This PDF contains the contents of a folder from the Wang 2200 development group, labeled

Cipher Streaming Cartridge Tape Drive

It contains manuals from Cipher, as well as some internal Wang memos and specifications.

STREAMING CARTRIDGE TAPE DRIVE

STREAMING CARTRIDGE TAPE DRIVE

Overview

The Streaming Cartridge Tape Drive (SCTD) subsystem is designed as a mass storage backup and recovery device for Wang PC and APC systems equipped with Winchester disk drives and supported by the MS-DOS operating system. Cartridges allow up to 43MB on a quarter-inch magnetic tape at data transfer rates of 5.2MB per minute. The tape drive subsystem attaches to the APC/PC via a cable that plugs into a controller card installed in the APC/PC chassis. Controller cards can be purchased separately to enable users with multiple APC/PCs to share one SCTD subsystem. The SCTD subsystem allows users to backup and restore entire disk volumes or individual directories or files on a single user APC/PC, as well as on multiple APC/PCs attached to the LIO.

Highlights

- MS-DOS 2.01 or higher operating system support.
- A tape streamer provides faster, more efficient Winchester backup than diskettes. A 30MB Winchester can be backed up on a single tape cartridge.
- Backup and restore support through the LIO provides the user with the flexibility to backup and restore volumes, files or directories from several PCs on a single SCTD subsystem.
- The SCTD subsystem is portable and can be shared among multiple PC users. The Controller Cards are sold separately, making it possible to install cards in several PCs. This facilitates the sharing of one SCTD subsystem through a detachable interface cable.
- A 450 foot tape cartridge can store the contents of an entire 30MB Winchester at less than half the cost of the 90 floppy diskettes required to backup the same 30MB Winchester to diskette.
- Continuous backup operation enables the user to initiate the backup of an entire volume and run it to completion unattended.
- The user can select which files are to be restored, using the selection backup feature.
- Only the files modified since the last backup may be selected for backup, using the selective backup feature.
- Multiple volumes (up to 16 volumes) can be selected for backup, allowing the user to backup partitioned Winchesters on one cartridge (up to the capacity of the tape cartridge).

Product Description

The Model PC-PM038-1 Streaming Cartridge Tape Drive is a nine track streaming tape drive which records 8000 bits per inch at 90 inches per second, allowing data transfer rates up to 5.2MB per minute. The quarter inch wide tape is packaged in a 450 foot cartridge, which stores a complete 30MB Winchester.

The magnetic tape winds on two hubs in a protective plastic shell. A cover automatically closes over the tape surface when the cartridge is removed from the drive to protect the tape in storage. A write-protect selector can be engaged to prevent a tape from being overwritten or erased by mistake. Additional tape cartridges are available from Wang Direct.

By minimizing the number of interblock gaps, this technique enables more efficient utilization of the tape for data storage.

The PC-PM038-C Controller Card is installed in an option slot of the Wang APC/PC Chassis and connects to the tape drive with a 9 foot long twisted pair cable. The card includes a 50-pin connector to accept the connector on the cable. A loopback connector and diagnostic diskettes are included with the SCTD to test the card for proper operation independently of the tape drive.

The SCTD is supported by a specialized menu driven utility software which is included with each Controller Card. Complete instructions on operating the software (accessed through a menu pick) are included.

Product Strategy

By offering the controller card independently from the tape drive, Wang Laboratories enables multiple PC and APC users without LIO to share the backup facilities of a single device. The high density of the tape and the size of the cartridges will enable users to copy large amounts of data from Winchester disk volumes to single tape cartridges. The high speed of the device will make backup an efficient part of normal operations. This will result in time savings and a higher degree of security against loss of data. By supporting backup and recovery via the LIO, APC/PC users with LIO are able to take advantage of having one SCTD to support their backup requirements.

Configuration Requirements

The Model PC-PM038-1 Streaming Cartridge Tape Drive requires a PC-PC038-C Controller Card to be installed in the APC/PC chassis. For performance reasons, the software utilities will run only with 256KB or larger systems . The utilities work best when user memory is available for buffers. The software utilities will run with MS-DOS 2.01 or higher.

Since the tape drive has its own built in power supply, it will run on either the 5-or 8-slot PC and APC chassis.

Support Policy Information

The PC Streaming Cartridge Tape Drive is covered by the standard PC/APC warranty on hardware maintenance, and the standard PC/APC support policies. Refer to the Field Technical Support Policy for detailed information on the standard PC/APC maintenance and support policies. Telephone support will be provided by the Customer Action Line (CAL) formally PCAC. The PC Streaming Cartridge Tape Drive comes with complete user documentation.

Auto Enclosures

MODEL PC-PM038-1 STREAMING CARTRIDGE TAPE DRIVE

PART NUMBER	DESCRIPTION
PC-PM038-C	Controller Card
715-0206A	Option Card Installation Instructions
715-0266	SCTD User's Manual
715-0265	SCTD Installation Instructions
715-1227	Blank Tape Cartridge (450 feet)
734-0233	SCTD Utilities Diskette
732-0022-F	PC Diagnostic Diskette
732-8015-A	PC Diagnostic Diskette
715-0222	PC Diagnostic Instructions
421-0043	Loop Back Connector
286-0028	Screwdriver Set
714-0076	Read Me First Letter

MODEL PC-PM038-C CONTROLLER CARD

PART NUMBER	DESCRIPTION
210-9079	PC Board Controller Card
715-0206A	Option Cards Installation Instructions

Product Specifications

Power Supply:	65 Watts
Cables:	9.0 ft. (2.7M) twisted pair data cable 7.0 ft. (2.1M) power cable
Connector:	50-pin parallel
Dimensions:	
Height:	6.57 inches (16.69 cm)
Width:	11.38 inches (28.91 cm)
Depth:	15.81 inches (40.16 cm)
Weight:	22.5 lbs. (10.21 kg)
Recording Density:	8000 bpi
Physical tracks:	9
Tape Speed:	90 inches per second (IPS)
Transfer Rate:	86.7 KB/second at 90 IPS
Recording Mode:	Single track serpentine (read after write)
Power Requirements:	115 VAC, 50/60Hz (domestic) 220 VAC, 50/60Hz (International)
Operating Environment:	
Temperature:	44° F to 82° F(5°C to 28°C)
Relative Humidity:	20% to 80%, non-condensing

Pricing and Availability

Refer to the Pricing and Availability Sections of the APC Product Announcement in this FOCUS Special Edition for Streaming Cartridge Tape Device and Controller Card model numbers and availability. Detailed pricing information is provided in the Pricing section of this FOCUS Special Edition.

Questions and Answers

Q1. Can the Streaming Cartridge Tape Device (SCTD) be used for APC back-up?
A1. Yes, the Streaming Cartridge Tape Device should be positioned as the back-up solution for the Wang APC. However, the SCTD is not supported under XENIX or IN/ix. This device will back-up 43MB of data on tape cartridges.

Q2. Is the Streaming Cartridge Tape Device also supported on the PC?
A2. Yes.

Q3. Which MS-DOS version supports the Streaming Cartridge Tape Device?
A3. MS-DOS 2.01 or higher is needed. Since APC Single User Software 2.5 (MS-DOS 2.11 based) is included with all pre-configured APC systems, this requirement is met. The SCTD is not supported under XENIX or IN/ix.

