B-2. GCR Tape Format

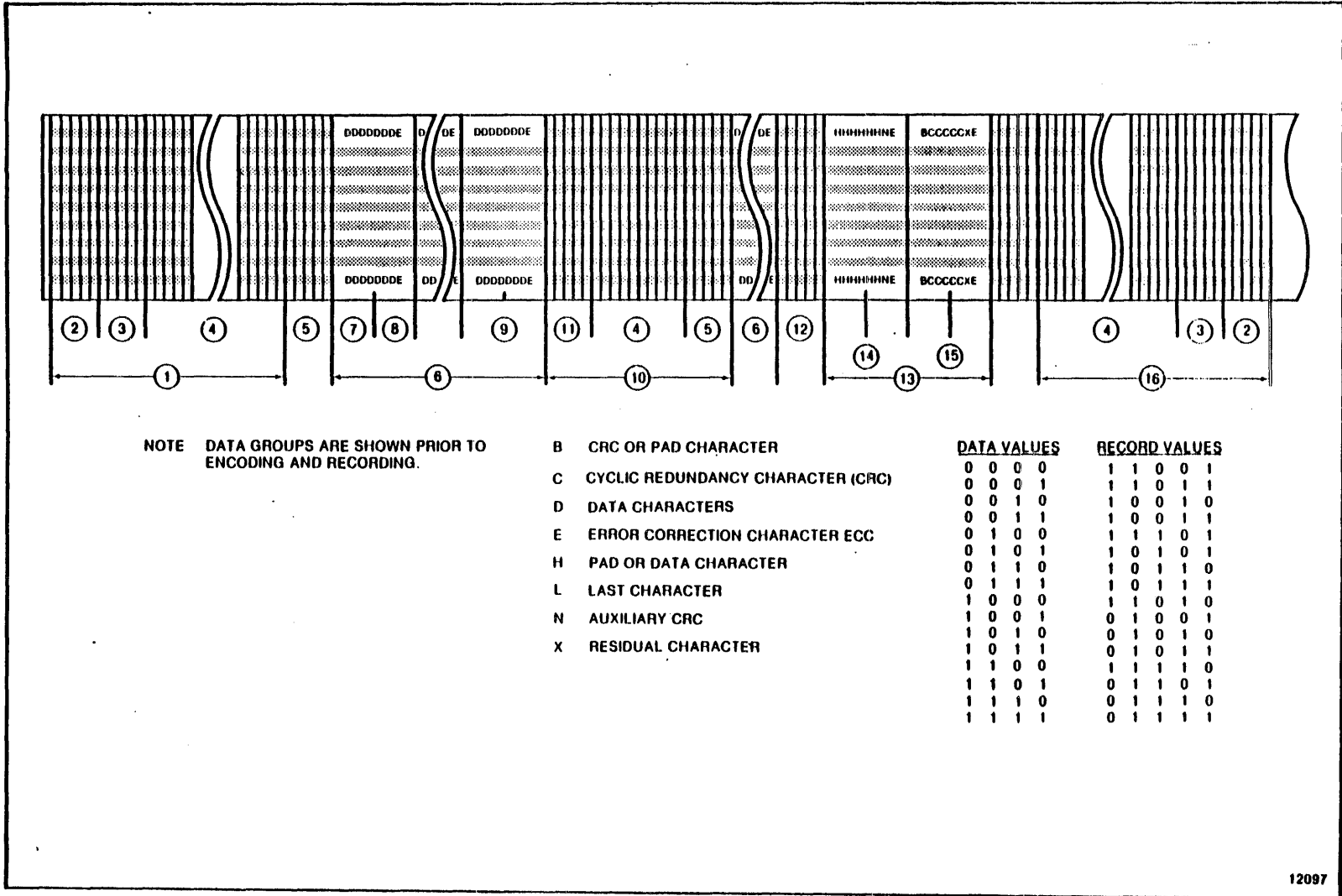


Figure B-3. GCR Data Block Format (Sheet 1 of 3).



The following are notes that explain sheet 1 of the figure. These notes are numbered to correspond with the numbers on the illustration.

- ① Preamble - Sixteen subgroups of five bytes each. The subgroups initiate the read circuits and synchronize them.
- ② Terminator Control Subgroup - The data in this subgroup provides for a long wave length input to the read detection circuits, thus ensuring high level inputs into the circuits at the beginning of a read operation. These inputs in turn ensure that the Read Detectors are turned ON before they are synchronized.

The Terminator Control Subgroup is one set of nine parallel 5 bit serial values of 10101 in all tracks located at the ROT end of each block and 1010L at the EOT end of each block, where L represents the resetting of the test character (which restores the Write Triggers to the erase state).

- ③ The Second Control Subgroup - This is a part of sync, explained below. The second Control Subgroup consists of 5 bit serial values of 01111 in all tracks for the BOT end of the block and 11110 for the EOT end of the block.
- ④ Sync Control Subgroup - These are fourteen 5-byte subgroups which synchronize the Read Reference Oscillator. Each subgroup consists of 5-bit serial values of all '1's' in all tracks.
- ⑤ Mark 1 Control Subgroup - This subgroup marks the coming of data. It ensures that the buffer counters are properly initiated so the data being read is formatted into the correct 5 byte groups. This is necessary for correct decoding (retranslation from five to four bit codes) of the data which is being read. The Mark 1 Control Subgroup is one set of 5 bit serial values of 01111 on all tracks. On backward operations, the Mark 1 becomes the Mark 2 Subgroup.
- ⑥ Data - Any recorded section of the tape which has only data and the ECC recorded on it (no Control Subgroups). The data is formatted into groups and the groups are divided into subgroups. These data subgroups are identified as data subgroup A and data subgroup B. Data subgroup A consists of four data bytes before translation (the storage group). The same is true for data subgroup B except that it is made up of three bytes and one ECC (Error Correction Character) before translation. The ECC is used for data correction. All data correction in GCR is done on the 8-byte data groups (byte 8 is the ECC).

