
4500 Tape Subsystem

**Product Description
Manual**

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Storage Technology Corporation

**4500 SERIES TAPE SUBSYSTEM
PRODUCT DESCRIPTION MANUAL**

1983

PN E0-050-1

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PREFACE

SCOPE

This document contains a description of the Storage Technology Corporation Model 4500 Tape Subsystem. The material in this document is intended for the use of Storage Technology Corporation marketing representatives, customers, independent consultants, and service representatives.

ORGANIZATION

Chapter 1 - PRODUCT DESCRIPTION: Presents the Storage Technology Corporation Model 4500 Tape Subsystem and describes, in general terms, the machine configurations, capacities, model differences, features, and available options.

Chapter 2 - PRODUCT SPECIFICATIONS: Presents the physical, electrical, and environmental specifications of the 4500 Tape subsystem.

Chapter 3 - CONTROLS AND INDICATORS: Describes the functions of all tape subsystem switches and indicators.

Chapter 4 - CHANNEL INTERFACE: Briefly describes the modes of data transfer and provides detailed definitions of the channel interface status and sense bytes.

Chapter 5 - DIAGNOSTICS: Describes the on-board diagnostics utilized by the 4500 Tape Subsystem.

Chapter 6 - INSTALLATION PLANNING: Provides general guidelines for planning the installation of the 4500 Tape Subsystem.

Appendix A - GLOSSARY

RELATED PUBLICATIONS

4500 Tape Unit Maintenance Manual, PN 9716
4500 Tape Control Unit Maintenance Manual, PN 9363
4500 Tape Subsystem Installation Manual, PN 9619
4500 Tape Subsystem Illustrated Parts Catalog, PN 9608
4600 Tape Subsystem Diagnostics Manual, PN 95574

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CHAPTER 1

PRODUCT DESCRIPTION

1.1 INTRODUCTION

The 4500 Tape Subsystem (Figure 1-1) is a nine-track tape transport and control unit designed to be attached to the IBM 370/135, 138, 145, 148, 155, 158, 3000, or 4000 systems.

1.2 GENERAL DESCRIPTION

The 4500 Tape Subsystem is packaged in two types of tape units (Figure 1-2): The A-unit contains a tape control unit (TCU), a tape unit (TU), and a maintenance facility; the B-unit contains a tape unit only. The minimum 4500 Tape Subsystem is one A-unit (1x1). From one to seven additional tape units (B-units) may be attached to the A-unit TCU for a 1x8 maximum configuration. The Communicator option permits the addition of a second TCU with its tape units for a 2x16 maximum configuration.

A principal innovation of the 4500 Tape Subsystem is the extensive application of microprocessor technology used for control functions previously requiring many logic circuits. The use of microprocessors makes possible an extremely compact subsystem with unique operational advantages. Foremost among these advantages is the ability to attach tape units of different characteristics (velocity and format) to a single TCU.

Microprocessors in the TCU provide more complete and accurate tape unit control without the necessity of being devoted to the particular tape unit which is operating. Another important feature of the 4500 Tape Subsystem is its extensive diagnostic capability. Through the subsystem diagnostics, the field engineer can test the condition of the tape subsystem, online (inline diagnostics) or offline.

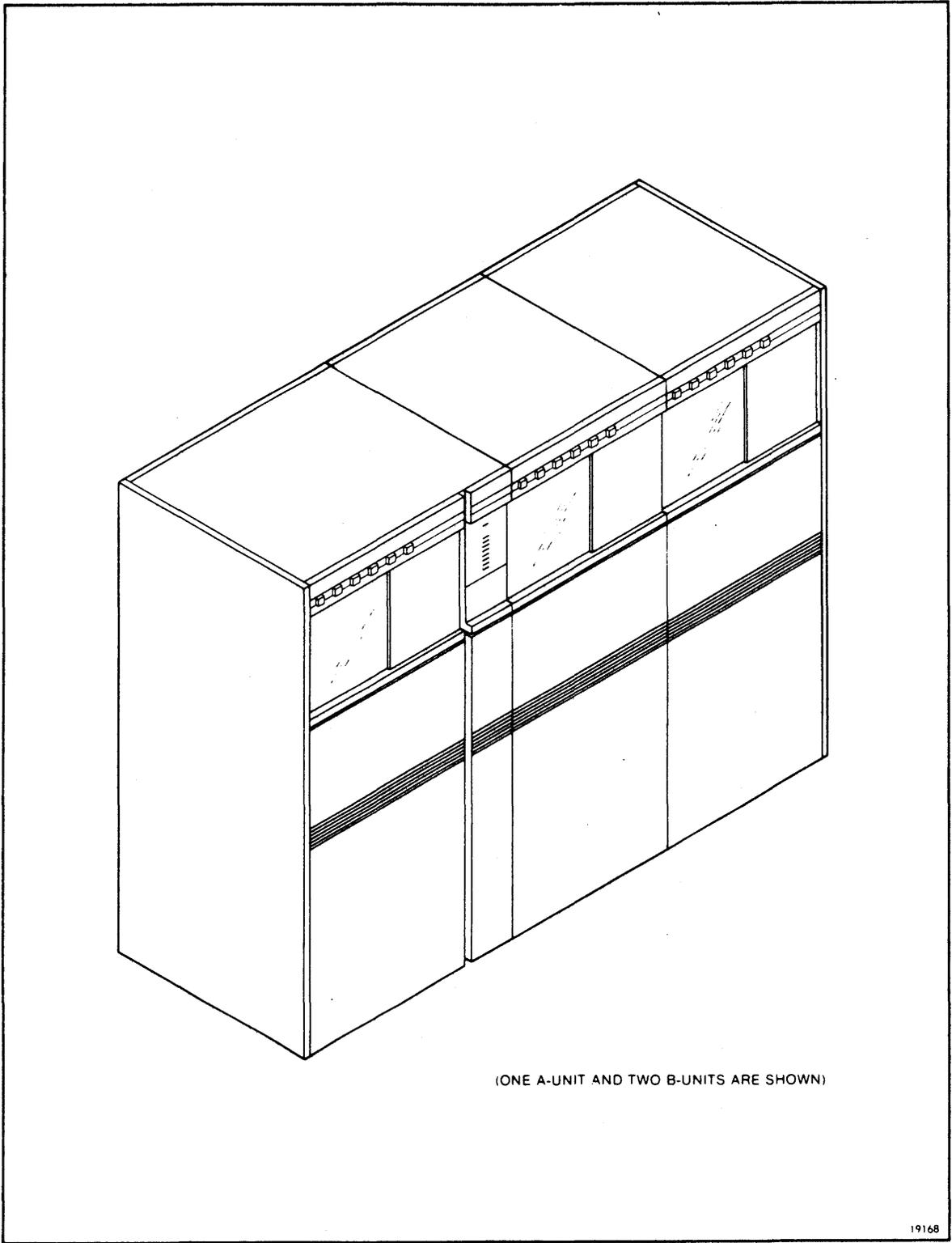


Figure 1-1. 4500 Tape Subsystem

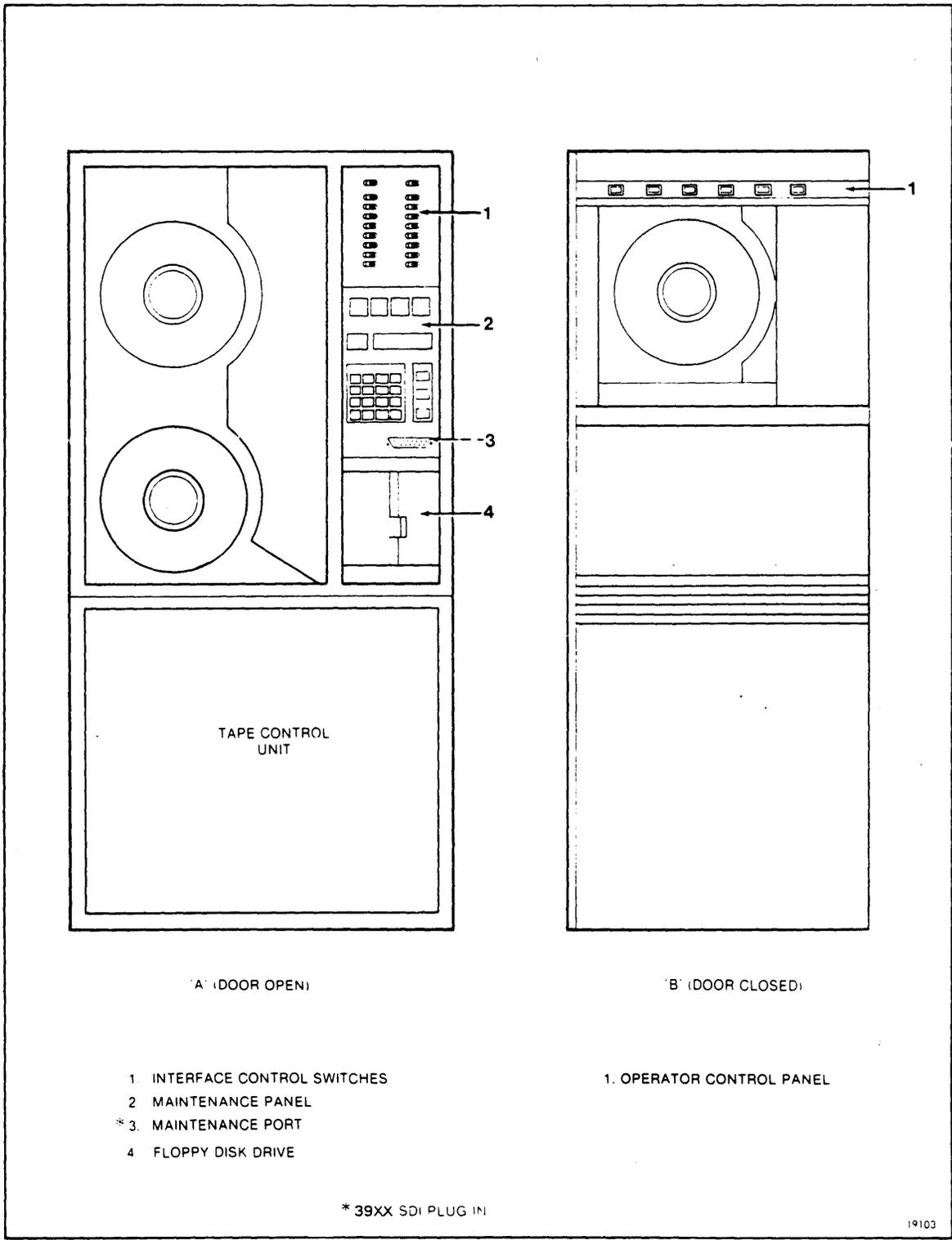


Figure 1-2. 4500 Tape Subsystem A- and B-Units

The 4500 Tape Subsystem will write and read magnetic tapes as specified by ANSI X3.54-1976 (GCR), ANSI X3.39-1973 (PE), and (optionally) ANSI X3.22-1973 (NRZI). The tapes will be bilaterally interchangeable to other tape subsystems, including IBM subsystems, if those subsystems are compatible to the ANSI standards.

The 4500 Tape Subsystem is available in a number of configurations to comply with a wide variety of user requirements. Performance specifications for the various models are listed in Table 1-1.

1.2.1 SUBSYSTEM DESCRIPTION

Figure 1-3 shows the relationship of the channel, TCU, and tape unit(s). The TCU connects to the channel through two cables: Bus and Tag. The Bus lines inbound to the TCU carry device addresses, data to be recorded, and commands to the TCU; the Bus lines outbound from the TCU carry device identification, data retrieved from tape, and status information to the channel. The tag lines indicate the type of information on the Bus lines.

Write data lines, read data lines, control lines, and status lines connect the TCU to the tape units. Write data lines carry the data to be recorded on tape; read data lines carry data retrieved from tape to the TCU. Control lines carry operational commands to the tape unit; status lines carry tape unit operation and performance information to the TCU.

1.2.2 TAPE CONTROL UNIT DESCRIPTION

The TCU provides the interface to the channel, controls the operation of the tape unit, and formats or deformats the data to be recorded on or retrieved from tape. The TCU is divided into five major functional areas: interface channel adapter, formatter, write sequencer, read sequencer, and tape unit adapter. The TCU interface channel adapter is designed to interface with an IBM 360/370 selector or block multiplexer channel, making the channel type invisible to the formatter and tape unit adapter.