Q4. What is the minimum PC/APC memory configuration required to support the SCTD?
A4. The minimum PC/APC memory requirement is 256KB to provide maximum performance on the SCTD.

Q5. What is the maximum capacity that can be stored on a tape cartridge?
A5. Currently, a user can store up to 43MB of data on one cartridge.

Q6. Is the SCTD supported on the PC/APC Local Interconnect Option?
A6. Yes, the SCTD does support back-up and restore facilities on the Local Interconnect Option under MS-DOS. One or more Winchester drives may be selected for back-up on one tape cartridge. This allows the user to back-up MS-DOS files from several PC/APCs without physically detaching the SCTD.

Q7. Can multiple PC/APC users without the Local Interconnect Option purchase the SCTD and use it to back-up and restore multiple PC/APCs?
A7. Yes. The controller board (PC-PM038-C) for the SCTD is available as a separate option for this reason. Each user wishing to use the SCTD must purchase the Streaming Tape Controller. This controller takes up one slot in the PC/APC chassis. By physically detaching and attaching the SCTD to the PC/APC that the user wishes to back-up/restore, one SCTD may be used on several PC/APCs.

Q8. What is the maximum MS-DOS Winchester partition size that may be backed-up?
A8. The maximum Winchester partition size that can be backed-up is 32MB.

Q9. Does the SCTD support multiple MS-DOS partitions?

A9. Yes, the user may select up to 16 partition requests prior to proceeding with the actual back-up. The total partitions selected for back-up may not exceed the size (43MB) of the tape cartridge selected. For example, let's assume that a 30MB Winchester drive has been partitioned into three 10MB logical partitions (Partitions One, Two and Three). All three partitions may be backed-up onto one cartridge. With one back-up request, all three partitions may be backed up simultaneously. However, if the user wishes to back up each partition separately, three separate back up requests must be initiated. In addition, three tape cartridges will be required.

The recommended method for utilizing the SCTD is for the user to select all the partitions to be backed up prior to proceeding with the actual back up. As mentioned above, the total number of partition back up requests may not exceed sixteen, nor the capacity of the tape cartridge (43MB).

Q10. Does the SCTD support Selective Back-up?

A10. Yes. All files modified since the last back-up can be selectively backed up on a separate tape cartridge.

Q11. Does the SCTD support Selective restore?

A11. Yes. The user can select from One to All files to be restored.

Q12. Is the SCTD supported under XENIX and/or IN/ix?

A12. No. The SCTD is only supported under MS-DOS.

cipher® data products, inc.

Series 540 ¼" Cartridge Tape Drive

5¼" Form Factor — 45 and 55 MB Capacity

Winchester Disk Backup

Cipher's family of QIC-compatible ¼-inch streaming cartridge tape drives was designed specifically for backup of Winchester disks, using either the DC300XLP or the DEI 555 cartridge. These products provide the capability for backing up 45 or 55 Megabytes of data at a rate in excess of 4.5 Megabytes per minute. They are available in either the 5¼-inch form factor or the 8-inch form factor, and either formatted or unformatted.

The use of read-after-write recording technology allows the tape drive to detect and correct errors automatically without host system intervention, thus off-loading these tasks from the host processor. An interface line provides optional parity checking during data transfer to and from the host system.

Standardization

The Model 540 cartridge tape drives provide the maximum degree of standardization. They use either DC300XLP (or equivalent) or DEI 555 media. The recording format is in full accordance with the QIC-24 standards as submitted to ANSI and ECMA. The available interfaces include a formatted interface in full compliance with the QIC-02 standards and a basic unformatted interface in full compliance with QIC-36. Systems, therefore, now have the advantages of data interchange, multiple product sourcing, and multiple source media availability. All 540 Series products provide full data interchange with all other 540 Series products and with any other cartridge tape drive that fully complies with the QIC-24 standards, making program and data distribution between user sites now feasible.

Program distribution is further simplified due to the large capacity of ¼-inch cartridge tapes. With the 540 products, software distribution no longer requires a "box full of floppies".

Mechanical Integrity

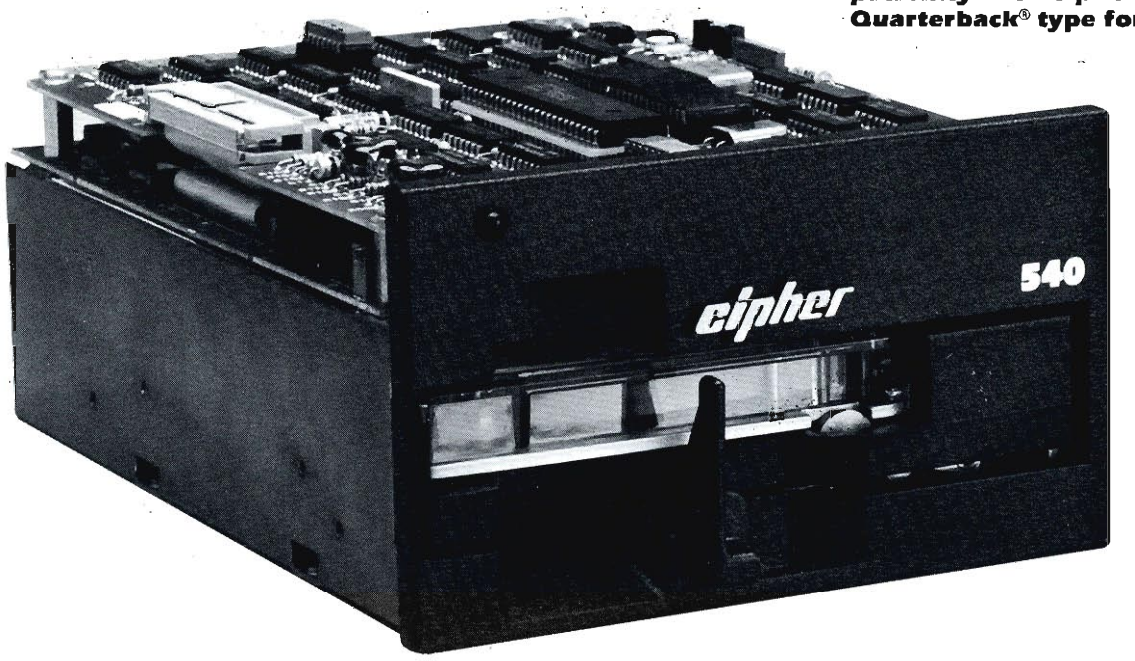
Media interchange can only be accomplished when steps are taken to ensure the utmost repeatability in head positioning. The physical relationship between the cartridge, the head, and the EOT/BOT sensor is of utmost importance. This relationship is best established during the manufacturing cycle. The use of a rotating subdeck assembly allows these three critical elements to be aligned optically in the factory. This relationship is then never disturbed by the relative motion of either the cartridge, the head, or the sensor, with respect to each other.

Since a wide variance of cartridge tolerances can be encountered, Cipher has designed a custom, brushless DC motor specifically to maximize the power efficiency and yet to provide the necessary torque to maintain the tape speed over wide variances of cartridges.