Data Values/Record Values - During GCR recording, four bits from each track are translated into the 5 bit code. After translation, the 5 bit code is moved serially to the IU for recording. The data values and record values show the bit patterns before and after translation. During read operations, the 5 bit code is reconverted to the original four bits. Thus, the data sent to CPU is in its original form.

- ⑦ Data Subgroup A consists of four data bytes before translation (the storage group).
- ⑧ The same is true for Data Subgroup B except that it is made up of three data bytes and one ECC (Error Correction Character) before translation. The ECC is used for data correction. All data correction in GCR is done on the 8 byte data groups (byte 8 is the ECC).
- ⑨ There may be no more than 158 contiguous data groups in a recorded data block. If there are more than 1112 data bytes (before translation) in an incoming record, resynchronization is necessary before the recording can be continued.
- ⑩ Resync Burst - This burst is used to resynchronize the data of falling tracks: when a data record is longer than 1112 data bytes (before translation). See notes 8 through 9.
- ⑪ Mark 2 Control Subgroup - This subgroup marks the ending of data and the coming of nondata information. The Mark 2 Control Subgroup consists of one set of 5 bit serial values of 11100 on all tracks. On backward operations, the Mark 2 becomes the Mark 1 Subgroup.
- ⑫ End Mark Control Subgroup - This subgroup warns of the approach of the Residual Data Group, which is defined in note 14. The End Mark Control Subgroup consists of one set of 5 bit serial values of 11111 on all tracks.
- ⑬ RES/CRC Data - This data includes both the Residual Data Group and the CRC Data Group (these groups are described in notes 14 and 15). These two groups are written at the end of a data record.
- ⑭ Residual Data Group - This group is formed when there are six or less data bytes remaining in a data record. If six data bytes remain, the seventh byte of the Residual Data Group is the Auxiliary CRC Character (a data validity check character) and byte eight is the normal ECC. If there are less than six residual data bytes, pad characters of all ZEROS with correct parity are added to the data group to pad it to six bytes. Thus, the Residual Data Group consists of the remaining bytes, the pad characters, the Auxiliary CRC Character (H), and the ECC (E). (All data groups must have eight bytes total in GCR mode).
- ⑮ Before this data group is written, the CRC character normally has odd parity if there was an odd number of data groups, and even parity if there was an even number of data groups. If the record has an odd number of data groups, the CRC character is even. Since an even parity byte is not allowed in a GCR Data Group, the CRC character must be made odd. To accomplish this an additional pad byte consisting of all ZEROS and a parity bit (B) is added to the record. The addition of this byte changes the number of bytes in the CRC generation and provides an odd parity CRC character.

Figure B-3. GCR Data Block Format (Sheet 2 of 3)

The next five bytes of the CRC Data Group are identical CRC characters. The additional CRC characters serve to fill the CRC Data Group, since there is no more data to be read.

Next in the CRC Data Group is the Residual Character (X). By definition this character is used as a record data counter. Bits 3-7 are the module 32 counter. These bits are used by StorageTek in a proprietary manner. Bits 0-2 are used as a module 7 count of the Residual Data Group bytes are data. The module 7 count of the Residual character indicates how many data bytes are to be retrieved from the Residual Data Group.

The ECC in this data group, as in all other groups, is used to verify the correctness of data in the group and to isolate the error, if any, during read operations for data correction.

(16) Postamble - The Postamble is the mirror image of the Preamble except for the terminator control subgroup. In read backward operations, the Postamble is used the same way the Preamble is used in read forward operations. See the description of Preamble in notes 1 through 4.

Check Characters - Three Check Characters are used in the GCR tape format: CRC (B), Auxiliary CRC (N), and ECC (E).

The CRC characters are used to verify data validity during write and read back check operations. The ECC is used to verify data and validity, and for error identification and correction during read operations.

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## APPENDIX C

### MEMORY ALLOCATION, STK STANDARD INTERFACE - 2921

#### C.1 MEMORY MAP

0000 1FFF	PROM 1 (Functional)	(0000-1FFF)	8k
2000 3FFF	PROM 2 (Functional)	(2000-3FFF)	8k
4000 5FFF	PROM 3 (Diagnostics)	(4000-5FFF)	8k
6000 7FFF	Memory-Mapped I/O	(6000-7FFF)	8k
8000 8FFF	Diagnostic RAM (8000-87FF) 2k The first 64 bytes (8000-803F) constitute the internal LWR buffer.		
9000 9FFF	Not Used		
A000 AFFF	Functional Ram	(A000-A7FF)	2K
B000	Not Used		
FFFF	Not Used		

## C.2 KEYBOARD/OP PANEL REGISTER ALLOCATION

Read Keyboard (0 = key depressed)

KBDATA

6010  
R/O

			Co14	Co13	Co12	Co11	Co10
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## C.3 DIAGNOSTIC REGISTER ALLOCATION

Diagnostic Status (IDG)

DIAGSTAT

6014  
R/O

					Diag Read Done RDFIN	Diag Write Done WTFIN	Diag Prty Error PRITY
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Read Diagnostic Download Byte