1.2.3 TAPE UNIT DESCRIPTION

The tape unit is designed to read and write ANSI-compatible, half-inch, nine-track magnetic tape at either 125 or 75 inches per second (ips).

Table 1-1. Performance Specifications

Models	A-Unit B-Unit	4530 4534	4531 4535	4550 4554	4551 4555
Tape Velocity		75 ips 190.5 cm/s	75 ips 190.5 cm/s	125 ips 317.5 cm/s	125 ips 317.5 cm/s
Recording Formats		GCR PE	GCR PE NRZI	GCR PE	GCR PE NRZI
Data Rates					
GCR (6250 bpi) (2461 bpcm)		468 kB/s	468 kB/s	780 kB/s	780 kB/s
PE (1600 bpi) (630 bpcm)		120 kB/s	120 kB/s	200 kB/s	200 kB/s
NRZI (800 bpi) (315 bpcm)		----	60 kB/s	----	60 kB/s
Access Time (nominal)					
GCR		2.55 ms	2.55 ms	1.72 ms	1.72 ms
PE		2.55 ms	2.55 ms	1.72 ms	1.72 ms
NRZI		----	3.88 ms	----	2.52 ms
Interblock Gap					
GCR		0.30 in. 0.76 cm	0.30 in. 0.76 cm	0.30 in. 0.76 cm	0.30 in. 0.76 cm
PE		0.60 in. 1.52 cm	0.60 in. 1.52 cm	0.60 in. 1.52 cm	0.60 in. 1.52 cm
NRZI		----	0.60 in. 1.52 cm	----	0.60 in. 1.52 cm
Rewind Time (maximum) (2400-foot reels)		60 sec	60 sec	60 sec	60 sec

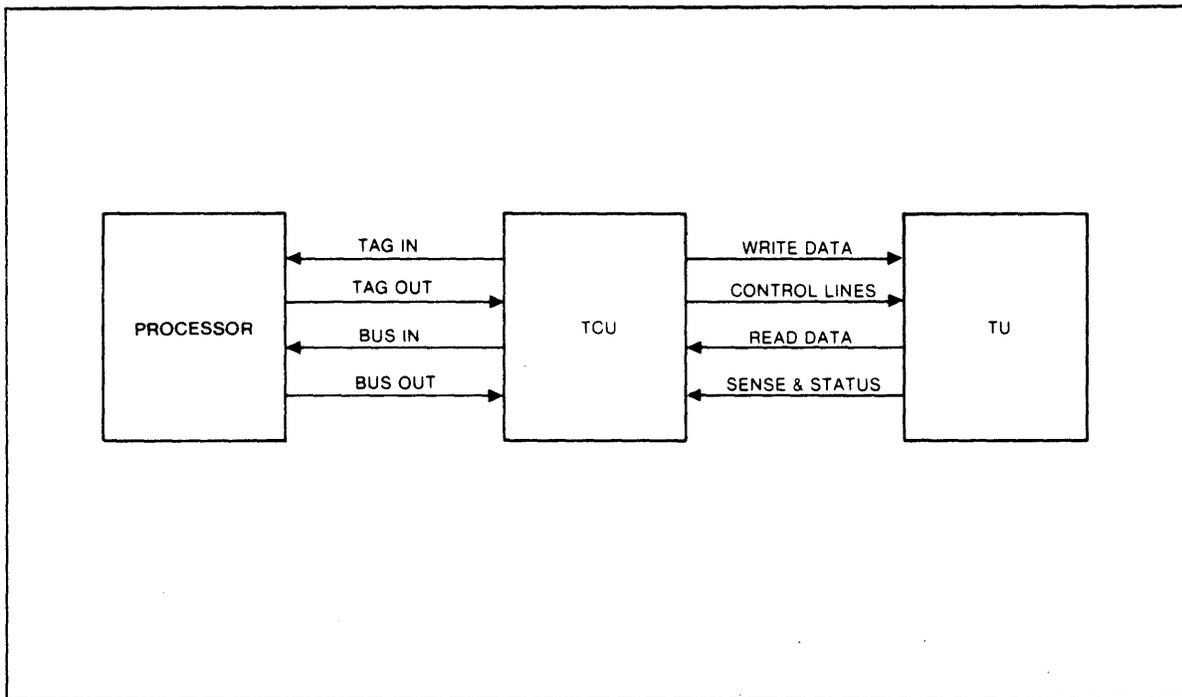


Figure 1-3. System Block Diagram

All tape unit configurations have the capability to write and read group-coded recording (GCR) format data at 6250 bpi and phase encoded (PE) format data at 1600 bpi. The optional tri-density tape unit configuration can also write and read non-return-to-zero indicated (NRZI) format data at 800 bpi. The tape unit is conditioned for the data to be recorded or read by the program from the tape control unit (TCU) when the tape is positioned at the beginning of tape (BOT) marker.

The tape unit can read when tape is moving either forward or backward but data recording can be performed only during forward tape motion. Separate write and read data paths permit read during write to provide immediate verification of recorded data.

The tape transport mechanism is mounted on an aluminum deck casting which is mounted on hinges to provide access for maintenance to all elements of the tape unit behind the casting and inside the electronics frame.

1.3 STANDARD FEATURES

For optimal performance and reliability, the 4500 Tape Subsystem is equipped with an extensive set of standard features.

1. Single Vacuum-Assisted Capstan: Ensures positive tape-to-capstan contact.
2. Dual Vacuum Columns: Provides sufficient tape slack for maximum tape control within a compact space.
3. Power Window (Plexiglass): Automatically lowers into the open position following the completion of a tape unload operation and automatically raises prior to a tape threading operation.
4. Automatic File Reel Hub: A quick-release high-torque hub, pneumatically operated to ensure fast, positive attachment of file reels.
5. Automatic Tape Thread and Load: Automatically feeds the tape leader (including the leader from open reels) through the threading channel and loads the tape into the columns.
6. Dual-Gap Read/Write Head with Full-Width Erase Head: Provides improved data transfer between head and tape and permits a read-after-write operation for data transfer accuracy verification.
7. Head Azimuth Adjustment: Facilitates precise parallel alignment of the read/write head and the tape.
8. Vacuum-Assisted Tape Cleaner: Reduces particulate contamination of the tape for enhanced data read/write accuracy.
9. Beginning of Tape and End of Tape Sensing: Ensures accurate tape handling control by electronically sensing the beginning of tape (BOT) and end of tape (EOT) markers.
10. File Protect: Protects against accidental erasure of data files.
11. Microprogram Control: Provides greater system adaptability, improved tape unit control, and extensive subsystem diagnostics.

12. Resident Maintenance Controls: Allows the operator or field engineer to initialize the subsystem, perform maintenance functions and diagnostic tests, and force certain TCU operations; status information is provided by indicators on the control panel.

1.4 SELECTIVE FEATURES

The specifications of the following features are chosen by the customer prior to shipment of the subsystem. Conversions can be performed in the field, if necessary.

1. Tape Unit Operational Velocity: 75 or 125 inches per second (190.5 or 317.5 cm per second).
2. Nominal Input Power: 200, 208, or 240 Vac at 60 Hz, 360 or 415 Vac at 50 Hz.
3. Altitude Range: The pneumatics system is adaptable to three altitude ranges: 0 to 1100 feet (0 to 335 meters) or 1100 to 6000 feet (335 to 1830 meters); for high altitudes, a pulley option provides a range of 6000 to 8500 feet (1830 to 2600 meters).

1.5 OPTIONAL FEATURES

There are several options available for the 4500 Tape Subsystem. Each option can be installed in the field or at the time of manufacture. Following is a list of the available options:

1. Non-Return-to-Zero-Indicated (NRZI) Recording Format: Provides the capability to also read and write nine-track, 800 bpi NRZI format tapes by the simple installation of a card set in the TCU and the TU.
2. Two-Channel Switch: Permits a second channel (from the same or a separate processor) to access the TCU. The second channel can be an IBM 360/370 selector or a block multiplexer. The switch can be under manual or program control.

4. Communicator: Permits the addition of a second TCU for a maximum subsystem configuration of two A-units and fourteen B-units (2x16) as shown in Figure 1-4. Either TCU can address any tape unit within the subsystem. Any or all tape units can be rendered inaccessible to either or both TCUs by switches on the enable/disable panel.

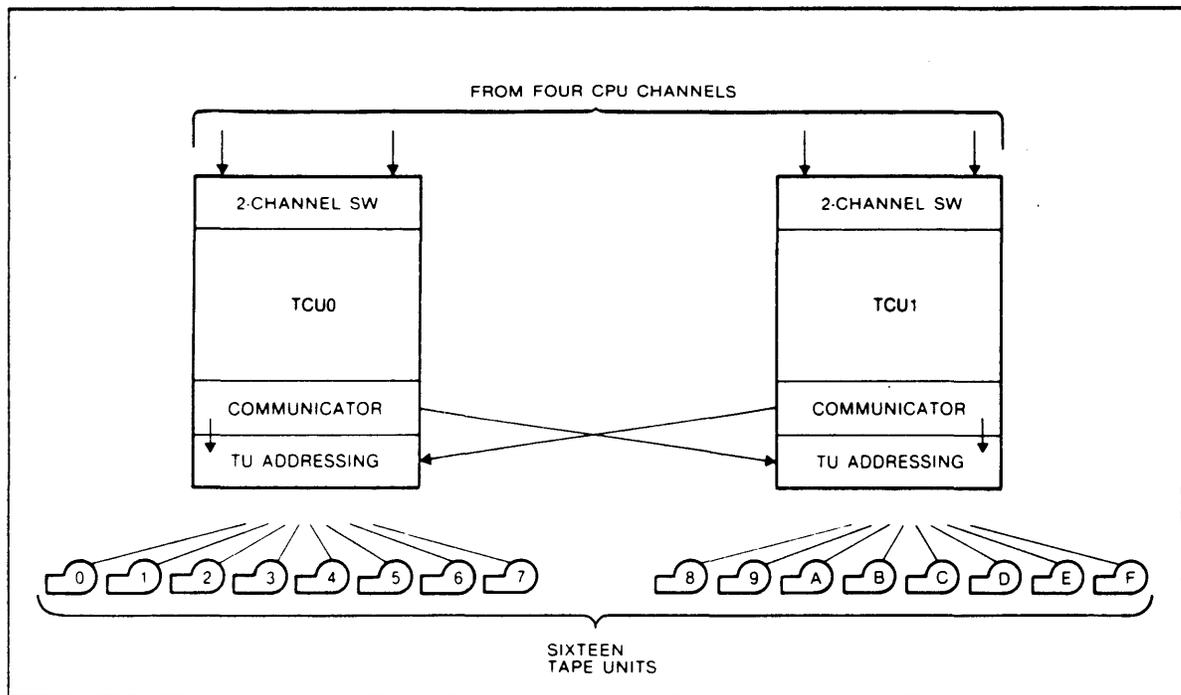


Figure 1-4. 2x16 Configuration

5. Buffer: A high-speed, 32 kilobyte buffer that accelerates the throughput capacity of the subsystem by allowing the TCU to operate in Data Streaming mode. The TCU equipped with the buffer option accepts read/write commands from the processor in the normal manner, then disconnects from the channel, leaving the channel free for other operations while the buffer manages data transfer to or from the tape unit. With this option, a single record can be transferred at a rate of 2 or 3 megabytes per second on a single data bus.

CHAPTER 2

PRODUCT SPECIFICATIONS

2.1 INTRODUCTION

The specifications of the tape unit include physical dimensions, electrical characteristics, environmental requirements, and heat dissipation. This information is invaluable when planning the installation of the 4500 Tape Subsystem.

2.2 PHYSICAL DIMENSIONS

Refer to Figure 2-1, Tape Subsystem Dimensions

	A-UNIT	B-UNIT
Height	62 inches (157.5 cm)	62 inches (157.5 cm)
Width	31 inches (78.8 cm)	24 inches (61.0 cm)
Depth	29 inches (73.7 cm)	29 inches (73.7 cm)
Weight	750 pounds (340 kg)	450 pounds (205 kg)

Dimensions are given for the width of the A- and B-units without side covers. Two side covers are shipped with the A-unit but are removed during subsystem installation to be attached to the exposed ends of the subsystem. Each side cover is 0.75 inches (1.9 mm) thick, for an addition of 1.5 inches (3.8 mm) to the overall width of the subsystem assembly.