The head positioner is designed with high lubricity components, resulting in extremely low friction. This allows the use of a very small, low-powered stepper with minimum input power.

All of the major structural and critical interfacing components are die-cast to provide repeatability and long life. The extensive use of LSI components minimizes the component count necessary to maintain the long-term reliability of the 540.

- ☐ **Form factor: 5¼-inch form factor (optional 8-inch form factor)**
- ☐ **Capacity: 45 or 55 megabytes formatted**
- ☐ **Power: +12 and +5 VDC (optional +24 and +5 VDC)**
- ☐ **Speed: 90 inches per second**
- ☐ **Interface: QIC-02, or QIC-36**
- ☐ **Recording Format: QIC-24**
- ☐ **Front Loading: for user convenience**
- ☐ **Compatibility: read compatibility with Cipher Quarterback® type format**



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Lee W. Payne
Application Engineer

Series 540 Cartridge Tape Drive Specifications

Drive Performance

Capacity (Formatted)
- 45 MB (DC300XLP, or equivalent)
- 55 MB (DEI 555)

No. Recorded Tracks
- 9 tracks

Recording Mode
- read-after-write
- single track serpentine

Data Transfer Rate
- 87 Kbytes/sec. avg.

Tape Speed
- read/write
  - 90 IPS
- rewind
  - 90 IPS

Data Block Transfer Time
- 5 ms*

Start/Stop Time
- 350 ms

*To maintain streaming

Environmental (Operating)

Temperature
- +5°C to +45°C

Relative Humidity
- 20% to 80% non-condensing
- 26°C max. wet bulb

Altitude
- −200 ft. to +10,000 ft.

Data Integrity

Read Error (Recoverable)
- less than 1 in 10^8 bits

Read Error (Non-Recoverable)
- less than 1 in 10^{10} bits

Interface Parity
- optional

Error Detection
- CRC

Power

DC Voltage
- +12 VDC ±5%* @ 1.0 Amp (typical)
  @ 2.6 Amp (max.)
- +5 VDC ±5% @ 1.5 Amp (typical)
  @ 2.2 Amp (max.)

*Optional:
- +24 VDC ±10% @ 1.3 Amp (max.)

Power Dissipation
- 19.5 Watts, nominal ≙ 66 BTU/hr
- 42.2 Watts, maximum ≙ 143 BTU/hr

Physical Characteristics

5¼-inch Form Factor (540)
- Depth: 8.0 inch (203 mm)
- Width: 5.75 inch (146 mm)
- Height: 3.25 inch (826 mm)
- Weight: 4.5 lbs (2.0 Kg)

8-inch Form Factor (440)
- Depth: 9 inch (229 mm)
- Width: 8.55 inch (217 mm)
- Height: 4.5 inch (114 mm)
- Weight: 5.0 lbs (2.25 Kg)

Front Loading

Media

¼-inch Standard 3M Tape Cartridge
- DC300XLP, or equivalent
  - 45 MB capacity
- DEI 555
  - 55 MB capacity

Interface

QIC-02 as proposed to ANSI and ECMA or QIC-36 (540B)

Format

QIC-24 as proposed to ANSI and ECMA

Compatibility Mode

Cipher Quarterback® type format cartridges can be read on the 540 or 440 cartridge tape units.

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Series 540
Cartridge Tape Drive
Product Description

cipher® data products, inc.

FRONTISPIECE

This equipment generates and uses radio fequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interefence by one or more of the following measures:

*Reorient the receiving antenna

*Relocate the computer with respect to the receiver

*Move the computer away from the receiver

*Plug the computer into a different outlet so that computer and receiver are on different branch circuits

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SECTION I

GENERAL DESCRIPTION

INTRODUCTION

The 540 and 440 are innovative 1/4-inch cartridge tape products manufactured by Cipher Data Products, Inc. The only difference between the 540 and the 440 is the size. The 540 is built to the 5 1/4-inch form factor; the 440 to the 8-inch form factor. For this reason, except for discussions of size, information on the 540 is applicable to both products.

The 540 is a low-cost, high-performance streaming tape drive capable of storing up to 45 megabytes of (formatted) data on a standard 450-foot, 1/4-inch tape cartridge or up to 55 megabytes on a 555-foot cartridge. The drive operates on +5 volts and 12 volts or, optionally, on +5 volts and 24 volts. The specifications for the 540 can be found in Appendix A.

The 540 is available as a full formatted drive or as a basic unit without a formatter. The basic unit is explained in Appendix B. The 540 with an integrated formatter conforms to the Quarter Inch Committee's QIC-02, Revision D, Intelligent Interface Standard and QIC-24, Revision D, Data Interchange Format Standard agreed upon by the industry and proposed by 1/4-inch cartridge tape drive manufacturers to the American National Standards Committee (ANSC).

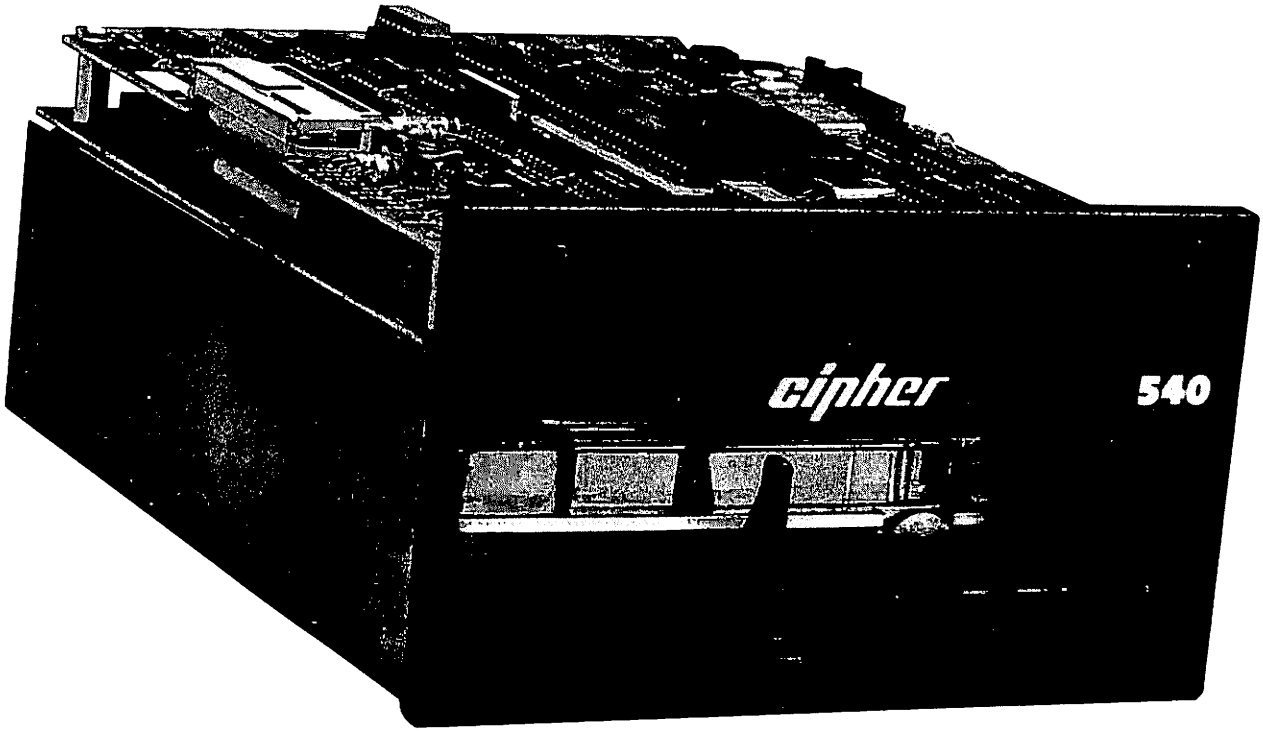


Figure 1. Cipher's 540 1/4-Inch Tape Drive

The form factors are also standard. The 540 has a mounting structure identical to the industry standard 5 1/4-inch floppy disk or Winchester drives. The 440, the same in all other respects as the 540, is housed in an add-on 8-inch frame assembly which makes it identical to the industry standard 8-inch floppy disk drive's mounting structure. Both drives are designed for horizontal or vertical rack mounting to provide system integrators with maximum flexibility.