DIAGDWNL

6017  
R/O

msb	...	...	...	...	...	...	lsb
-----	-----	-----	-----	-----	-----	-----	-----

Servo Diagnostic Status

DIAGSERV

6050  
R/O

Tach Phase A TACHA	Tach Phase B TACHB			Mach Pump Down MPD	Mach Pump Up MPU	File Pump Down FPD	File Pump Up FPU
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Diagnostic Sense (ISN)

DIAGSENS

6078  
R/O

Diag Switch 1	Diag Switch 0	Buper	Stop	Trak	Diag Sel 2	Diag Sel 1	Diag Sel 0
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## C.4 CAPSTAN CONTROL REGISTER ALLOCATION

		Read Position Count						PCREAD
6025	R/O	msb	...	...	...	...	...	1sb

		Read Capstan Velocity						VR
6027	R/O	msb	...	...	...	...	...	1sb

## C.5 REEL CONTROL REGISTER ALLOCATION

		Read Machine Position Count						READMPOS
6034	R/O	msb	...	...	...	...	...	1sb

		Read File Position Count						READFPOS
6035	R/O	msb	...	...	...	...	...	1sb

		Reel Status (RSS)					SRVOSENS	
6036	R/O	Mach Phase B MPHSB	Mach Phase A MPHSA	File Phase B FPHSB	File Phase A FPHSA	Watch Dog EPO WDERR	Loop Out EPO LOOPF	Power Fail EPO PWRF

		Read Thread Counter						THRDREAD
603B	R/O	msb	...	...	...	...	...	1sb

## C.6 DATA PATH CARD REGISTER ALLOCATION

### Dead Track Register (-)

DTREG

6040 R/O	(-) Dead TRK 7	...	...	...	...	...	...	(-) Dead Trk 0
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### Data Path Status A (DSA)

DPSTATA

6041 R/O	Write TM Check WTMCK	Uncor Error UNCOR	Part Rec PRTRC	Mult Track Error MTE	Read Corr RDCOR	End Data Check ENDCK	Vlcty Check VELCK	
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### Data Path Status B (DSB)

DPSTATB

6042 R/O	Cmd Rej REJ	ID Check IDCHK	Read Ovrfl ROVR	Write Ovrfl WOVR	CRC C CRCC	CRC A CRCA	CRC CRC	Buper BUPER
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### Data Path Status C (DSC)

DPSTATC

6043 R/O	Over Block BLOCK	Data Avail DAVAIL	PE ID PEID	GCR ID GCRID	TM Stat TMS	-DT P NDTP	AS P ASP	PH P PHASP
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### Phase Pointers

PHASREG

6044 R/O	Phase Pntr Trk 7	...	...	...	...	...	...	Phase Pntr Trk 0
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### Amp Sensors

AMPSREG

6045 R/O	Amp Sense Trk 7	...	...	...	...	...	...	Amp Sense Trk 0
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## C.7 WRITE DRIVER AND SENSOR REGISTER ALLOCATION

Sensors (SS1)							SENSORS
6060 R/O	EOT	BOT	Tape Prsnt TAPE	Leadr Seen LEADR	File Prot FILEP		Sensr Error ERROR

Current Monitor (WMN)					CURRNTM		
6061 R/O	All Trks Wrt WRTAL	Erase Curr On ERS	All Trks Off WROFF	(-) Wrt F Itrpt CUROK	Arms Extnd XTEND	File Arm Index FINDX	Mach Arm Index MINDX

## C.8 INTERFACE REGISTER ALLOCATION

Interface Command (ICM)						INTFCMD		
6077 R/O	Sys Reset Latch SYSRS	Addr Match SELCT	Dens Sel 1 NRZI	Dens Sel 0 GCR	Cmd Bit 3	Cmd Bit 2	Cmd Bit 1	Cmd Bit 0



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## APPENDIX D

### MEMORY ALLOCATION, STK STANDARD INTERFACE - 2922

#### D.1 MEMORY MAP

0000	PROM 1 (Functional)	(0000-1FFF)	8k
1FFF			
2000	PROM 2 (Functional)	(2000-3FFF)	8k
3FFF			
4000	PROM 3 (Functional)	(4000-5FFF)	8k
5FFF			
6000	Memory-Mapped I/O	(6000-7FFF)	8k
7FFF			
8000	Diagnostic RAM	(8000-87FF)	2k
	The first 64 bytes (8000-803F) constitute the internal LWR buffer.		
8FFF			
9000	Not Used		
9FFF			
A000	Functional RAM	(A000-A7FF)	2k
AFFF			
B000	Not Used		
BFFF			
C000	PROM 4 (Diagnostic)	(C000-DFFF)	8k
DFFF			
E000	PROM 5 (Diagnostic)	(E000-FFFF)	8k
FFFF			

## D.2 KEYBOARD/OP PANEL REGISTER ALLOCATION

Read Keyboard (0 = key depressed)

KBDATA

6010 R/O				Co14	Co13	Co12	Co11	Co10

## D.3 DIAGNOSTIC REGISTER ALLOCATION

Diagnostic Status (IDG)

DIAGSTAT

6014 R/O						Diag Read Done RDFIN	Diag Write Done WTFIN	Diag Prty Error PRITY

Read Diagnostic Download Byte

DIAGDWNL

6017 R/O	msb	...	...	...	...	...	...	lsb

Servo Diagnostic Status

DIAGSERV

6050 R/O	Tach Phase A TACHA	Tach Phase B TACHB			Mach Pump Down MPD	Mach Pump Up MPU	File Pump Down FPD	File Pump Up FPU

Diagnostic Sense (ISN)