2.3 ELECTRICAL CHARACTERISTICS

2.3.1 PRIMARY POWER

The tape subsystem receives its primary power through a three-phase power distribution system. Internal cables connect from one unit to the next in the string, rotating the phases in each unit. No phase rotational sequence need be observed on the input cable to the system.

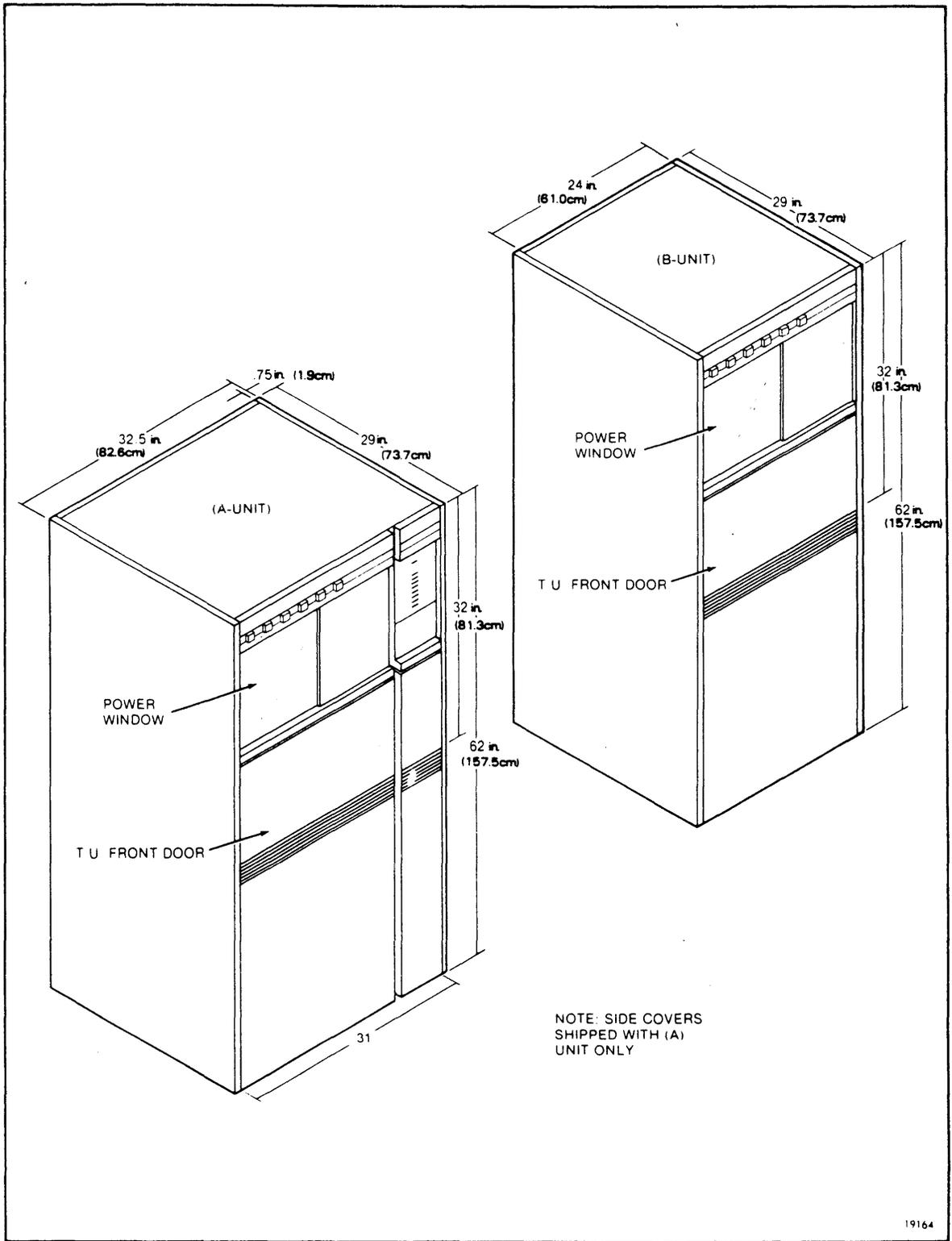


Figure 2-1. Tape Subsystem Dimensions

The tape subsystem may be operated from any one of the following ac power sources. The subsystem is conditioned for the input power by jumpers on the primary side of the input power transformers. These jumpers are installed at the factory and may be changed at the customer site if necessary.

60 Hz (± 0.5 Hz) primary power:

- 200 Vac (+6% -10%), phase-to-phase
- 208 Vac (+6% -10%), phase-to-phase
- 240 Vac (+6% -10%), phase-to-phase

50 Hz (± 0.5 Hz) primary power:

- 380 Vac (+6% -10%), phase-to-phase
(operated phase-to-neutral to provide 220 Vac to each unit)
- 415 Vac (+6% -10%), phase-to-phase
(operated phase-to-neutral to provide 240 Vac to each unit)

2.3.2 POWER CONSUMPTION

For 60 Hz voltages, the service requirement is 60 amps/phase; for 50 Hz voltages, the service requirement is 40 amps/phase. Refer to Table 2-1 for the power consumption and power factor (PF) values of the various tape subsystem configurations.

Table 2-1. Power Consumption

	60 Hz					50 Hz				
	Operating		Ready		Minimum Service at 208 Vac	Operating		Ready		Minimum Service at 220 Vac
	kVa	PF	kVa	PF		kVa	PF	kVa	PF	
1x1	1.8	0.98	1.6	0.91	15A	2.1	0.95	1.7	0.94	10A
1x2	3.2	0.93	3.0	0.90	25A	3.4	0.97	2.9	0.97	15A
1x3	4.1	0.97	3.9	0.98	30A	4.5	0.98	4.0	0.96	25A
1x4	5.4	0.96	5.1	0.96	30A	5.7	0.99	5.2	0.99	30A
1x5	6.6	0.97	6.2	0.98	40A	7.0	0.99	6.5	0.99	30A
1x6	7.4	1.00	7.1	1.00	40A	8.2	0.99	7.6	1.00	40A
1x7	8.6	0.99	8.3	0.99	50A	9.3	1.00	8.8	1.00	40A
1x8	9.8	0.99	9.7	0.97	60A	10.5	1.00	9.9	1.00	40A

2.3.3 POWER DISTRIBUTION AND CONTROL

The power distribution system is comprised of the main power distribution assembly (PDA) in the A-unit and subsidiary PDA's in the B-units. The power distribution system provides three-phase ac power for distribution to the A-units and the B-units in a manner which balances the phases in a subsystem of any size. Power is supplied phase-to-phase in 60 Hz subsystems and phase-to-neutral in 50 Hz subsystems. (No phase sequence need be observed as no equipment is operated three-phase.)

The A-unit PDA provides ac power to the B-units as well as to the A-unit and also sequences power on and emergency powers off (EPO) the tape subsystem. The power on sequence is: A-unit TCU, A-unit tape unit, right side B-units, left side B-units. There is a delay of 25 milliseconds between the power up of each unit.

Power is controlled by a circuit breaker on the A-unit PDA, the circuit breaker on each A-unit power supply and the TCU power supply, the REMOTE/LOCAL switch on each A-unit and B-unit PDA, and the POWER ON switch on the FE panel. Power may be either remotely or locally controlled.

Remote Power Control: With all circuit breakers in the ON position, all REMOTE/LOCAL switches in the REMOTE position, and the FE panel POWER ON switch in the unlatched position, subsystem power may be remotely controlled by the processor through the EPO cable. The subsystem returns a signal through the EPO cable to the processor to indicate the successful completion of the power on sequence.

Local Power Control: With all circuit breakers in the ON position, the A-unit PDA REMOTE/LOCAL switch in the LOCAL position, and all B-unit PDA REMOTE/LOCAL switches in the REMOTE position, subsystem power may be locally controlled by the FE panel POWER ON switch.

2.3.4 REGULATORY AGENCIES

1. Underwriters Laboratories: The 4500 Tape Subsystem has UL478 listing (208 Vac, 60 Hz operation only).
2. Canadian Standards Association: The 4500 Tape Subsystem has CSA Standard C22.2 No. 154-1975 certification (208 Vac, 60 Hz operation only).
3. VDE: The 4500 Tape Subsystem is designed with respect to VDE requirements, and has been tested for certain EMC and EMI characteristics.

2.4 ENVIRONMENTAL REQUIREMENTS

The following are the environmental conditions in which the tape subsystem data integrity is guaranteed. However, these requirements are for only the tape subsystem and not for the magnetic media or any auxiliary equipment.

2.4.1 TEMPERATURE (ROOM AMBIENT)

Operating: +60°F to +90°F (+16°C to +32°C)
Storage: +50°F to +110°F (+10°C to +43°C)
Shipping: -40°F to +140°F (-40°C to +60°C)

The storage environment must not be outside the limits of the operating environment longer than six months. The shipping environment must not be outside the limits of the storage environment for a period longer than 72 hours.

2.4.2 RELATIVE HUMIDITY

Operating: 20% to 80% (noncondensing)

Storage: 10% to 80% (noncondensing)

Shipping: Any (noncondensing)

The storage environment must not be outside the limits of the operating environment longer than six months. The shipping environment must not be outside the limits of the storage environment longer than 72 hours.

2.4.3 ALTITUDE

Operating: 0 to 6000 feet (0 to 1830 meters)
6000 to 8500 feet (1830 to 2600 meters)
with high altitude option

Non-Operating: 0 to 50,000 feet (0 to 15 250 meters)

2.5 HEAT DISSIPATION

Table 2-2 provides the heat dissipation rates of the various tape subsystem configurations.

Table 2-2. Heat Dissipation

	60 Hz				50 Hz			
	Operating		Ready		Operating		Ready	
	BTU/hr	kCal/hr	BTU/hr	kCal/hr	BTU/hr	kCal/hr	BTU/hr	kCal/hr
1x1	6,140	1550	5,120	1290	7,170	1805	5,460	1375
1x2	10,240	2580	9,210	2320	11,260	2840	9,560	2410
1x3	13,650	3440	12,970	3270	15,360	3870	13,650	3440
1x4	17,750	4475	16,720	4215	19,450	4900	17,750	4475
1x5	21,840	5505	20,820	5245	23,550	5935	21,840	5505
1x6	25,250	6365	23,890	6020	27,640	6965	25,940	6535
1x7	29,010	7310	27,980	7050	31,740	8000	30,000	7560
1x8	33,100	8340	30,080	7580	35,830	9030	34,130	8600

CHAPTER 3

CONTROLS AND INDICATORS

3.1 INTRODUCTION

This chapter describes all controls and indicators: those that are accessible to and used by the operator for normal operations and those that are available to trained and qualified personnel for maintenance and diagnostic functions.

3.2 OPERATOR CONTROL PANEL

The operator control panel contains switches to permit operation of the tape unit and indicators to provide tape unit status information. Figure 3-1 shows the operator control panel and, in the insert, its location on the tape unit.