The 540 functions in a streaming mode. The advantages of tape streaming over conventional start/stop tape operation are simplified mechanics and a highly efficient use of the tape. Basic drive functions are microprocessor controlled and a second microprocessor, an integral part of the intelligent formatter, controls the overhead functions of tape formatting. This formatter microprocessor also provides the QIC-02 compatible interface which can be adapted easily to the requirements of most host systems.

Because of simplified streaming mechanics and the elimination of the long start/stop Inter-Record Gap lengths, the 540 is a low-cost, high capacity drive that is particularly well suited to backing up Winchester disks.

PHYSICAL DESCRIPTION

General

The 540 consists of these component parts:

- Die-cast aluminum substructure
- Unique cartridge loading and seating mechanism
- Vertical head-positioning stepper motor
- Bi-directional Read/Write head assembly
- Separate full-width Erase bar mounted on the head
- Brushless direct drive DC capstan motor
- BOT/EOT photosensing assembly with Write-Protect and Cartridge-In-Place sensing switches
- Printed circuit board (pcb) with microprocessor control of basic drive operations
- Microprocessor controlled formatter (optional) which provides QIC-24, Rev. D, formatting and QIC-02, Rev. D, interfacing

Aluminum Substructure

The die-cast aluminum substructure provides the structural rigidity necessary to support the major mechanical assemblies. It also maintains the required mechanical tolerances to which the drive was designed. These tolerances are required, to maintain the QIC-24 interchange specifications for track position, and assure the interchangeability of cartridges.

Cartridge Loading & Seating Mechanism

The cartridge tray loading mechanism is activated by a front-mounted lever. Capable of a 90 degree rotation, the lever is moved to the vertical position to lock the cartridge in place. In the horizontal position, it allows removal or insertion of the cartridge. When the loaded cartridge and the tray are pressed gently back into the unit, the cartridge-protect door is opened. Then, when the cartridge and tray are pressed home, the lever can be rotated to the lock position. This causes the cartridge to be located by three registration point deck pins, as per the ANSI specification. This procedure automatically seats and holds the cartridge in the best position relative to the Read/Write head and other pertinent assemblies.

Head-Positioning Motor

Head positioning is done by an unipolar four-phase stepping motor. This motor is controlled bi-directionally by a driver circuit which is controlled by the main pcb microprocessor.

Read/Write Heads

There are two Read head gaps to accommodate the bi-directional Read operation required for serpentine recording. In addition, there are two Write head gaps to accommodate bi-directional writing. One head gap records in the forward direction and the other records in the reverse direction. Tracks are recorded sequentially as shown in Figure 2. Even-numbered tracks are recorded forward and odd numbers in reverse, using the serpentine method.

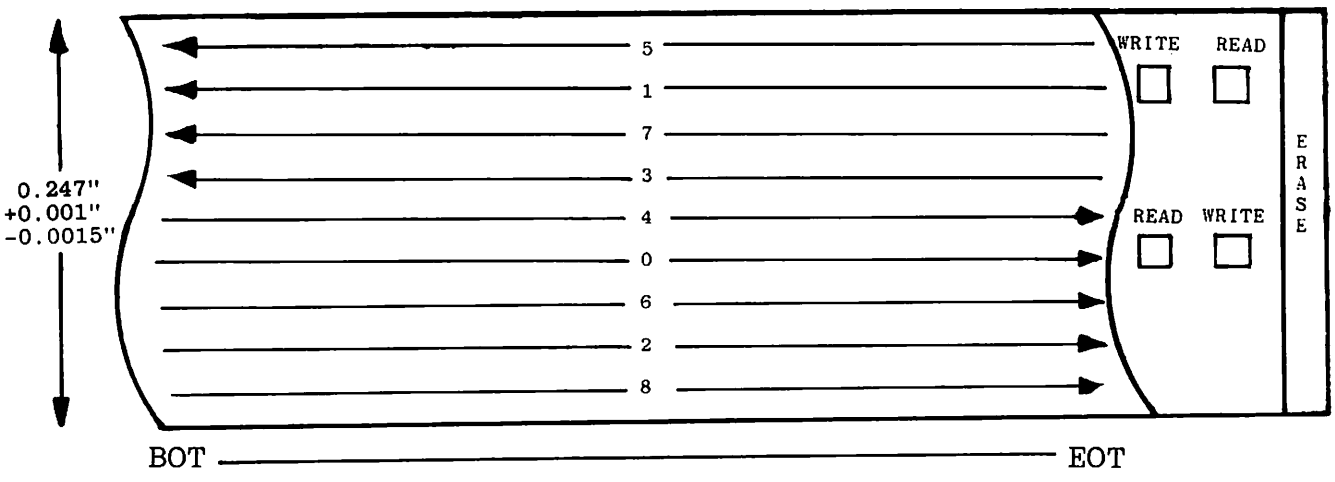


Figure 2. Tape Tracks With Read/Write Heads

Erase Bar

A full width Erase bar is mounted on the head assembly. The erase operation is controlled separately and can be used when these three conditions exist: (1) the unit is recording on track 0, (2) the cartridge is not on safe, and (3) the head is not being repositioned.

DC Capstan Motor

The tape is driven by a long-life brushless DC three-phase motor. The speed of the motor is controlled by a tachometer derived from three Hall-Effect motion position sensors. The motor, driving a 5/8-inch capstan, is capable of accelerating the tape cartridge to running speed in 350 ms.

BOT/EOT Photosensing Assembly

This assembly senses holes punched through the tape. The sensing is accomplished by illuminating the back of the tape with Light Emitting Diodes (LEDs) and recognizing the light with two photo transistors.

Main Printed Circuit Board

The main pcb assembly performs:

- Tape speed control
- Head positioning control
- BOT/EOT detection
- Read/Write/Erase signal processing

An integrated microprocessor controls the tape direction, head positioning, and detection of the tape holes.

The main pcb provides the basic interface between the physical drive and the formatter control board.

Formatter Printed Circuit Board

This optional formatter is a pcb that fits inside the 540 form factor. It provides the QIC-02 interface and QIC-24 block formatting.