DIAGSENS

6078 R/O	Diag Switch 1	Diag Switch 0	Buper	Stop	Trak	Diag Sel 2	Diag Sel 1	Diag Sel 0

## D.4 CAPSTAN CONTROL REGISTER ALLOCATION

		Read Position Count						PCREAD
6025	R/O	msb	...	...	...	...	...	1sb

		Read Capstan Velocity						VR
6027	R/O	msb	...	...	...	...	...	1sb

## D.5 REEL CONTROL REGISTER ALLOCATION

		Read Machine Position Count						READMPOS
6034	R/O	msb	...	...	...	...	...	1sb

		Read File Position Count						READFPOS
6035	R/O	msb	...	...	...	...	...	1sb

		Reel Status (RSS)						SRVOSENS
6036	R/O	Mach Phase B MPHSB	Mach Phase A MPHSA	File Phase B FPHSB	File Phase A FPHSA	Watch Dog EPO WDERR	Loop Out EPO LOOPF	Power Fail EPO PWRP

		Read Thread Counter						THRDREAD
603B	R/O	msb	...	...	...	...	...	1sb

## D.6 DATA PATH CARD REGISTER ALLOCATION

### Dead Track Register (-)

DTREG

6040 R/O	(-) Dead TRK 7	...	...	...	...	...	...	(-) Dead Trk 0
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### Data Path Status A (DSA)

DPSTATA

6041 R/O	Write TM Check WTMCK	Uncor Error UNCOR	Part Rec PRTRC	Mult Track Error MTE	Read Corr RDCOR	End Data Check ENDCK	Vlcty Check VELCK	
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### Data Path Status B (DSB)

DPSTATB

6042 R/O	Cmd Rej REJ	ID Check IDCHK	Read Ovrfl ROVR	Write Ovrfl WOVR	CRC C CRCC	CRC A CRCA	CRC CRC	Buper BUPER
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### Data Path Status C (DSC)

DPSTATC

6043 R/O	Over Block BLOCK	Data Avail DAVAIL	PE ID PEID	GCR ID GCRID	TM Stat TMS	-DT P NDTP	AS P ASP	PH P PHASP
-------------	------------------------	-------------------------	------------------	--------------------	-------------------	---------------	-------------	---------------

### Phase Pointers

PHASREG

6044 R/O	Phase Pntr Trk 7	...	...	...	...	...	...	Phase Pntr Trk 0
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### Amp Sensors

AMPSREG

6045 R/O	Amp Sense Trk 7	...	...	...	...	...	...	Amp Sense Trk 0
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## D.7 WRITE DRIVER AND SENSOR REGISTER ALLOCATION

Sensors (SS1)							SENSORS
6060 R/O	EOT	BOT	Tape Prsnt TAPE	Leadr Seen LEADR	File Prot FILEP		Sensr Error ERROR

Current Monitor (WMN)							CURRNTM	
6061 R/O	All Trks Wrt WRTAL	Erase Curr On ERS	All Trks Off WROFF	(-) Wrt F Itrpt CUROK		Arms Extnd XTEND	File Arm Index FINDX	Mach Arm Index MINDX

## D.8 INTERFACE REGISTER ALLOCATION

Interface Command (ICM)							INTFCMD	
6077 R/O	Sys Reset Latch SYSRS	Addr Match SELCT	Dens Sel 1 NRZI	Dens Sel 0 GCR	Cmd Bit 3	Cmd Bit 2	Cmd Bit 1	Cmd Bit 0

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## APPENDIX E

### MEMORY ALLOCATION, INDUSTRY STD INTERFACE - 292X

#### E.1 MEMORY MAP

0000 1FFF	PROM 1 (Functional)	(0000-1FFF)	8k
2000 3FFF	PROM 2 (Functional)	(2000-3FFF)	8k
4000 5FFF	PROM 3 (Functional)	(4000-5FFF)	8k
6000 7FFF	PROM 4 (Diagnostic)	(6000-7FFF)	8k
8000 9FFF	PROM 5 (Diagnostic)	(8000-9FFF)	8k
A000 AFFF	Diagnostic RAM	(A000-A0FF)	256 bytes
B000 BFFF	Not Used		
C000 CFFF	RAM (Functional)	(C000-C7FF)	2k
D000 DFFF	Not Used		
E000 EFFF	Memory-Mapped I/O	(E000-E0FF)	256 bytes
F000 FFFF	Not Used		



## E2 KEYBOARD/OP PANEL REGISTER ALLOCATION

Read Keyboard (0 = key depressed)

KBDATA

E008 R/O				Co14	Co13	Co12	Co11	Co10

## E3 DIAGNOSTIC REGISTER ALLOCATION

Diagnostic Status (IDG)

DIAGSTAT

E028 R/O	Ready	Rewnd	Formt Busy		100 ips		Diag W/R Done WTFIN	Diag Prty Error PRITY

Read Diagnostic Download Byte

DIAGDWNL

E038 R/O	msb	...	...	...	...	...	...	lsb

Servo Diagnostic Status

DIAGSERV

E0D0 R/O	Tach Phase A TACHA	Tach Phase B TACHB			Mach Pump Down MPD	Mach Pump Up MPU	File Pump Down FPD	File Pump Up FPU

Diagnostic Sense (ISN)