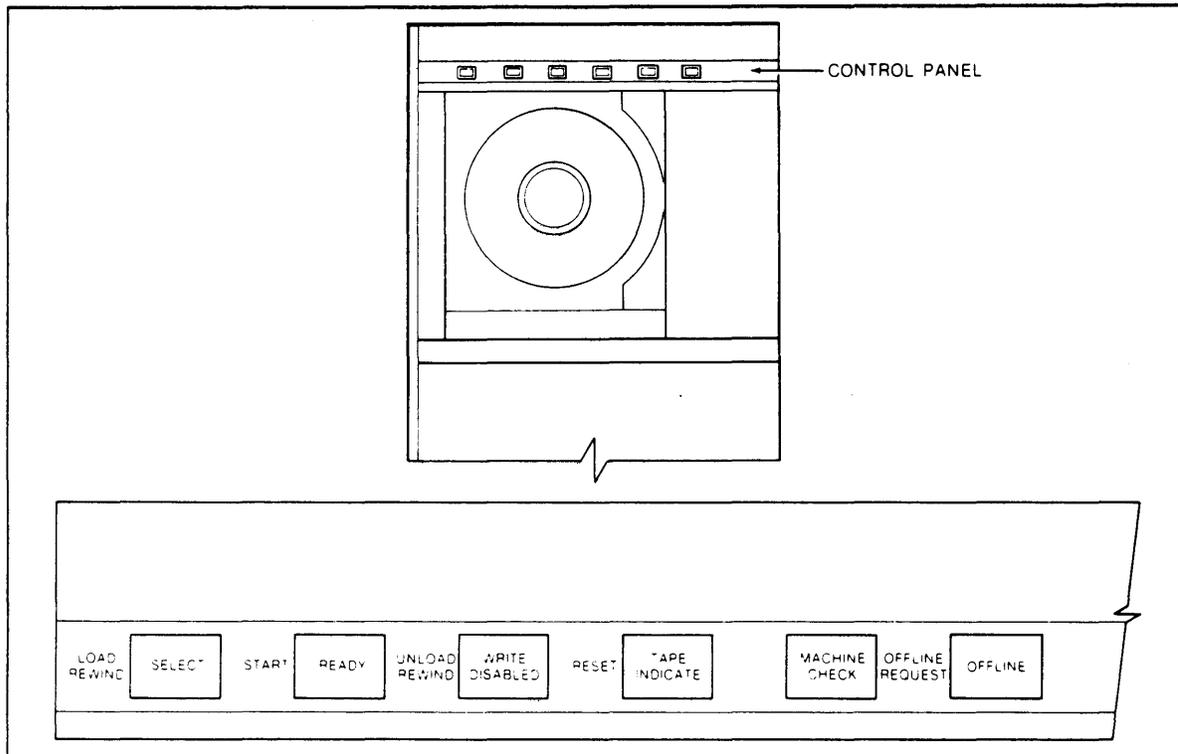


Figure 3-1. Operator Control Panel

3.2.1 LOAD/REWIND SWITCH

If the tape unit is not already loaded, pressing the LOAD/REWIND switch closes the window, latches the file hub, and initiates the automatic thread/load operation. If the tape unit is loaded, pressing the LOAD/REWIND switch initiates a rewind to BOT. The switch is operational only when the READY and MACHINE CHECK indicators are not illuminated.

3.2.2 START SWITCH

Pressing the START switch enables the tape unit to accept commands from the tape control unit (TCU) provided that the tape unit is loaded (Ready Status). If the tape unit is performing a thread/load operation when the START switch is pressed, the tape unit enters Ready Status when the tape reaches BOT.

3.2.3 REWIND/UNLOAD SWITCH

If tape is present in the columns, pressing the REWIND/UNLOAD switch initiates a high speed rewind to BOT. When BOT is detected, tape unloads onto the file reel (this conditions the power window, cartridge, and file hub to allow removal of the file reel). The switch is operational only when the READY and MACHINE CHECK indicators are not illuminated.

3.2.4 RESET SWITCH

Pressing the RESET switch ends the tape unit Ready Status, allowing the use of the other operator control panel switches.

Pressing the RESET switch also clears a machine check if the condition causing the check is no longer present.

Pressing the RESET switch once during a high-speed rewind operation slows the tape to normal tape speed. Pressing RESET a second time stops the tape completely. Pressing RESET during a rewind/unload operation affects rewind as described and unload is either prevented or is halted if already in progress by the disabling of both the pneumatics and reels systems.

Pressing the RESET switch during a load operation terminates the operation, leaving the tape unit in one of two possible states: If tape is loaded into the columns, RESET halts the search for BOT but keeps the pneumatics and reels systems enabled (pressing the REWIND switch resumes the search for BOT). If tape is not loaded into the columns, pressing RESET disables both pneumatics and reels systems.

3.2.5 OFFLINE REQUEST SWITCH

The OFFLINE REQUEST switch determines tape unit availability to the channel. If the tape unit is in Offline Status, pressing OFFLINE REQUEST changes the tape unit to Online Status. If the tape unit is in Online Status, pressing OFFLINE REQUEST changes the tape unit to Offline Status following the completion of the current command.

3.2.6 SELECT INDICATOR (WHITE)

Illumination of SELECT indicates that the tape unit has been selected for use by the TCU.

3.2.7 READY INDICATOR (GREEN)

Illumination of READY indicates that the tape unit is loaded with tape and is in Ready Status.

3.2.8 WRITE DISABLED INDICATOR (RED)

WRITE DISABLED illuminates when the tape unit is not in Ready Status or when a write enable ring is not in place on the file reel. The write operation is prohibited when the write enable ring is absent.

3.2.9 TAPE INDICATE INDICATOR (WHITE)

TAPE INDICATE illuminates when the end-of-tape (EOT) marker is at or past the EOT sensor. The indicator remains lit until a backward read or rewind operation moves the EOT marker back past the EOT sensor. EOT Status is automatically reset when a rewind operation is initiated.

3.2.10 MACHINE CHECK INDICATOR (RED)

Flashing of MACHINE CHECK indicates a load check which is operator-correctable; continuous illumination indicates a malfunction requiring service by a field engineer.

3.2.11 OFFLINE INDICATOR (RED)

Illumination of OFFLINE indicates that the tape unit is in Offline Status.

3.3 ENABLE/DISABLE PANEL

The enable/disable panel located on the A-unit contains a vertical bank of switches that control channel access to the individual tape units. Figure 3-2 shows the enable/disable panel for 2x16 configurations. The switch must be in the Enable position to allow channel access to the associated tape unit. If the switch for a tape unit is transferred from the Enable to the Disable position while the tape unit is selected by the channel, it will have no immediate effect: the tape unit will not become disabled until the operation in progress is completed and Select is reset.

On tape subsystems with the communicator feature installed, the panel contains two vertical banks of switches to permit manual partitioning of the 2xX tape subsystem. These switches control access of the two channels cabled to the TCU of that A-unit. The left bank controls access to the tape units cabled to that TCU; the right bank controls access to the tape units cabled to the second TCU. In addition, the panel also contains two switches to disable the access of either channel to the tape subsystem.

3.4 FE PANEL

The FE panel (Figure 3-3) located at the A-unit maintenance facility permits local power control and initialization of the tape subsystem, the performance of maintenance functions and diagnostic routines, and the forcing of certain TCU operations. Indicators on the panel provide status information.

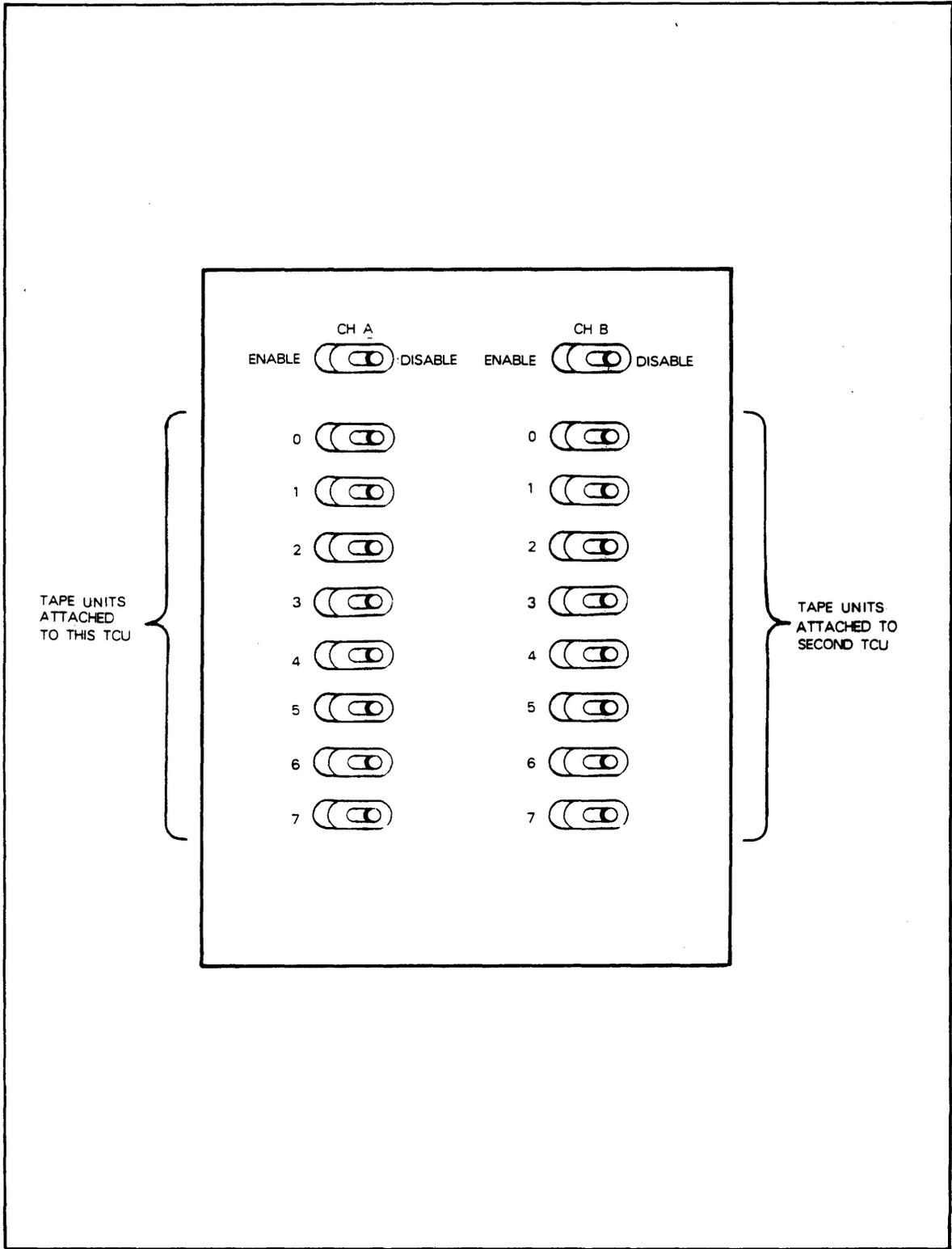


Figure 3-2. Enable/Disable Panel

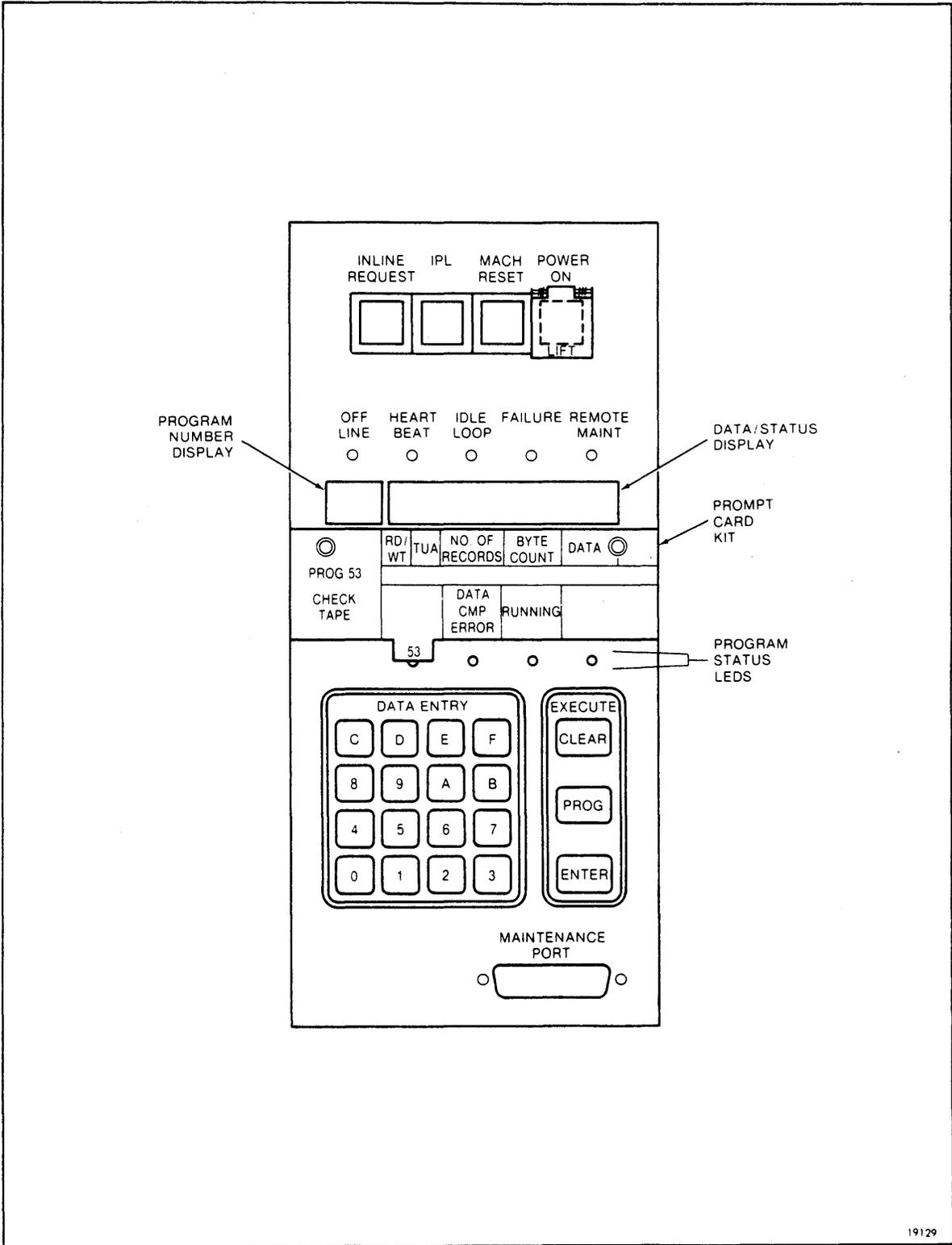


Figure 3-3. FE Panel

3.4.1 POWER ON

POWER ON is a combined alternate action switch and indicator. Depressing the Power On switch powers and initializes the tape subsystem. The Power On switch must be in the unlatched (out) position to permit remote power on. The Power On indicator is illuminated when power is on.