The formatter board contains independent Read and Write control circuitry, four 4,096-bit data buffers, a host interface, a tape drive interface, and a microprocessor. The formatter performs three major functions by: (1) recognizing and formatting data written to, or read from, tape, (2) multiplexing a 16K x 1-bit memory into four 4,096-bit data buffers, and (3) providing control and handshake signals for the interface.

FUNCTIONAL DESCRIPTION

Introduction

The 540 drive functions in a streaming mode with a data density of 8,000 bits per inch (bpi). Recording is done in a bit serial recording format, using a serpentine stream configuration illustrated in Figure 3. This illustration, for the sake of clarity, shows only four tracks. The actual nine track recording continues this sequential pattern.

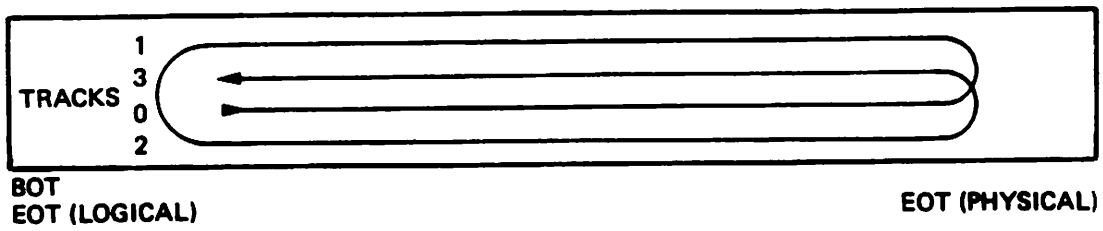


Figure 3. Serpentine Recording Format

Data is encoded to (0,2) Run Length Limited (RLL) code and recorded at 10,000 flux changes per inch (fci) on the nine tracks. The streaming format provides constant tape motion and very short interblock gaps with minimal format overhead. This format maximizes data throughput efficiency. To take full advantage of the streaming format, the host system must maintain a constant data transfer rate, so the 540 is not forced to stop and reposition.

The advantages of streaming over the conventional start/stop operation can be explained most easily by tape use efficiency, which is the ratio of data record length to Inter-Record Gap (IRG) length, plus data record length.

In conventional start/stop drives, data is stored in records that can be accessed individually and updated. To preserve this update capability, the tape must stop and start between each record. This start/stop function requires the incorporation of a rather long IRG between the records. The length of these IRGs must be considered in the trade-offs of tape use efficiency versus data accessibility.

Although conventional drives provide sequential access to individual records, their tape use efficiency is typically low, because of the long IRGs. The ratio of record length to record length plus IRG can vary from 20 to 80 percent; but at 80 percent, the data record length is about four kbytes, so the advantages of having short individual records are lost.

Tape use efficiency is also proportional to the tape drive data throughput rate; therefore, tape use efficiency is greater for applications that do not require updating of individual records.

In the 540, maximum tape use efficiency, which includes very short IRGs and constant-speed tape motion, can approach 100% and so, at 90 ips, a data throughput of 45 mb can be achieved easily in only slightly more than nine minutes.

Tape Cartridge Description

The 540 uses a 4 x 6-inch data recording cartridge that conforms to ANSI specifications X3.55-1977 and X3B5.82-89 for unrecorded cartridges. The cartridges are available in both 450-foot (3M DC300XL, or equivalent) and 555-foot lengths.

The 1/4-inch wide magnetic tape is wound on two coplaner hubs. The hubs are driven by an internal drive belt which is coupled by an internal belt capstan. The capstan is driven by the 540 capstan roller and drive motor assembly. This configuration is illustrated in Figure 4.

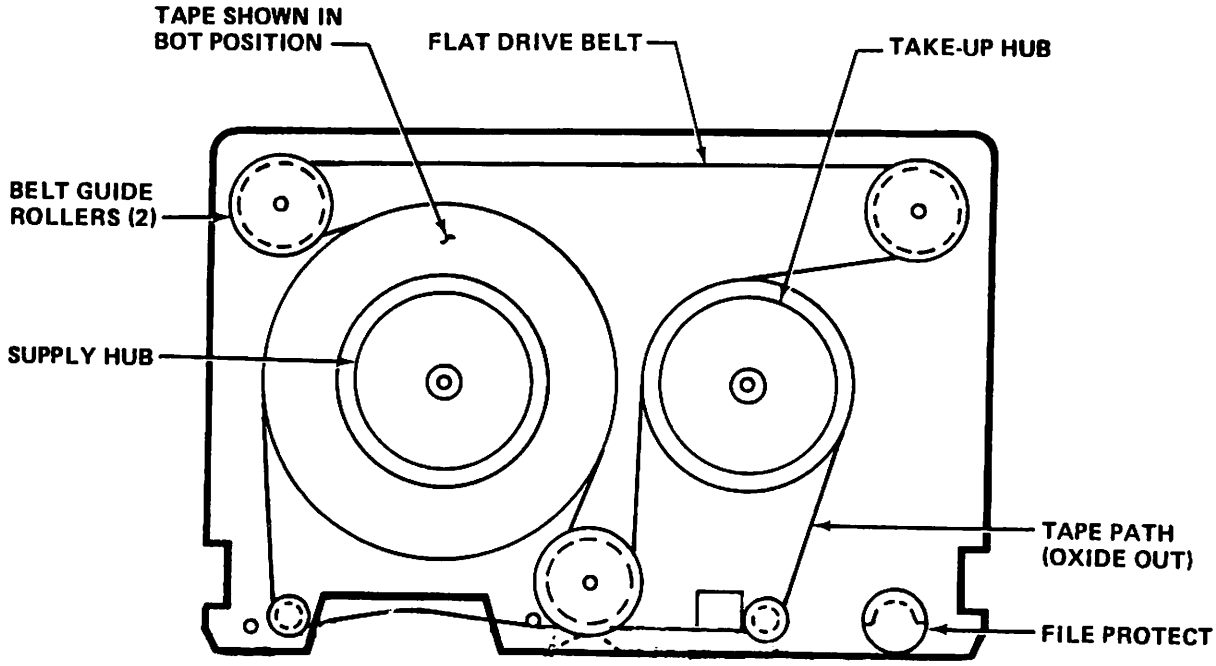


Figure 4. Tape Cartridge Configuration

SECTION 2

PRODUCT FEATURES

INTRODUCTION

The 540 provides high-performance backup for fixed-disk applications. The advantages of the 540 include:

- Low original cost and low maintenance costs
- Storage of up to 45 megabytes (mb) or 55 mb of formatted data
- 5 1/4-inch or 8-inch form factors with mounting holes
- Integrated formatter providing transparent error detection and correction and 4 x 512-byte buffering
- 12V, +5V or 24V, +5V power source adaptibility
- Backup of 45 mb at 90 ips in approximately nine minutes
- Conformance to QIC-02, Revision D and QIC-24, Revision D standards
- Internal self-test diagnostics using QIC-02 commands
- Optional data bus parity bit check and generation
- Cipher Quarterback^{TM} tape Read capability

INTELLIGENT TAPE DRIVE

The 540 intelligent tape drives provide the low-cost solution to backing up the smaller rigid disk drives. The 540 is designed with two microprocessor controlled pcbs: the formatter and the basic tape drive board.