DIAGSENS

E030 R/O		Diag Switch 0	Buper	Stop	Trak	Diag Sel 2	Diag Sel 1	Diag Sel 0

## E4 CAPSTAN CONTROL REGISTER ALLOCATION

		Read Position Count						PCREAD
E0A5	R/O	msb	...	...	...	...	...	1sb

		Read Capstan Velocity						VR
E0A7	R/O	msb	...	...	...	...	...	1sb

## E5 REEL CONTROL REGISTER ALLOCATION

		Read Machine Position Count						READMPOS
E0B4	R/O	msb	...	...	...	...	...	1sb

		Read File Position Count						READFPOS
E0B5	R/O	msb	...	...	...	...	...	1sb

		Reel Status (RSS)					SRVOSENS	
E0B6	R/O	Mach Phase B MPHSB	Mach Phase A MPHSA	File Phase B FPHSB	File Phase A FPHSA	Watch Dog EPO WDERR	Loop Out EPO LOOPF	Power Fail EPO PWRF

		Read Thread Counter						THRDREAD
E0BB	R/O	msb	...	...	...	...	...	1sb

## E6 DATA PATH CARD REGISTER ALLOCATION

Dead Track Register (-)

DTREG

EOC0 R/O	(-)							(-)
	Dead TRK 7	...	....	...	...	...	...	Dead Trk 0

Data Path Status A (DSA)

DPSTAT A

EOC1 R/O	Write TM Check WTMCK	Uncor Error UNCOR	Part Rec PRTRC	Mult Track Error MTE	Read Corr RDCOR	End Data Check ENDCK	Vlcty Check VELCK	

Data Path Status B (DSB)

DPSTAT B

EOC2 R/O	Cmd Rej REJ	ID Check IDCHK	Read Ovrfl ROVR	Write Ovrfl WOVR	CRC C CRCC	CRC A CRCA	CRC CRC	Buper BUPER

Data Path Status C (DSC)

DPSTAT C

EOC3 R/O	Over Block BLOCK	Data Avail DAVAIL	PE ID PEID	GCR ID GCRID	TM Stat TMS	-DT P NDTP	AS P ASP	PH P PHASP

Phase Pointers

PHASREG

EOC4 R/O	Phase Pntr Trk 7	...	...	...	...	...	...	Phase Pntr Trk 0

Amp Sensors

AMP SREG

EOC5 R/O	Amp Sense Trk 7	...	...	...	...	...	...	Amp Sense Trk 0

## E.7 WRITE DRIVER AND SENSOR REGISTER ALLOCATION

Sensors (SS1)					SENSORS			
E0E0 R/O	EOT	BOT	Tape Prsnt TAPE	Leadr Seen LEADR	File Prot FILEP			Sensr Error ERROR

Current Monitor (WMN)					CURRNTM			
E0E1 R/O	All Trks Wrt WRTAL	Erase Curr On ERS	All Trks Off WROFF	(-) Wrt F Itrpt CUROK		Arms Extnd XTEND	File Arm Index FINDX	Mach Arm Index MINDX

## E.8 INTERFACE REGISTER ALLOCATION

Interface Command (ICM)					INTFCMD			
E020 R/O	Cmd Bit 7	Cmd Bit 6	Cmd Bit 5	Cmd Bit 4	Cmd Bit 3	Cmd Bit 2	Cmd Bit 1	Cmd Bit 0

Read Switches and Stop					INTSTATD			
E030 R/O		Erase Stop	Stop Wrt	Swrch 6	Swrch 5	Swrch 4	Swrch 3	Match

R/W Port A of 8155					INTSTATA			
E001 R/W	Load Point	File Prot	+Runn 100ips	Lwr	Wide Point	Back Wards	GCR	Mach R/W 100ips

R/W Port B of 8155					INTSTATB			
E002 R/W	Wrt Stat	EOT	Corr Error	File Mark	Hard Error	Data Busy	ID Burst	Enble Stop

R/W Port C of 8155

INTSTATC

E003  
R/W

		Z80 to Host (Read)	Z80 fr Host (Wrt)	Fake WRSTB	Fake RDSTB	-Enb1 WRSTB	-Enb1 RDSTB
--	--	--------------------------	-------------------------	---------------	---------------	----------------	----------------

Interface Registers

INTCLR

E019  
W/O

Ready	Rewnd	Formt Busy					
-------	-------	---------------	--	--	--	--	--

## APPENDIX F

### MEMORY ALLOCATION STK STANDARD INTERFACE 2925

#### F.1 MEMORY MAP

0000 1FFF	PROM 1 Functional (0000-1FFF)	8K
2000 3FFF	PROM 2 Functional/Diagnostic (2000-3FFF)	8K
4000 5FFF	Not Used	
6000 7FFF	Not Used	
8000 8FFF	Not Used	
9000 9FFF	Not Used	
A000 BFFF	RAM Functional/Diagnostic (A000-BFFF)	2K
C000 DFFF	Memory Map I/O (C000-DFFF)	8K
E000 FFFF	Memory Map I/O (E000-FFFF)	8K

#### F.2 HOST INTERFACE REGISTER ALLOCATION

The following paragraphs show the register allocation for both the StorageTek Standard Interface and the Industry Standard Interface. When reading the lists the code is the first column and the bit positions are shown in the remaining columns in a

descending order (Bit 7 to Bit 0).