3.4.2 MACH RESET

MACHINE RESET is a combined momentary switch and indicator. When the Machine Reset switch is pressed, the microprocessor terminates the execution of the present program and re-initializes the TCU. The Machine Reset indicator illuminates when a parity error is detected in the formatter microprocessor memory.

3.4.3 IPL

IPL is a combined momentary switch and indicator. Pressing the IPL switch initializes the TCU, accessing an Initial Program Load (IPL) which contains wake-up tests and a diskette loader program to load the first track into memory. The IPL indicator is illuminated throughout the IPL process.

3.4.4 INLINE REQUEST

INLINE REQUEST is a combined alternate action switch and indicator which generates an inline request to the TCU. Pressing the Inline Request switch while the TCU is operating enables input from the FE panel or 39XX, stores any current error log information, and prevents any further error logging until the Inline Request switch is released.

At IPL, the status of Inline Request determines whether the TCU will be brought online. If the Inline Request is on, the TCU is not brought online and the Offline indicator is illuminated. If Inline Request is off, the TCU is brought online.

The Inline Request indicator illuminates when the Inline Request switch is depressed.

3.4.5 OFFLINE

The Offline indicator illuminates when the TCU is offline to the channel.

3.4.6 HEARTBEAT

The Heartbeat indicator is illuminated when the TCU is operating. The Heartbeat indicator is controlled by a subroutine of the operating system microcode. If the subroutine is not accessed within a given time limit, a delay times out, the indicator is extinguished, and an alarm is sounded. Pressing the IPL switch starts the program and illuminates the Heartbeat indicator.

3.4.7 IDLE LOOP

The Idle Loop indicator illuminates when the subsystem operating program is in its idle loop, that is, awaiting an instruction from the ICA or maintenance facility. The idle loop indicator extinguishes during processing.

3.4.8 FAILURE

The Failure indicator illuminates when a Unit Check (Section 5.3.6) is detected. (The Failure indicator does not illuminate during an IPL sequence failure.)

3.4.9 REMOTE MAINT

The Remote Maintenance indicator illuminates when a 39XX Detached Diagnostic Device (Section 6.3) or acoustic coupler is connected and data is being transferred across the maintenance port (Section 4.4.15).

3.4.10 PROGRAM NUMBER DISPLAY

The Program Number Display is a two-digit display that indicates the number of the current FE panel program or an IPL error code.

3.4.11 DATA/STATUS DISPLAY

The Data/Status Display is an eight-character display which indicates variable program data and test status for FE panel programs. Field delimiters are displayed as periods; dashes are displayed in areas not being used.

3.4.12 PROMPT CARD KIT AND PROGRAM STATUS LEDS

The prompt card kit is a set of charts that identify the fields of the program number, the data/status displays, and the program status LEDs. Each chart uniquely identifies a specific FE panel program. When a program is called, the upper half of the chart identifies the fields into which the program has divided the data/status display. The lower half of the chart identifies the functions assigned to the program status LEDs located below the chart.

3.4.13 DATA ENTRY KEYPAD

The Data Entry keypad is a hexadecimal keypad used to enter program numbers and program parameters. The Execute keys (Clear, Prog, and Enter) to the right of the keypad are used to control data entered on the keypad.

3.4.14 EXECUTE KEYS

Pressing the Enter (ENTER) key causes data entered at the keypad to be entered into a data register in the FE panel and initiates program execution. During execution of some FE panel programs, the Enter key has special functions which are described in the 4600 Tape Subsystem Diagnostics Manual.

Pressing the Clear (CLEAR) key before the Enter key is pressed clears the current keypad entry. The Clear key may also be used for special functions defined in the 4600 Tape Subsystem Diagnostics Manual.

Pressing the Program (PROG) key cancels the current program and enables the keypad to input a new program number.

3.4.15 MAINTENANCE PORT

The maintenance port is an RS-232-C connector used to attach a 39XX Detached Diagnostic Device (Section 6.3) or an acoustic coupler to the TCU for additional diagnostic capacity. This port accesses only the diagnostic programs of the tape subsystem.

3.5 TAPE UNIT MAINTENANCE PANEL

A circuit card in the tape unit contains a tape unit maintenance panel (Figure 3-4). This panel provides a set of switches for invoking tape unit test procedures and an eight-bit display for monitoring tape unit performance and status. The tests are used for exercising tape unit components, for examining microprogram storage areas, and for exercising the tape unit.

The control switches are:

1. Start/Reset: A bidirectional momentary toggle switch used for invoking a test and stepping through it; also used to exit a test by resetting the tape unit.
2. Backward/Forward: a bidirectional momentary toggle switch used for selecting the direction of tape motion.
3. Maintenance Control: An eight-bit position slide DIP switch used for selecting the test (three Program Select switches) and for setting test variables (such as write density).
4. Variables Select: An eight-bit position slide DIP switch used for setting test variables such as write bit selection and shoeshine rate.
5. IPL Request: A unidirectional momentary toggle switch used to initiate a tape unit IPL sequence.

Eight LED indicators display various maintenance test information. If a machine check is detected during normal tape operations, these indicators display a machine check code.

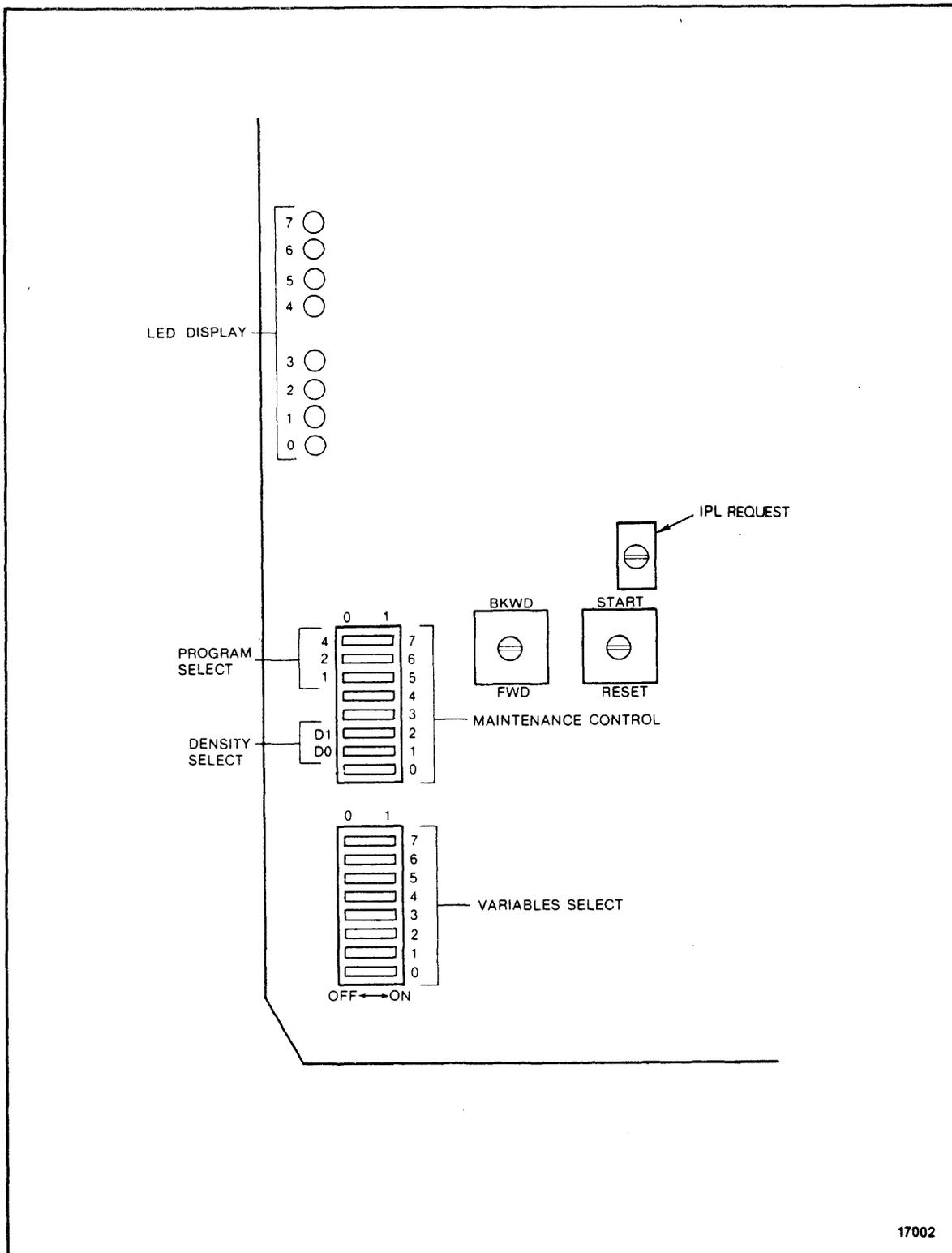


Figure 3-4. Tape Unit Maintenance Panel

CHAPTER 4

CHANNEL INTERFACE

4.1 INTRODUCTION

The channel interface is comprised of bus lines, tag lines, selection control lines, and a mark line, through which the TCU and channel exchange control and data signals (refer to Table 4-1). The TCU decodes commands received from the channel, interprets the commands for the tape units, and provides the signal sequence for executing the operation.

4.2 MODES OF DATA TRANSFER

Selection of a TCU is controlled by a signal that permits each TCU to respond to channel signals sequentially. A TCU remains logically connected to the channel until information is exchanged or until the channel signals the TCU to disconnect.

There are four modes of data transfer: DC Interlock, Offset Interlock, Service In Only, and Data Streaming at 2 or 3 megabytes per second:

1. DC Interlock sequences remove dependence on circuit speed and make the interface applicable to a wide variety of circuits and data rates. DC Interlock transfers data using Service In-Service Out and Data In-Data Out tags in handshaking mode. All channels are capable of operating in DC Interlock mode.
2. The Offset Interlock mode permits the use of channel interface cables up to 350 feet (105 meters) in length with no adverse effect on data transfer rate. Offset Interlock mode performs data transfer using Service In-Service Out and Data In-Data Out tags without handshaking. Offset Interlock mode operates on selector or block multiplexer channels.
3. Service In Only mode uses only Service In-Service Out tags for handshaking. Service In Only mode operates on block multiplexer channels.
4. Data Streaming mode requires the buffer feature and is applicable for read and write commands only; sense and control commands use DC Interlock or Offset Interlock modes.

Table 4-1. Channel Interface Lines

LINE GROUP	LINE NAME	USE
Bus Out Lines	P,0-7	These lines are used to send information such as data, I/O device address, and commands from the channel to the TCU.
Bus In Lines	P,0-7	These lines are used to send information such as data, I/O identification, sense data, and status information from the TCU to the channel.
Tag Lines	Address Out Address In Command Out Status In Service Out Service In Data Out Data In Disconnect In	These lines are used for interlocking and controlling information on the buses and for any special sequences.
Selection Control Lines	Operational Out Operational In Hold Out Select Out Select In Suppress Out Request In	These lines are used for scanning or the selection of the attached I/O devices.
Mark Line	Mark 0 In	This line is used to request the command retry functions.