Microprocessor-Controlled Formatter

The optional formatter board performs these functions:

- QIC-02 interfacing
- QIC-24 block formatting
- Drive selection
- Reading status
- Tape retension
- Tape erasing
- Tape writing
- Tape reading

Host Interface Control

A 8051 microprocessor controls the host interface and a single 48-pin CMOS gate array of 1,500 gate complexity. This microprocessor interprets host commands and input control lines; contols tape motion, track positioning, Write and Read sequences; and interprets the status of the basic drive. With output control and status lines, the microprocessor also controls date transfer to, and from, the host.

Data Transfer Control

The gate array is the main component in the data transfer between the basic drive and the host interface. It controls the 16K X 1-bit RAM, which is used as a 4-block data buffer between the host and the drive. The gate array also provides internal status to the microprocessor during Read/Write sequences. The gate array receives serial data from the on-board formatter phase lock loop, and stores if sequentially in the 16K X 1 RAM during a Read sequence. The block address bytes are saved, and CRC is verified. Then, the data is transferred from RAM through the gate array; assembled in parallel bytes; and transferred to the host. During a Write sequence, the host data is converted from parallel to serial; transferred through the gate array to the RAM; and, then, written serially to the tape with the appropriate format parameters and CRC.

MAIN DRIVE PCB

The main pcb assembly performs these functions:

- Tape speed control
- Head positioning control
- Read/Write signal processing

Tape Speed Controlling

The speed of the tape drive motor is controlled by a tachometer derived from three Hall-Effect motor position sensors. The sensors are processed by a control Programmable Read-Only Memory (PROM) and routed to a frequency-to-voltage converter. The resulting voltage is compared to a nominal value. The difference signal is compared to a sawtooth voltage which, then, generates the motor control voltage.

Head Positioning

Head positioning is done by a unipolar, four-phase stepper motor. It is driven by a microprocessor controlled integrated circuit which applies the proper step and direction controls to step the motor to the required position. The positioning mechanism for the glass and graphite linear bearing used on the 540 is illustrated in Figure 5.

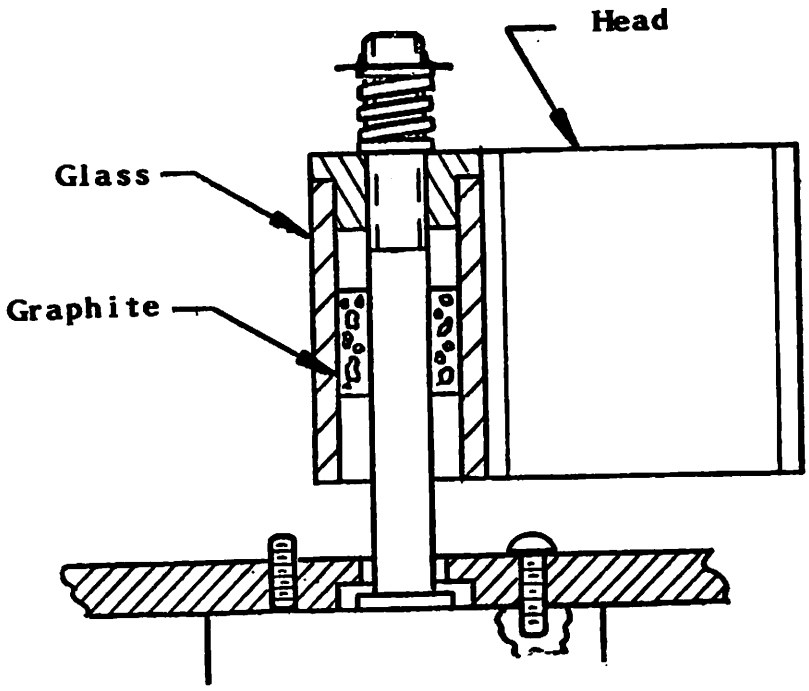


Figure 5. Head Positioning Mechanism

Read/Write/Erase Signal

Separate Write and Erase controls are provided by a 34-pin interface between the formatter and the basic pcb. The Erase operation produces a full-width AC field. Erasing is controlled by the formatter, when recording is being done on Track 0, and during standard Erase command.

The Write operation is made bi-directional by using two Write head gaps. One head gap writes in the forward tape motion direction. The other head gap writes in the reverse direction of the tape. The selected head gap is provided with +12V, regardless of the applied voltage. The selection is made by the TR0 signal provided by the formatter.

Two Read head gaps are provided to accommodate the bi-directional reading required for serpentine recording. The applicable Read head gap is also selected by the TR0 signal.

The dual head gap configuration allows the 540 to perform an internal Read-After-Write check during a Write operation.

RECORDING METHOD

Although magnetic tape is an extremely reliable, cost-effective mass storage medium, even the highest quality tapes are subject to errors caused by small imperfections in the tape oxide coating. Sensitivity to these imperfections, usually a result of manufacturing error or repeated use, is proportional to the recording density. For this reason, the 540 uses the Non-Return-to-Zero (NRZI) recording method to reduce sensitivity to tape imperfection through lower density recording. In the NRZI method, however, the normal 8-bit binary sequence can result in a data pattern with a large number of successive zeros. To preclude the need for Read circuits that require complex data-bit window functions, the 8-bit bytes from the host are converted to a 0,2 RLL code before being written on the tape. This code is reconverted to the NRZI code in subsequent Read operations. The RLL code provides a 10-bit serial stream with no more than two consecutive zeros in any data pattern. It also permits the data stream to be used to track the Read circuits to the data rate, so that speed variations between tape drives do not affect compatibility.

Recording Format

The 540 data format is compatible to the Quarter Inch Committee's standard QIC-24, Revision D.

The 540 does 9-track serpentine recording to cut the data transfer time. As shown previously in Figure 3, even numbered tracks are recorded in the forward tape direction, odd numbered tracks in the reverse tape direction.

All data for interchange is recorded in designated tape areas:

- Even tracks - from Load Point (LP) marker to End-Of-Tape (EOT) marker.
- Tracks 3 and 5 - from the Early Warning (EW) marker to the Beginning-Of-Tape (BOT) marker.
- Tracks 1 and 7 - from the EW marker to the LP marker.

Tracks are recorded sequentially, from 0 through 8.

Data Block Formatting

The data block is formatted as shown in Figure 6.

Preamble	1 Byte	512 Data Bytes	4 Byte Block Address	2 Byte CRC	Postamble

Figure 6. Data Block Recording Format

The preamble is used to synchronize the phase-lock loop in the Read electronics with the data frequency. The preamble is also used to measure the average preamble amplitude. There are three preamble lengths, measured by a range of flux transistions recorded at the maximum nominal recording density of 10,000 flux transitions per inch (fti). These preambles lengths are:

- Normal (120 to 300 flux transitions).
- Elongated (3,500 to 7,000 flux transitions). This preamble precedes the first data block recorded after an underrun.
- Long (15,000 to 30,000 flux transitions). This preamble precedes the first data block for interchange, recorded at the beginning of track 0.

The data block marker identifies the start of the data block.

The data block contains 512 bytes of data for interchange. The data is encoded according to the 0,2 RLL transformation table. (A file mark block has a format identical to the data block, except the data field contains a unique pattern which does not occur in a data block.)