## F.2.1 StorageTek Standard Interface

### Host Status A (IHASTAT)

EFF0	Host EOT Stat	Host BOT Stat	Host End Data	Host Data Chk	Host Buper	Host CorEr Stat	Host Rej Stat	Host T Mrk Stat
------	---------------------	---------------------	---------------------	---------------------	---------------	-----------------------	---------------------	-----------------------

### Host Status B (IHBSTAT)

EFF1	Host Wrt Stat	Host Rdy Stat	Host Exp Data	Host Onl Stat	Host Rew Stat	Host Op In Comp	Host Ovrn Stat	Host EPROM P Err
------	---------------------	---------------------	---------------------	---------------------	---------------------	-----------------------	----------------------	------------------------

### Error Multiplex Bux Byte 0 (IHEMUX0)

EFF2	Dead Trk 7	Dead Trk 6	Dead Trk 5	Dead Trk 4	Dead Trk 3	Dead Trk 2	Dead Trk 1	Dead Trk 0
------	---------------	---------------	---------------	---------------	---------------	---------------	---------------	---------------

### Error Multiplex Bux Byte 1 (IHEMUX1)

EFF3	WTM Chk	Un- corr Err	Part Rec	Multi Trk Err	Not Used	End Data Chk	Vel- Err	Diag Mod Latch
------	------------	--------------------	-------------	---------------------	-------------	--------------------	-------------	----------------------

### Error Multiplex Bux Byte 2 (IHEMUX2)

EFF4	Diag Aid 7	Diag Aid 6	Diag Aid 5	Diag Aid 4	Diag Aid 3	Diag Aid 2	Diag Aid 1	Diag Aid 0
------	---------------	---------------	---------------	---------------	---------------	---------------	---------------	---------------

### Error Multiplex Bux Byte 3 (IHEMUX3)

EFF5	EOT Stat	BOT Stat	Not Used	File Pro Stat	Back ward Stat	High Den Stat	Rdy Stat	Onl Stat
------	-------------	-------------	-------------	---------------------	----------------------	---------------------	-------------	-------------

### Parity Bits of Error Multiplex Bus (IHEMUXP)

EFF6	Res Host Busy	Clr Host Reset	Not Used	Not Used	EMUX3 P Wrt Stat	EMUX2 Tach	EMUX1 CRC Error	EMUX0 P DT Par
------	---------------------	----------------------	-------------	-------------	------------------------	---------------	-----------------------	----------------------

Host Command Bits (IHCMD)

EFF7	Sys Res Lchd	Dev Match	Den Sel 1	Den Sel 0	Cmd 1	Cmd 2	Cmd 3	Cmd 4
------	--------------	-----------	-----------	-----------	-------	-------	-------	-------

Set Block to Host (IHBLOCK)

EF81	Send Host Block Pulse: When written to.							
------	---	--	--	--	--	--	--	--

Host Interface Register (IHIFACE)

EFB3	Early EOT SASB	Not Used	Host Busy	Host Sys Res	Host Stop LTH	Sel EMUX 2	Sel EMUX 1	Sel EMUX 0
------	----------------	----------	-----------	--------------	---------------	------------	------------	------------

Host Interface Register (IHINTF)

EFE3	Host SSC	Host ID Burst	Long Rec Mode	Gate STP Block	Dis-able Empty	Sel MUX 2	Sel MUX 1	Sel MUX 0
------	----------	---------------	---------------	----------------	----------------	-----------	-----------	-----------

F.3 INDUSTRY STANDARD INTERFACE

Host Status A (PHASTAT)

EFF0	P Host EOT Stat	P Host BOT Stat	P Host High Speed	P Host Hard Err	Not Used	P Host Corr Err Stat	P Host ID Burst Stat	P Host Tape Mark Stat
------	-----------------	-----------------	-------------------	-----------------	----------	----------------------	----------------------	-----------------------

Host Status B (PHBSTAT)

EFF1	Cntrl Erase Gate	Data Busy Bypass	Host Data Busy	Host Online Stat	Not Used	Not Used	Not Used	Not Used
------	------------------	------------------	----------------	------------------	----------	----------	----------	----------

Host Status C (PHCSTAT)

EF90	Host Format Busy	Host Ready Stat	Host Go Latchd	Host Reset Latchd	Host Rewind Stat	Host RewCmd Latchd	Host OvrRun Latchd	Host Offl Cmd Latchd
------	------------------	-----------------	----------------	-------------------	------------------	--------------------	--------------------	----------------------



Host Command Reg (PHCMD)

EFB0	PerHos Cmd 7	PerHos Cmd 6	PerHos Cmd 5	PerHos Cmd 4	PerHos Cmd 3	PerHos Cmd 2	PerHos Cmd 1	PerHos Cmd 0
------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------

Host Interface Reg (PHINTF)

EFE3	Diag File ProSt	Diag GCR Stat	Sync Mode	Gate File Pro & GCR	Disabl Empty	Tape Sel Mux 2	Tape Sel Mux 1	Tape Sel Mux 0
------	-----------------------	---------------------	--------------	------------------------------	-----------------	-------------------------	-------------------------	-------------------------

Host Interface Reg (PHIFACE)

EFB3	EL EOT SASB	Device Match	Not Used	Not Used	Host Stop LTH	Not Used	Not Used	Not Used
------	----------------	-----------------	-------------	-------------	---------------------	-------------	-------------	-------------

F.4 SWITCHS REGISTER ALLOCATION

IIPORT2

EFD0	Not Avail	Not Avail	Not Avail	Not Avail	TD BLK Pulse Latchd	SWTCH1 Sync Mode	1MSCLK INPT For Timr 3	SWTCH1 Spare
------	--------------	--------------	--------------	--------------	---------------------------	------------------------	---------------------------------	-----------------