4.3 STATUS INFORMATION

The Status Byte is transmitted to the channel during the initial selection sequence, to present Channel End at the termination of data transfer, to present Device End or Control Unit End when the tape unit or TCU become free, to present stacked status or to present externally-initiated status. Once the Status Byte has been accepted by the channel, it is reset and is not presented again. When Status In is up, the Status Byte appears on Bus In. The Status Byte indicates the current status of the TCU and the tape unit whose address appeared on Bus In with Address In during the polling or selection portion of the sequence.

When a TCU has the optional two-channel switch feature installed, the status resulting from channel-initiated operations will be presented only to the channel that initiated the associated I/O operation.

4.3.1 STATUS MODIFIER (BIT 1)

Status modifier, when set with Busy (bit 3) set, indicates the TCU is busy rather than the tape unit. Status modifier is never presented alone.

4.3.2 CONTROL UNIT END (BIT 2)

The Control Unit End (CUE) bit indicates the following conditions:

1. The TCU has previously responded to interrogation by a channel with a status byte containing the Busy and Status Modifier bits and is now available to communicate with the channel.
2. The TCU detected a Unit Check or Unit Exception condition while it was busy, but after Channel End was accepted by the channel.

A pending CUE causes the TCU to appear unavailable for initiation of new operations. However, if CUE is being presented to one interface of a dual channel TCU, a short-busy sequence will be the response to an attempted selection by the other interface.

Control Unit End causes command chaining to be suppressed.

4.3.3 BUSY (BIT 3)

Busy indicates that a TCU or a tape unit cannot accept a command because it is executing a previously-initiated operation or that a status condition exists at initial selection. Busy status can be presented only during an initial selection sequence and causes command chaining to be suppressed.

Busy As A Result Of Status: If the status condition that causes a busy indication is for the addressed tape unit, the Busy bit is set along with the existing status providing the command is other than Test I/O. If the status is not for the addressed tape unit, Status Modifier is set along with the Busy bit to indicate the TCU is busy.

Busy As A Result of Dual Channel Interface Operation: TCUs with the two-channel switch feature installed will appear busy to one interface while they are attached or maintaining a contingent connection to the other interface. The status presented under such a situation is an Immediate Busy status.

TCUs with the two-channel switch feature will also appear busy to one interface while a System Reset or Selective Reset is occurring on the other interface.

Busy As A Result of Inline Diagnostics: Execution of inline diagnostics will cause a Short Busy response to an attempted selection by the channel interface.

4.3.4 CHANNEL END (BIT 4)

Channel End indicates that the transfer of data or the control information portion of an I/O operation between the channel and the TCU is complete. Channel End is generated only once per I/O operation. Channel End is set when a Read, Read Backward, Write, or Sense command has been completed, or when a control command has been accepted.

4.3.5 DEVICE END (BIT 5)

Device End indicates the completion of an I/O operation at the tape unit. Each I/O operation causes only one Device End condition.

When command chaining is performed, the channel makes available to the program only the Device End for the last command in the chain. If the Device End is received without unusual conditions detected, the channel initiates the next command chain. If an unusual condition is detected, the command chain is terminated without presenting Device End.

If the two-channel switch option is installed and tape units are shared by the two channels, Device End is presented to both channels when a shared tape unit goes from the not-ready to ready state.

Device End is set when any of the following conditions occur:

1. A rewind/unload operation is completed at the TCU.
2. When the tape reaches BOT during a rewind operation or EOT during a data security erase operation.
3. A control command is completed at the tape unit.

4. Other commands are completed, along with Channel End.
5. On the first initial selection sequence after the tape unit becomes ready if the TCU has not been armed.
6. When a tape unit becomes not busy after selection was attempted while it was busy.
7. If a selected tape unit drops Ready during an operation except upon acceptance of a Rewind, Rewind/Unload, or Data Security Erase (DSE) command.

4.3.6 UNIT CHECK (BIT 6)

Unit Check indicates that the tape unit or TCU has detected an unusual condition. The conditions causing Unit Check are detailed by information available as sense data.

Unit Check may indicate a programming or equipment error, a not-ready state of a tape unit that has affected execution of a command, or an exceptional condition not included in the Unit Exception indication has occurred. An error condition sets Unit Check only during the execution of a command or when performing an activity associated with an I/O operation.

Unit Check is not set if the TCU can execute the command although the addressed type unit has become not-ready as a result of the operation. Test I/O can clear the not-ready state of the tape unit without setting Unit Check. However, a subsequent Test I/O issued to the device will cause a Unit Check indication. A Test I/O or No Operation command issued to a not-ready device with no interruption pending will cause a Unit Check indication.

Unit Check is set when any of the following conditions occur:

1. Any bit in Sense Byte 0 is set.
2. A read backward, backspace block, or backspace file operation is initiated at or into BOT.
3. A rewind/unload operation is completed at the TCU.
4. Sense Byte 1, bit 7 (Not Capable) is set.
5. Sense Byte 5, bit 3 (ID Burst Check) is set.
6. Sense Byte 1, bit 0 (Noise) is set.

7. Mark 0 In and Status In rise indicating a command retry operation.

4.3.7 UNIT EXCEPTION (BIT 7)

Unit Exception indicates an unusual condition that is not necessarily an error. A sense operation is not required as a response to acceptance of a Unit Exception condition. Unit Exception is generated only while executing an I/O operation or performing an activity associated with an I/O operation and the condition is of immediate significance. Unit Exception indicates that no action will be taken by the tape unit in response to a command.

Unit Exception is set when any of the following conditions occur:

1. If Tape Indicate is on during a write, write tape mark, or erase gap operation. Unit Exception is set after a subsequent Write, Write Tape Mark, or Erase Gap command if Tape Indicate is not reset.
2. If a tape mark is sensed during a read, read backward, forward space block, or a backspace block operation. Unit Exception is set only for the tape mark read and is reset for any subsequent command.

4.4 SENSE BYTES

The Sense Bytes supplement the information contained in the Status Byte. A sense command transfers the Sense Bytes to the channel. The information contained in the Sense Bytes includes error and unusual conditions associated with the last operation and provides information about the current conditions present in the TCU and tape unit.

A summary of the Sense Bytes is given in Table 4-2.

Table 4-2. Sense Bytes

BYTE	BIT (HEX VALUE)							
	0 (8)	1 (4)	2 (2)	3 (1)	4 (8)	5 (4)	6 (2)	7 (1)
0	COMMAND REJECT ³	INTERVEN REQUIRED ³	BUS OUT CHECK ³	EQUIPMENT CHECK ³	DATA CHECK ³	OVERRUN ³	WORD COUNT ZERO ³	0
1	NOISE ²	TU STAT A	TU STAT B	0	BOT	WRITE STATUS	FILE PROTECT	NOT CAPABLE ³
2	TRACK-IN-ERROR (TIE)							
3	R/W VRC ²	MTE/LRC ²	SKEW ERROR ²	EDC/CRC ²	ENV/ECC ²	PE IN TU	BACKWARD STATUS	C/P COMPARE ²
4	MP HDW CHECK	REJECT TU ¹	TAPE INDICATE	WRITE VRC ²	0	LWR	TU CHECK	0
5	0	NEW SUBSYSTEM	WTM CHECK ²	ID BURST CHECK ³	0	PARTIAL RECORD ²	POSTAMBLE ERROR ²	0
6	0	WRITE CHECK ¹	DD TU	TU NOT IN PE	TU MODEL	TU SPEED		
7	COLUMN OUT	FILE COL CHECK	MACHINE COL CHECK	RESET KEY	DSE CHECK	ERASE CHECK	0	LOAD CHECK
8	IBG DETECTED ²	0	0	0	0	0	0	0
9	6250 CORR	VELOCITY CHANGE ²	CHANNEL BUFFER CHECK	CRC III ²	6250	0	0	TCU RESERVED
10	COMMAND STAT REJ ¹	0	0	REC NOT DETECTED ¹	0	TACH START FAILURE ¹	0	VELOCITY CHECK ¹
11	SPARE							
12	SPARE							
13	TCU FEATURES		TCU SN (HIGH)					
14	TCU SN (LOW)							
15	TU SN (HIGH)							
16	TU SN (LOW)							
17	TWO CHNL SWITCH	COMMUNICATION	0	0	TCU LEVEL			
18	0	0	0	0	TU LEVEL			
19	DEVICE END TU 7	DEVICE END TU 6	DEVICE END TU 5	DEVICE END TU 4	DEVICE END TU 3	DEVICE END TU 2	DEVICE END TU 1	DEVICE END TU 0
20	DEVICE END TU F	DEVICE END TU E	DEVICE END TU D	DEVICE END TU C	DEVICE END TU B	DEVICE END TU A	DEVICE END TU 9	DEVICE END TU 8
21	0	0	0	0	0	0	0	0
22	FAULT SYMPTOM CODE							
23	SUBSYSTEM ID							
1. Sets Equipment Check 2. Sets Data Check 3. Sets Unit Check in Status Byte								

4.4.1 SENSE BYTE 0

Bit 0, Command Reject, is set when:

1. A Write, Write Tape Mark, or Erase command is issued to a file protected tape unit.
2. An invalid command is received by the TCU.
3. A Data Security Erase command is not chained to an Erase Gap command or is issued to a tape unit positioned at EOT.
4. A Sense Reserve or Sense Release command is issued to a TCU that does not have two-channel switch capability or when a Sense Reserve or Sense Release command is issued other than as the first command in a chain.

Bit 1, Intervention Required, is set when the addressed tape unit is not ready or is nonexistent (not TU Status A).

Bit 2, Bus Out Check, is set when Bus Out has incorrect (even) parity during a command or data byte transfer.

Bit 3, Equipment Check, is set on a TCU operation when:

1. Microprocesosr Hardware Check (Byte 4, bit 0) is set.
2. Reject TU (Byte 4, bit 1) is set.
3. Command Status Reject (Byte 10, bit 0), Record Not Detected (Byte 10, bit 3), Tach Start Failure (Byte 10, bit 5), or Velocity Check (Byte 10, bit 7) is set.
4. In GCR, no beginning of record is detected in GCR ID.

Bit 4, Data Check, is set when:

1. Noise (Byte 1, bit 0) is set.
2. R/W VRC (Byte 3, bit 0), MTE/LRC (Byte 3, bit 1), Skew Error (Byte 3, bit 2), EDC/CRC (Byte 3, bit 3), ENV/ECC (Byte 3, bit 4) or C/P Compare (Byte 3, bit 7) is set.
3. Write VRC (Byte 4, bit 3) is set.
4. WTM Check (Byte 5, bit 2) is set.
5. In PE or GCR, Partial Record (Byte 5, bit 5) is set or Postamble Error (Byte 5, bit 6) detects an IBG too soon after end of data on a write operation.

6. In PE or GCR, IBG Detected (Byte 8, bit 0) is set.
7. Velocity Change (Byte 9, bit 1) is set. In PE or GCR, CRC III (Byte 9, bit 3) is set.

Bit 5, Overrun, is set during a write operation when the channel cannot supply data to the TCU fast enough. Overrun during a write operation terminates the write operation and stops tape motion inhibiting further data requests to the channel. Overrun is set during a read or read backward operation when the channel cannot take data from the TCU fast enough. Overrun during a read operation terminates data transfer but allows tape motion to continue until an IBG is detected. If Data Check is set, overrun is suppressed.

Bit 6, Word Count Zero, is set when Command Out responds to the first Service In of a write operation or when a Halt is received before data transfer occurs during a write operation.

Bit 7 is not used; always zero.

4.4.2 SENSE BYTE 1

Bit 0, Noise, is set when:

1. Data is detected during an ERG or the erase portion of WTM.
2. Creased tape is detected during a read or read backward operation.
3. Data Check is set for a read or read backward operation.
4. If overrun occurs followed by a Data Check during a write, read or read backward operation.
5. In PE or GCR, if no data is transferred during a read or read backward operation and the block is not detected as a tape mark.
6. In PE or GCR, when IBG is detected too late after end of data (long preamble) or too soon after end of data (short postamble).

Bit 1, TU Status A and Bit 2, TU Status B. TU Status A is set when an addressed tape unit is selected, ready, and not busy. TU Status B is set when an addressed tape unit is rewinding, switched, or not ready. The bit definitions that follow indicate the status of the addressed tape unit.