The block address contains four bytes that provide a unique identification for the data block recorded on tape. This address includes:

- The 8-bit track number in byte 0.
- A 4-bit control block in byte 2 that defines the contents of the data block as being user data or file mark (0), control information (1), or reserved (2-15).

  QIC-24 control blocks are not implemented on the 540.
- The 20-bit block address in the other four bits of byte 1, plus bytes 2 and 3. Block addresses are not reset at the end of a track.

See Figure 7 for QIC-24 format parameters.

Cyclic Redundancy Check

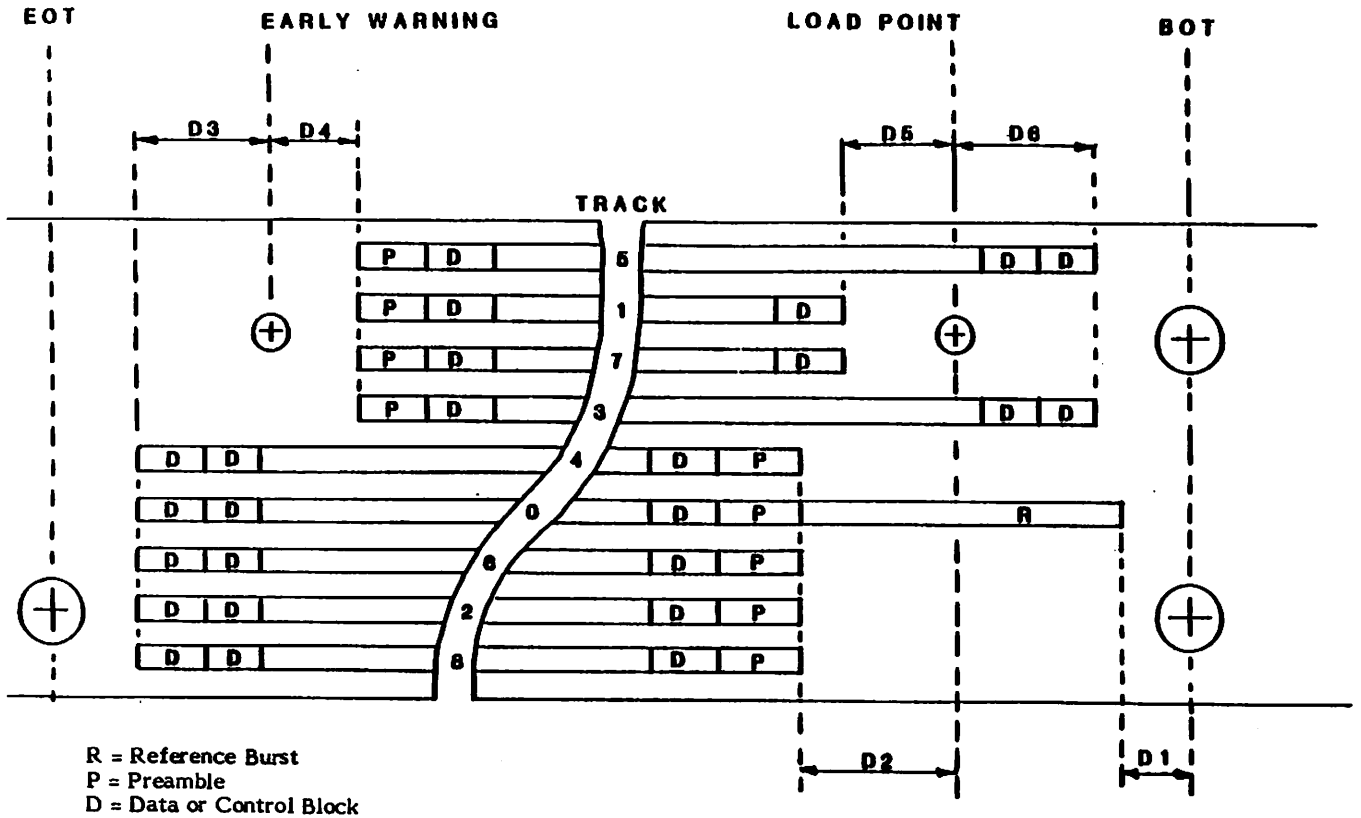
The Cyclic Redundancy Check (CRC) consists of two bytes calculated over the 512 bytes of interchange data and the 4-byte block address. CRC starts with an initial value which is all ones and uses this CRC generating polynomial:

$$X^{16} + X^{12} + X^5 + 1$$

The CRC is encoded, using the 0,2 RLL transformation table.

The postamble is recorded after the CRC and serves as a guard band. The postamble can have two lengths:

- Normal, which is 20 flux transitions at the maximum nominal flux density.
- Elongated (3,500 to 7,000 flux transitions) recorded at maximum nominal flux density following an underrun sequence.



Dimension	Min (in)	Max (in)	Description
D1	0	15	BOT to start of track reference burst
D2	3	4	Load point to end of track reference burst and start of preamble on even tracks
D3	-	36	Early warning to end of data on even tracks
D4	1	2	Early warning to start of preamble on odd tracks
D5	0.1	4	End of data to load point on Tracks 1 and 7
D6	-	27	Load point to end of data on Tracks 3 and 5

Figure 7. QIC-24 Format Parameters

Block Rewriting

If all requirements for a data interchange are not met, the data and file mark blocks are rewritten and tested again by the Read-After-Write operation. The sequence reads block N while block N+1 is being written. If block N does not satisfy the requirements, it is rewritten after the writing of N+1 is completed. If N is now satisfactory, N+1 is also rewritten to preserve the correct sequence. A Block In Error (BIE) is written up to 16 times, before the recording operation is aborted.

Block rewriting also occurs when an underrun, End Of File (EOF), or EOT terminates the streaming operation. In these cases, block N is rewritten until all the interchange requirements are met. Then, after block N is properly recorded, an elongated postamble is written starting at 3,000 flux transistions from the end of the previous block. An elongated preamble is recorded for the next block (N+1).

Termination by an underrun can be prevented by the repeated recording of block N until an EOF or EOT occurs. This forced streaming operation uses only standard length format fields.

SECTION 3

INTERFACING

INTRODUCTION

Data and commands are transferred to, or from, the 540 on an 8-bit bi-directional data bus, using asynchronous handshaking techniques to eliminate tight timing constraints. Up to four devices can be supported by the interface which is compatible with the standard QIC-02, Revision D. The physical interface between the host and the formatter in the 540 is illustrated in Figure 8.