ISWITCH1

EFD1	SWTCH1 Early EOT	SWTCH1 Tape Mark Sync	SWTCH1 Read Retry CNT 1	10KHz Clk to Servo	SWTCH1 Read Retry Cnt 0	SWTCH1 Write Retry Cnt 1	SWTCH1 Write Retry Cnt 0	35 Micro- Second Offset
------	------------------------	--------------------------------	----------------------------------	--------------------------	----------------------------------	-----------------------------------	-----------------------------------	----------------------------------

ISWITCH2

EFD2	No GCR One TRK	Data Rate 2	Max Blk Size 1	Max Blk Size 0	INTF Ramp 1	INMTF Ramp 0	Data Rate 1	Data Rate 0
------	----------------------	----------------	----------------------	----------------------	----------------	-----------------	----------------	----------------

ISWITCH3

EFB7	Card Lvl 3	Card Lvl 2	Card Lvl 1	Card Lvl 0	Spare	host Adr 2	Host Adr 2	Host Adr 0
------	---------------	---------------	---------------	---------------	-------	---------------	---------------	---------------

F.5 DATA BUFFER REGISTER ALLOCATION

Start of Record (SOR) Pointer (ICSOR0)

EFE5	Temp or Start of Record, LSBYTE
------	---------------------------------

Start of Record (SOR) Pointer (ICSOR1)

EFE6	Temp or Start of Record
------	-------------------------

Start of Record (SOR) Pointer (ICSOR2)

EFE7	Temp or Start of Record, MSBYTE
------	---------------------------------

Load Fill Address Register (FAR) (ICFAR)

EF82	Transfer SOR to Fill Address Register
------	---------------------------------------

Load Drain Address Register (FAR) (ICFAR)

EF83	Transfer SOR to Drain Address Register
------	--

Read DAR or FAR (ICADRS0)

EFA0	Read Address 0, LSBYTE; Fill or Drain
------	---------------------------------------

Read DAR or FAR (ICADRS1)

EFA1	Read Address 1; Fill or Drain
------	-------------------------------

Read DAR or FAR (ICADRS2)

EFA2	Read Address 2, MSBYTE; Fill or Drain
------	---------------------------------------

Reset Full (ICRESFUL)

EF84 Reset Full; Written to, Will

Set Empty (ICSEMPY)

EF85 Set Empty; When Written to, Will

Data Buffer Mode 1 (ICMODE1)

EFEO	Disabl Fill/ DRA	Enable FAR Read	Enable DAR Read	Enable CRC Diag	Enable CAC Diag	Diag TRAK	Diag Stop	Diag Parity
------	------------------------	-----------------------	-----------------------	-----------------------	-----------------------	--------------	--------------	----------------

Data Buffer Mode 2 (ICMODE2)

EFÉ4	Reset Cache PAR ER	Reset CRC Check	Reset CRC Gener- ator	Res BLK PLS LT & EOD LT	Hard- ware Host Read Cmd	Hard- ware Host SRT Cmd	Hard- ware Host Read Cmd	Hard- ware Host WRT Cmd
------	--------------------------	-----------------------	--------------------------------	-------------------------------------	--------------------------------------	-------------------------------------	--------------------------------------	-------------------------------------

Data Buffer Status (ICSTAT)

EBF2	Cache Full	Cache Empty	Fill Done	Drain Done	Treq FRM Cache	Treq FRM Drive	Cache Stop	Cache Parity
------	---------------	----------------	--------------	---------------	----------------------	----------------------	---------------	-----------------

Data Buffer Interface (ICINTF)

EFE3	host SSC	Host ID Burst	Sync Mode	Gate STP & Block	Disabl Empty	Sel Mux 2	Sel Mux 1	Sel Mux 0
------	-------------	---------------------	--------------	------------------------	-----------------	--------------	--------------	--------------

Diagnostic Write Data to Data Buffer (ICWRITE)

EF87 Write Data To Cache;

- Diagnostic Read Data From Data Buffer (ICREAD)

EFA3 Read Data From Cache;

Data Buffer Error Status (ICERROR)

EFC2	Tape SSC	Tape ID Burst	Cache Par Err	Cache CRC Err	Tape Busy	Tape HDENS	Tape FPTS	Tape EMUX P
------	----------	---------------	---------------	---------------	-----------	------------	-----------	-------------

F.6 COUNTER I/O CHIP REGISTER ALLOCATION

Chip 1 Read/Write Control Port (IIADDR1)

EFC3	Not Avail	Not Avail	Contr1 ADR 5	Contr1 ADR 4	Contr1 ADR 3	Contr1 ADR 2	Contr1 ADR 1	Contr1 ADR 0
------	-----------	-----------	--------------	--------------	--------------	--------------	--------------	--------------

Chip 1 Read/Write Control Port (IIDATA1)

EFC3	R/W Data 7	R/W Data 6	R/W Data 5	R/W Data 4	R/W Data 3	R/W Data 2	R/W Data 1	R/W Data 0
------	------------	------------	------------	------------	------------	------------	------------	------------

Chip 2 Read/Write Control Port (IIADDR2)

EFD3	Not Avail	Not Avail	Contr1 ADR 5	Contr1 ADR 4	Contr1 ADR 3	Contr1 ADR 2	Contr1 ADR 1	Contr1 ADR 0
------	-----------	-----------	--------------	--------------	--------------	--------------	--------------	--------------

Chip 2 Read/Write Control Port (IIDATA2)

EFD3	R/W Data 7	R/W Data 6	R/W Data 5	R/W Data 4	R/W Data 3	R/W Data 2	R/W Data 1	R/W Data 0
------	------------	------------	------------	------------	------------	------------	------------	------------