Bit 1	Bit 2	Status
0	0	Nonexistent
0	1	Not ready
1	0	Ready and not rewinding
1	1	Ready and rewinding or switched

Bit 3 is not used; always zero.

Bit 4, BOT, is set when the selected tape unit is at beginning of tape (load point).

Bit 5, Write Status, is set when the selected tape unit is conditioned to write.

Bit 6, File Protect, is set when the selected tape unit is conditioned not to write by the absence of a write enable ring.

Bit 7, Not Capable, is set when departing the load point (BOT) with a read or write command and the density configuration of the tape unit and TCU density capability are not compatible.

4.4.3 SENSE BYTE 2

Bits 0-7, Track-In-Error (TIE), are set for any track containing an error. In PE or GCR, TIE bits indicate dead tracks at the end of an operation. In NRZI, after a read operation, all bits off indicates that Track P is in error; a single bit set with Data Check indicates the specific track in error; bits 6 and 7 set with Data Check indicates that the track-in-error cannot be found; and bits 6 and 7 set without Data Check indicates normal operation.

4.4.4 SENSE BYTE 3

Bit 0, R/W VRC (Read/Write Vertical Redundancy Check), is set in PE or GCR when incorrect parity is detected in the read/write data path. R/W VRC is set in NRZI when a VRC occurred during a read operation or when a missing byte is detected.

Bit 1, MTE/LRC (Multiple Track Error/Longitudinal Redundancy Check), is set in PE or GCR when multiple tracks are in error simultaneously during a read or write operation, or when Velocity Change (Byte 9, bit 1) is set. MTE/LRC is set in NRZI when an LRC error occurs during a read or write operation.

Bit 2, Skew Error, is set in GCR when excessive skew is detected during a read or write operation or when bit spacing within a

byte is greater than 14 bit cell times. Skew Error is set in PE and GCR when a track fails to start. Skew Error is set in PE when skew between consecutive bits exceed three bits. Skew Error is set in NRZI when excessive skew is detected during a write operation.

Bit 3, EDC/CRC (End Data Check/Cyclic Redundancy Check), is set in PE or GCR when CRC III (Byte 9, bit 3) is set. EDC/CRC is set in NRZI when a CRC Register error occurs during a read or write operation.

Bit 4, ENV/ECC (Envelope/Error Correction Check), ENV/ECC is set when there is insufficient data amplitude on a read or write operation. ENV/ECC is set in PE or GCR when no end of data occurs in a LWR operation, when an IBG is not detected during a write operation, or when WTM Check (Byte 5, bit 2) is set. ENV/ECC is set in NRZI when a byte with incorrect parity is detected during a write operation.

Bit 5, PE in TU, is set when the tape unit is in PE mode (1600 bpi).

Bit 6, Backward Status, is set when the tape unit is in backward status.

Bit 7, C/P Compare, is set in PE and GCR when the hardware detects an internal parity error.

4.4.5 SENSE BYTE 4

Bit 0, Microprocessor Hardware Check, is set to indicate a hardware error in the channel area. Subsystems with data streaming capability do not use this bit.

Bit 1, Reject Tape Unit, is set when:

1. The selected tape unit drops Ready during a tape motion command.
2. A change in read status occurs.
3. Command Status Reject (Byte 10, bit 0) is set.
4. Tach Start Failure (Byte 10, bit 5) is set.
5. Write Inhibit is not active when Go rises.
6. Velocity Check (Byte 10, bit 7) is set.

7. No IBG is found after the GCR or PE ID burst.

Bit 2, Tape Indicate, is set when the EOT marker is sensed during a forward tape motion.

Bit 3, Write VRC, is set in PE or GCR when data has incorrect parity during data transfer to the tape unit.

Bit 4. Spare; always zero.

Bit 5, LWR, is set when the last command was Loop Write-To-Read.

Bit 6, TU Check, is set to indicate tape unit failures such as write or erase head failures, etc.

Bit 7. Spare; always zero.

4.4.6 SENSE BYTE 5

Bit 0. Spare; always zero.

Bit 1, 4500 Subsystem, identifies the 4500 Tape Subsystem and is always set.

Bit 2, WTM Check, is set when a tape mark is not written properly.

Bit 3, ID Burst Check, is set in PE or GCR when an identification burst is not written correctly from BOT. ID Burst Check may be set in GCR when the ID burst is recognized but the ARA is not during a read operation.

Bit 4 is not used; always zero.

Bit 5, Partial Record, is set in PE or GCR when an IBG appears before end of data is recognized.

Bit 6, Postamble Error, is set when the IBG is not detected during the allowable time limits after end of data is recognized for a read or write operation.

Bit 7. Spare; always zero.

4.4.7 SENSE BYTE 6

Bit 0 is not used; always zero.

Bit 1, **Write Check**, is set when erase head current is flowing while the tape unit is in read status.

Bit 2, **DD TU (Dual Density Tape Unit)**, is always set, indicating that the addressed tape unit is capable of both GCR and PE operation.

Bit 3, **TU Not in PE**, is set to indicate that the addressed tape unit is in either GCR or NRZI mode.

Bit 4, **TU Density**, defines the density of the addressed tape unit. Set indicates that the tape unit is set in PE or GCR; reset indicates that the tape unit is set to NRZI.

Bits 5-7, **TU Speed**, define the tape speed of the addressed tape unit as indicated below:

	Bit 5	Bit 6	Bit 7
75 ips	0	1	1
125 ips	1	0	0

4.4.8 SENSE BYTE 7

Bit 0, **Column Out**, is set when tape in either vacuum column bottoms out or pulls out of the column. Column Out can be reset with the Reset switch.

Bit 1, **File Column Check**, is set when the tape loop in the file reel vacuum column extends beyond acceptable limits.

Bit 2, **Machine Column Check**, is set when the tape loop in the machine reel vacuum column extends beyond acceptable limits.

Bit 3, **Reset Key**, is set when the tape unit is not Ready because the Reset switch was actuated.

Bit 4, **DSE Check**, is set when a failure occurs during a Data Security Erase operation.

Bit 5, **Erase Check**, is set when erase head current is not present during write status or when erase head current is present during read status.

Bit 6 is not used; always zero.

Bit 7, **Load Check**, is set when the tape unit fails to load properly.

4.4.9 SENSE BYTE 8

Bit 0, **IBG Detected**, is set when an interblock gap is detected while writing a record.

Bits 1-7. Spare; always zero.

4.4.10 SENSE BYTE 9

Bit 0, **6250 Correction**, is set when a one- or two-track correction was attempted during a GCR read or write operation. This bit is set for information only and does not indicate an error.

Bit 1, **Velocity Change**, is set when an excessive velocity change is detected during a write operation.

Bit 2, **Channel Buffer Check**, is set when data sent in to the channel buffer does not match data sent out of the channel buffer.

Bit 3, **CRC III**, is set when a CRC error is detected for a read or write operation or when incorrect data is transferred through a portion of the read/write path during a read or write operation.

Bit 4, **6250**, is always set, indicating that the TCU has the capability of writing and reading GCR data (6250 bpi).

Bits 5 and 6. Spare; always zero.

Bit 7, **TCU Reserved**, is set when the TCU is in reserved status. This bit is set by a Sense Reserve command only with a TCU that has the two-channel switch option installed.

4.4.11 SENSE BYTE 10

Bit 0, **Command Status Reject**, is set in GCR and NRZI when the tape unit fails to return the proper command status. Command Status Reject is set in PE when the tape unit has improper erase status.

Bits 1 and 2. Spare; always zero.

Bit 3, **Record Not Detected**, is set when a record can not be found during a write or WTM operation.

Bit 4 is not used; always zero.

Bit 5, Tach Start Failure, is set when the tape unit did not achieve proper velocity within an expected time period.

Bit 6. Spare; always zero.

Bit 7, Velocity Check, is set when the tape unit fails to attain proper velocity in the specified time period.

4.4.12 SENSE BYTE 11

Bits 0-5 are always zero.

Bit 6 is set if the buffer feature is installed.

Bit 7 is set if no buffer feature is installed.

4.4.13 SENSE BYTE 12

Spare; always zero.

4.4.14 SENSE BYTE 13

Bits 0 and 1, TCU Features, identify TCU NRZI capability as defined below:

Bit 0	Bit 1	Feature
0	0	Not NRZI
0	1	Reserved
1	0	9-Track NRZI
1	1	Spare

Bits 2-7, TCU SN, provide the TCU serial number (high order).

4.4.15 SENSE BYTE 14

Bits 0-7, TCU SN, provide the TCU serial number (low order).

4.4.16 SENSE BYTE 15

Bits 0-7, TU SN, provide the tape unit serial number (high order).

4.4.17 SENSE BYTE 16

Bit 0-7, TU SN, provide the tape unit serial number (low order).

4.4.18 SENSE BYTE 17

Bit 0, Two Channel Switch, is set when the TCU contains two channel switch capability.

Bit 1, Communicator, is set when the TCU contains the communicator option.

Bits 2 and 3 are not used; always zero.

Bits 4-7, TCU Level, reflect the diagnostic level of the TCU. Hex value is 1 for standard tape subsystems and 8 for tape subsystems with data streaming capability.

4.4.19 SENSE BYTE 18

Bits 0-3 are not used; always zero.

Bits 4-7, TU Level, reflect the diagnostic level of the tape unit.

4.4.20 SENSE BYTE 19

Bits 0-7, Device End, are set as follows:

- Bit 0 - TU 7 Busy
- Bit 1 - TU 6 Busy
- Bit 2 - TU 5 Busy
- Bit 3 - TU 4 Busy
- Bit 4 - TU 3 Busy
- Bit 5 - TU 2 Busy
- Bit 6 - TU 1 Busy
- Bit 7 - TU 0 Busy

4.4.21 SENSE BYTE 20

Bits 0-7, Device End, are set as follows:

- Bit 0 - TU F Busy
- Bit 1 - TU E Busy
- Bit 2 - TU D Busy
- Bit 3 - TU C Busy
- Bit 4 - TU B Busy

Bit 5 - TU A Busy
Bit 6 - TU 9 Busy
Bit 7 - TU 8 Busy

4.4.22 SENSE BYTE 21

Not used; always zero.

4.4.23 SENSE BYTE 22

Bits 0-7, **Fault Symptom Code**, contain error information. Refer to the 4600 Tape Subsystem Diagnostics Manual, PN 95574.

4.4.24 SENSE BYTE 23

Bits 0 and 6, **Subsystem ID**, identify the subsystem designation. For 4500 Tape Subsystems, bits 6 and 0 are set (82 hex). (Bits 1 through 5 are reserved.)



CHAPTER 5

DIAGNOSTICS

5.1 INTRODUCTION

The 4500 Tape Subsystem features an on-board diagnostics package. The diagnostics package is used to verify proper subsystem operation, verify engineering changes, diagnose subsystem and input-output (I/O) errors, aid in problem isolation, and verify repairs.

The diagnostic hardware includes the FE panel (Section 4.4) and a floppy disk drive. The software includes an IPL program contained in the IPL PROM and the 4500 Diagnostic Monitor program which resides on one floppy diskette and contains wake-up diagnostics and functional/reliability tests.

5.2 WAKE-UP DIAGNOSTICS

Wake-up diagnostics are performed automatically whenever the tape subsystem is powered on and whenever an IPL sequence is initiated from the FE panel.

The first group of wake-up tests is executed directly from the IPL PROM and these tests verify the RAM, parity error detection, and the proper functioning of the floppy disk drive. The IPL PROM also contains a diskette loader program which loads the wake-up portion of the 4500 Diagnostic Monitor from the floppy diskette into the RAM. As these tests are loaded they are executed to verify the functional capability of the TCU. The FE panel displays a message to indicate the successful completion of these operations.

The TCU then downloads the tape unit microcode to each tape unit individually. When the tape unit downloading sequence is complete, the remainder of the 4500 Diagnostic Monitor is loaded from the floppy diskette, the TCU enters an idle loop, and the subsystem awaits further instruction from the channel (online or inline) or from the FE panel (inline or offline).

5.3 FUNCTIONAL/RELIABILITY TESTS

The functional/reliability routines are initiated at the FE panel. The majority of these routines may be invoked as inline diagnostics, that is, they may be executed while the subsystem is online and in use with only one tape unit offline. Inline diagnostics cannot execute the long record reliability tests or test the channel interface; these must be tested offline.