## F.7 TIMER/INTERRUPT REGISTER ALLOCATION

### NMI Timer Status (IIPORT1C)

EFC0	Not Avail	Not Avail	Not Avail	Not Avail	Early EOT CKT Done	Diag ERL EOT CAP PULS	NMI Timer3 Input	-NMI Timer3 Output
------	-----------	-----------	-----------	-----------	--------------------	-----------------------	------------------	--------------------

### Interrupt Status (IIPORT1B)

EFC1	End of Data PL Intrpt	Busy GOS In active Intrpt	Stop Sen To TD Intrpt	Timer1 Output ims	Timer2 Gate; Treq/ AK	Timer2 Trig- ger; Treq	Diag Erly EOT File PUL	Timer2 Out; Not Connec ted
------	-----------------------	---------------------------	-----------------------	-------------------	-----------------------	------------------------	------------------------	----------------------------

## F.8 TAPE DRIVE INTERFACE REGISTER ALLOCATION

### Tape Drive Status A (ITASTAT)

EFA5	Tape EOT Stat	Tape BOT Stat	Always Zero	Tape Data Check	Tape BUPER	Tape Corr Err Stat	Tape Reject Stat	Tape Tape Mark Stat
------	---------------	---------------	-------------	-----------------	------------	--------------------	------------------	---------------------

### Tape Drive Status B (ITBSTAT)

EFA6	Tape Write Stat	Tape Ready Stat	Tape Expect Data	Tape Online Stat	Tape Rewind Stat	Tape Oper Incomp	Tape OvrRun Stat	Tape EPROM ParErr
------	-----------------	-----------------	------------------	------------------	------------------	------------------	------------------	-------------------

### Tape Drive Error Multiplex Bus (ITEMUX)

EFA7	EMUX Bit 7	EMUX Bit 6	EMUX Bit 5	EMUX Bit 4	EMUX Bit 3	EMUX Bit 2	EMUX Bit 1	EMUX Bit 0
------	------------	------------	------------	------------	------------	------------	------------	------------

### Tape Drive Status C (ITCSTAT)

EFC2	Tape SSC	Tape ID Burst	Cache PAR ERR	Cache CRC ERR	Tape Busy	Tape HDENS	Tape FPTS	Tape EMUX P
------	----------	---------------	---------------	---------------	-----------	------------	-----------	-------------

Tape Drive Command Register (ITDMC)

EFE2	System Reset	Set Stop To Tape	Density Sel 1	Density Sel 0	Commnd 3	Commnd 2	Commnd 1	Commnd 0
------	-----------------	---------------------------	------------------	------------------	-------------	-------------	-------------	-------------

Pulse Start (ITSTART)

EFB6	Tape Drive Start Pulse; When Written To Will
------	--

Tape Drive Interface Register (ITINTF)

EFE3	Diag File Pro St	Diag GCR Stat	Sync Mode	Gate File Pro & GCR	Disabl Empty	Tape Sel Mux 2	Tape Sel Mux 1	Tape Sel Mux 0
------	------------------------	---------------------	--------------	------------------------------	-----------------	----------------------	----------------------	----------------------

F.9 EARLY END OF TAPE CIRCUITS REGISTER ALLOCATION

Reset Early EOT Circuit (IEOTRES)

EFB0	Reset the Early EOT Circuit;
------	------------------------------

Early EOT Capstan Count (IEACAP1)

EFB4	Capstan Counter, LSBYTE
------	-------------------------

Early EOT Capstan Counter (IECAP2)

EFB5	Capstan Counter, MSBYTE
------	-------------------------

Early EOT Swing Arm Count (IESWARM)

EFB6	Swingarm Counter
------	------------------

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## APPENDIX G

### 2920-3910 EXTERNAL DIAGNOSTIC ROUTINES

#### G.1 2920-3910 EXTERNAL DIAGNOSTIC ROUTINES

01-01-00 INTERFACE STATUS  
01-02-00 INTERFACE DATA BUS  
01-03-00 INVOKE INTERNALS  
03-02-00 50 IPS PE LWR BYTES 5-2048  
04-41-00 50 IPS GCR LWR BYTES 1-2048  
05-02-00 100 IPS PE LWR BYTE CNT 5-2048  
06-41-00 100 IPS GCR LWR BYTES 1-2048  
10-00-00 DRIVE APPLICABILITY TEST 50-DUAL  
14-01-01 50 IPS PE WRT REL/MED DEFECT  
14-02-00 50 IPS PE READ FWD RELIABILITY  
14-03-00 50 IPS PE READ BKWD RELIABILITY  
14-04-01 PE WRT LONG RECORDS/MED DEF  
14-41-01 50 IPS GCR WRT REL/MED DEF  
14-42-00 50 IPS GCR READ FWD RELIABILITY  
14-43-00 50 IPS GCR READ BKWD RELIABILITY  
14-44-01 GCR WRT LONG RECORDS/MED DEF  
14-51-00 100 IPS PE WRT REL/MED DEF  
14-52-00 100 IPS PE READ FWD RELIABILITY  
14-53-00 100 IPS PE READ BKWD RELIABILITY  
14-61-00 100 IPS GCR WRT REL/MED DEF  
14-62-00 100 IPS GCR READ FWD RELIABILITY  
14-63-00 100 IPS GCR READ BKWD RELIABILITY  
14-71-00 STRESS TEST -2 SPEED, 3 GAP-  
16-12-00 READ INTERCHANGE  
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