The first routines verify functional operation of the write path and read path in the TCU. Following functional verification, artificial stressing techniques are utilized to verify the error correction circuits: various types of flawed data are inserted and the output checked for proper error correction; excessively flawed data is also inserted to verify that the subsystem does not attempt correction on data that cannot be reliably corrected.

Subsequent routines perform loop write-to-read (LWR) testing, sample and analyze all tape unit Status Bytes, check all tape unit performance parameters, perform tape unit functional tests, and verify read/write reliability.

5.4 DETACHED DIAGNOSTICS

The 4500 Diagnostic Monitor can also interface with a Storage Technology 3910 or 3920 Detached Diagnostic Device (39XX) through the FE panel maintenance port. The 39XX is a portable maintenance processor contained in a carrying case (approximate dimensions: 8x15x21 inches; 30 pounds). The 39XX provides field engineering with a keyboard and CRT for two-way communication with the 4500 Diagnostic Monitor for enhanced diagnostic testing at the site or, through an acoustic coupler, over telephone lines to the Storage Technology Remote Maintenance Center (RMC) for remote diagnostics.

5.5 ERROR LOG

The 4500 Diagnostic Monitor also maintains an Error Log on the floppy diskette. The Error log is a record of the number of online operations, the number of correctable errors and uncorrectable errors, and Unit Check (Section 5.3.6) status information. The Error Log stores these subsystem performance statistics at the completion of online operation and may be accessed to aid in problem isolation or to measure tape subsystem performance.

CHAPTER 6

INSTALLATION PLANNING

6.1 INTRODUCTION

This chapter contains general guidelines for planning the installation of the 4500 Tape Subsystem. Information in this chapter is intended to briefly explain the requirements for subsystem layout and cabling. Refer also to the specifications provided in Chapter 2.

6.2 SUBSYSTEM LAYOUT

The physical layout of each subsystem depends on the amount of available space, the number of system components, and the customer's system application. A well-planned layout will take into consideration the following:

- operator access to equipment
- traffic flow
- material storage
- available power outlets
- machine gate and cover swing radii
- cable entry points
- service access (front and rear)
- fire hazards

6.3 SUBSYSTEM FLOORSPACE

The subsystem tape units are usually installed in a linear configuration; however, by utilizing the optional corner assembly, the string can be shaped to include right angles. Figure 6-1 shows the space required for the individual A- and B-units and for a complete eight-tape unit subsystem (linear configuration) and also illustrates the use of the corner assembly. The units are shipped separately and the frames bolted together at the installation site. Two side covers, each 0.75 inch (1.9 cm) thick, shipped attached to the A-unit and are, during installation, transferred to the exposed ends of the subsystem string.

The placement of the A-unit in the subsystem string is not critical except that, due to cabling restrictions, no more than four B-units may be installed on either side of the A-unit.

6.4 CABLING

The four different types of external cabling supplied for the installation of the 4500 Tape Subsystem are listed in Table 6-1.

Table 6-1. Subsystem Cable Types

Index	Cable Type	Maximum Length	Number Required
1	Channel Bus & Tag	See Table 7-2	2 per channel
2	EPO	No limitation	1 per subsystem
3	A-unit Power ¹	15 feet (4.5 meters)	1 per A-unit
4	Communicator ²	85 feet (25 meters)	2 per feature

1. Supplied as part of A-unit
2. Required only when communicator feature is installed

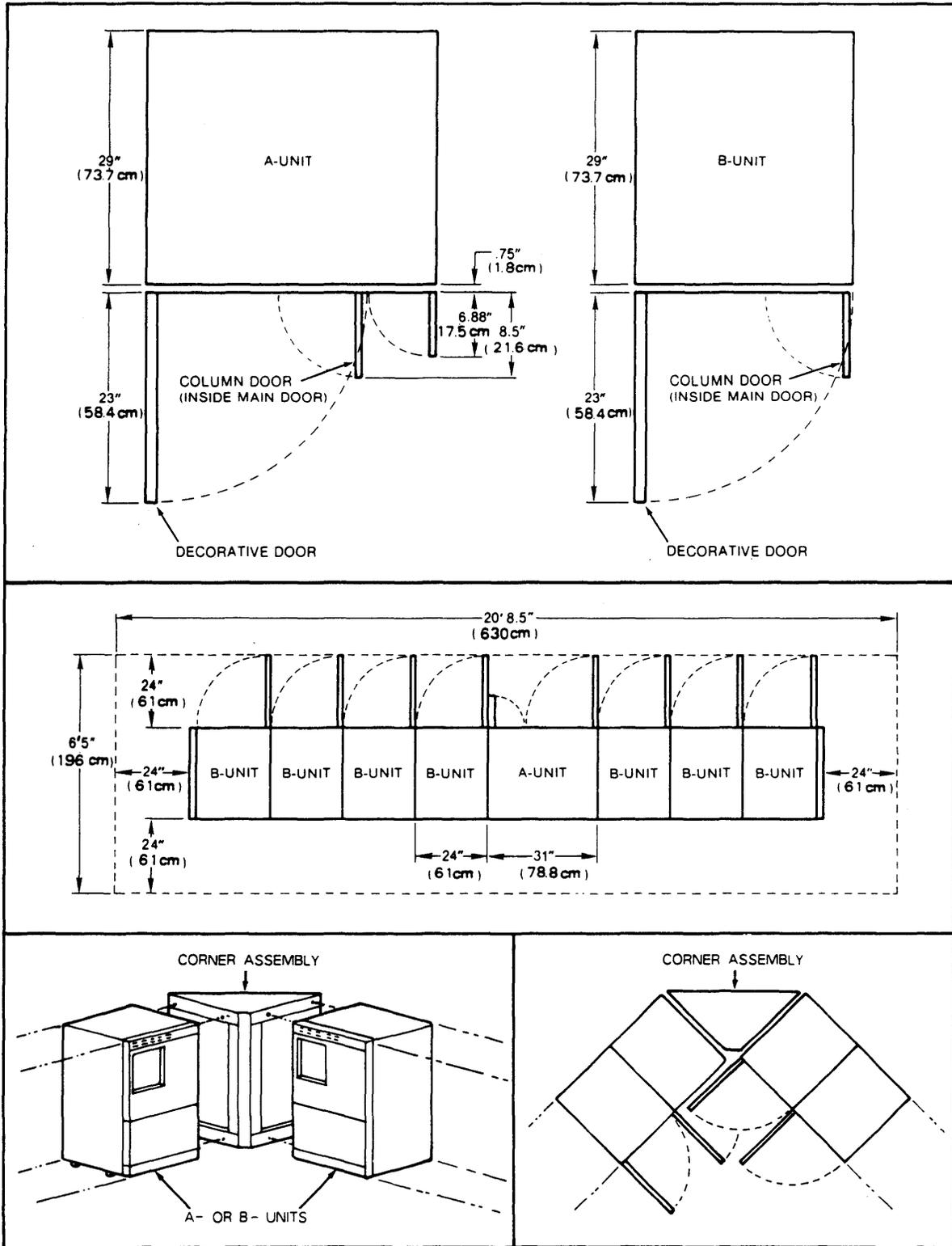


Figure 6-1. Floorspace Requirements

6.4.1 A-UNIT POWER CABLE

An external power cable is used to connect the A-unit power distribution assembly (PDA) to the facility's power source. Internal cables then connect from one PDA to the next PDA in the string. Raised floor access is not required to lay the cables.

The 60 Hz unit is provided with a shielded four-wire power cord: three phases and ground; 60 amps. The connector is a Russel and Stoll PN 7328 or equivalent. The compatible mating wall connector is Russel and Stoll PN SC7324 and the compatible mating cable connector is Russel and Stoll PN SC7428. The mating connector is not supplied.

The 50 Hz unit is provided with a shielded four-wire power cord: three phases neutral, and ground; 40 amps. The 50 Hz units are shipped without a power connector.

6.4.2 EMERGENCY POWER OFF (EPO) CABLE

The EPO cable permits remote power control of the tape subsystem from the processor.

6.4.3 CHANNEL BUS AND TAG CABLES

The channel bus and tag cables are the interface through which the TCU and channel exchange control and data signals. Refer to Table 6-2 for cable lengths. All lengths are given in feet (100 feet = 30 meters).

6.4.4 COMMUNICATOR CABLES

The communicator feature (Section 1.7, item 5) requires two cables to transfer information between both subsystem TCUs, thus allowing either TCU to address any tape unit within the subsystem.

6.4.5 TCU-TU INTERFACE CABLES

The TCU to TU interface cables are internal to the tape subsystem. Raised floor access is not required to lay these cables. Each tape unit is radially connected to the control unit; daisy-chained connections are not permitted.

Table 6-2. Channel Cable Length Restrictions

System	Channel	Maximum Cable Length	
		75 IPS	125 IPS
360/50	SEL	200 ¹	200 ¹
360/65-67 ²	2860	200	92
360/75	2860	200	92
360/85	2860 2880	200 200	200 200
360/91	2860	200	92
360/195	2860 2880	200 200	92 200
370/135-138	SEL	200	200
370/145-148	SEL	200	200
370/155-158	BLK MUX	200	200
370/165-168	2860 2880	200 200/350 ³	200 200/350 ³
370/195	2860 2880	200 200	200 200
4331 I	Data Streaming BLK MUX SEL	400 200/350 ³ 200/350 ³	400 200/350 ³ 200/350 ³
4331 II	Data Streaming BLK MUX SEL	400 200/350 ³ 200/350 ³	400 200/350 ³ 200/350 ³
4341	Data Streaming BLK MUX SEL	400 200/350 ³ 200/350 ³	400 200/350 ³ 200/350 ³
<p>1. Limited to channel 1 only. 2. 360/67 operating in 65 mode. 3. First value applies to subsystems configured for the standard interlock mode; second value applies to subsystems configured for the offset interlock mode.</p>			

APPENDIX A

GLOSSARY

---A---

ANSI American National Standards Institute

---B---

bit A ONE or a ZERO written in a single track of the nine-track recording tape

BOT Beginning of tape; load point; the physical point on tape marked by a reflective marker on the non-oxide side of the tape.

bpcm Bits per centimeter

bpi Bits per inch

BTU/hr British thermal units per hour

byte A group of nine bits (eight data bits plus a parity bit) written on tape as one bit per track.

---C---

cm Centimeter

cm/s Centimeters per second

CSA Canadian Standards Association

---D---

data Group of encoded data bytes recorded on tape.
block Nondata characters are also included in a data block (ie., preamble, postamble, etc.).

---E---

EMC Electromagnetic Compatibility
EMI Electromagnetic Interference
EOT End of tape; the non-recordable area of the tape, beginning with the leading edge of a reflective marker placed on tape (EOT marker) and extending to the physical end of the tape.
EPO Emergency power off

---F---

FE Field Engineer; trained and qualified service personnel.
file A group of data blocks recorded on magnetic tape. Tape marks separate different files.

---G---

GCR Group-coded recording; a format for recording information on magnetic tape.

---H---

Hz Hertz; cycles per second

---I---

IBG Interblock gap; an area of magnetic tape that is dc erased. An IBG precedes each data block. A tape mark IBG precedes each tape mark.
IEC International Electrotechnical Commission
I/O Input-output; information transmission from channel to device or from device to channel.
IPL Initial Program Load

ips Inches per second

---K---

KB Kilobyte

KB/s Kilobyte per second

KCal/hr Kilocalorie per hour

kg Kilogram

kVa Kilovolt-ampere

---L---

LED Light-emitting diode; used as an indicator

---N---

NRZI Non-return-to-zero-indicated; a format for recording information on magnetic tape.

---p---

PDA Power distribution assembly

PE Phase encoded; a format for recording information on magnetic tape.

PF Power Factor

PN Part number

---R---

record See data block

---T---

TCU Tape control unit; the tape unit controlling and formatting/deformatting portion of the tape subsystem.

TU Tape unit; the tape drive portion of the tape subsystem.

---U---

UL Underwriter Laboratories; an independent testing and approval agency.

---V---

Vac AC voltage

VDE Verband Deutscher Elektrotechniker; German agency analogous to UL.

39XX Storage Technology Model 3910 or 3920 Detached Diagnostic Device.

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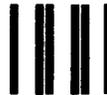
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