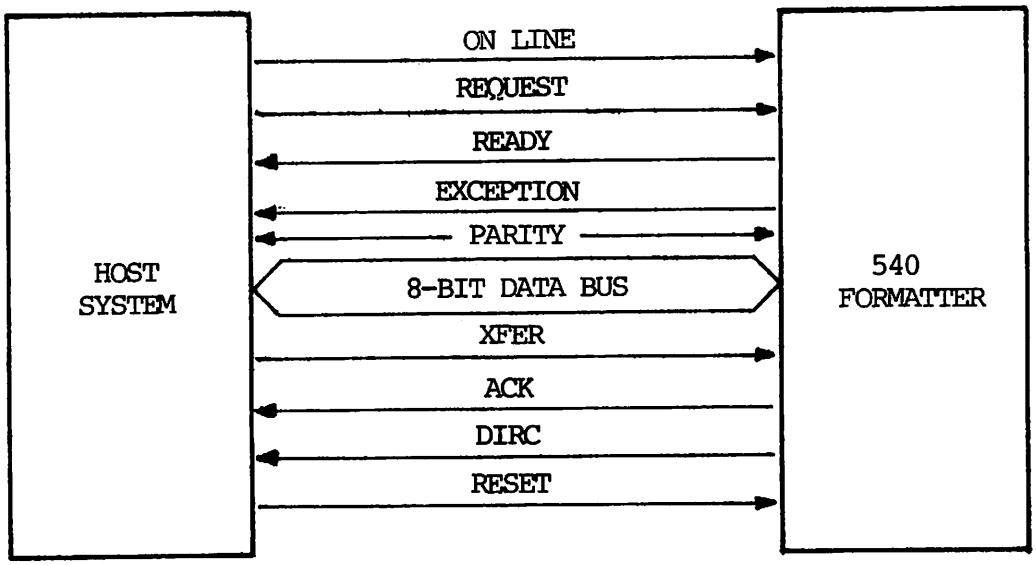


Figure 8. Host/Formatter Interface

ELECTRICAL INTERFACE

The signals are connected through a 50-conductor edge connector. The mating connector is a 3M 3415-0001, or equivalent. The signal cable is a 50-conductor flat ribbon cable, such as the 3M 3365/50. The maximum cable length supported by the interface is 9.84 feet (3 meters).

DC Power Interface

The standard termination is 220 ohms to +5 VDC and 330 ohms to ground, or the Thevenin equivalent. The bi-directional data bus and the four control signals from the host are terminated at the drive, or at the last drive on a daisy chain. The bus and four control signals from the drive are terminated at the host. A typical driver/receiver termination configuration is illustrated in Figure 9.

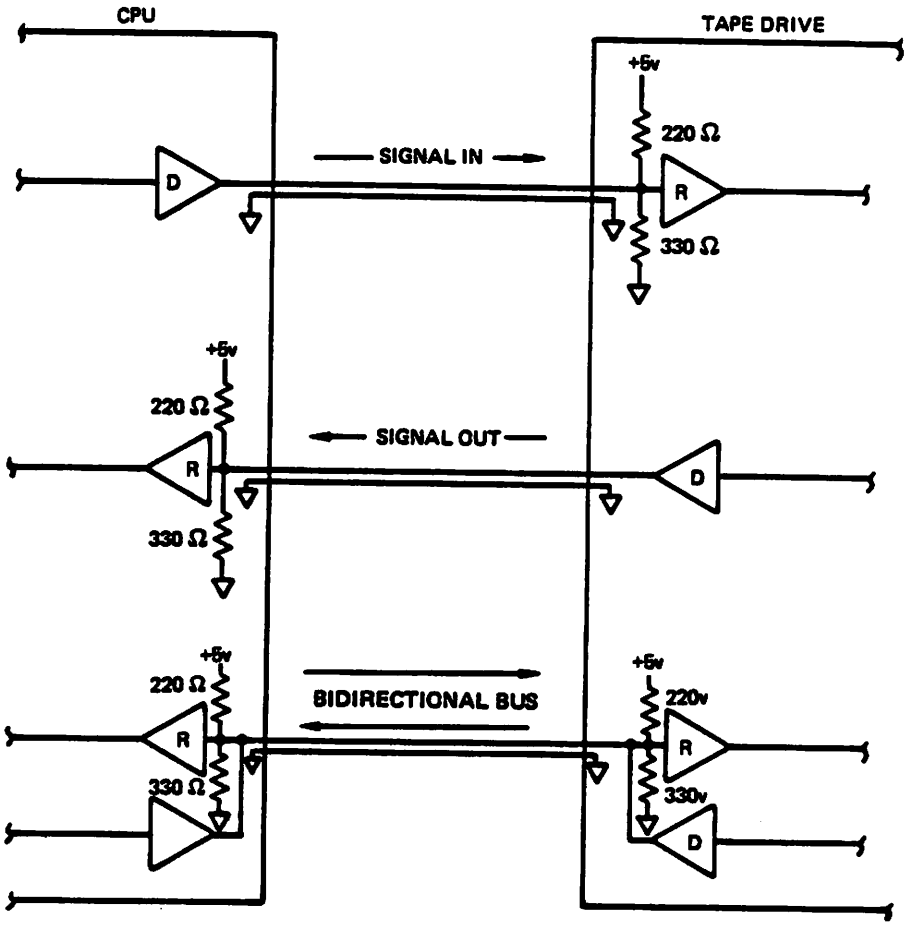


Figure 9. Line Driver/Receiver Termination

Signals loaded by the drive, or the host, onto the interface are no more than 2.0 mA, plus required terminations.

Interface Signal Levels

All signals to the host or to the drive use standard Transistor-Transistor Logic (TTL), as provided in Table 1.

Table 1. Signal Levels

Direction	Logic	0/1	Voltage (VDC)
Drive-----Host	False	0 (high)	2.4 - 5.25
	True	1 (low)	0 - 0.55
Host-----Drive	False	0 (high)	2.0 - 5.25
	True	1 (low)	0 - 0.8

The odd numbered pins are connected to signal ground (gnd). The assignments for the even numbered pins are listed in Table 2. In the "To" column in this Table, X means unused, B means bi-directional, D means drive, and H means host.

Table 2. Input/Output Pin Assignments

Pin #	Name	To	Description
02	N/U-	X	Not Used (N/U) - unconnected signal line
04	N/U-	X	
06	N/U-	X	
08	N/U-	X	
10	HBP-	B	Host Bus odd parity - optional
12	HB7-	B	Host Bus bit 7 - MSB on 8-bit bus
14	HB6-	B	Host Bus bit 6
16	HB5-	B	Host Bus bit 5
18	HB4-	B	Host Bus bit 4
20	HB3-	B	Host Bus bit 3
22	HB2-	B	Host Bus bit 2
24	HB1-	B	Host Bus bit 1
26	HB0-	B	Host Bus bit 0 - LSB on data bus
28	ONL-	D	On Line - Host activates signal before transferring or terminating a Read or Write.
30	REQ-	D	Request - Host activates signal to indicate that, in Command mode, command data has been placed on the data bus. Also used in Status Input mode to indicate status has been taken from the bus. REQ-is used only when RDY or EXC is asserted by the drive.
32	RST-	D	Reset - Initializes the drive with a default selection of drive 0 and the EXC signal is asserted.
34	XFR-	D	Transfer-Host generates signal to indicate, in Write mode, that data has been placed on the data bus. In Read Mode, it indicates that data has been taken from the bus.
36	ACK-	H	Acknowledge - Drive generates signal to indicate, in Write mode, data has been taken from the bus or, in Read mode, placed on the bus.

Table 2 (Continued)

Pin #	Name	To	Description
38	RDY-	H	Ready - Drive generates signal to indicate one of the following: 1. - In Command Transfer mode, data has been taken from the data bus or, in Status Input mode, data has been placed on the bus. 2. - A BOT, Cartridge Initialization, or Erase command has been completed. 3. - Drive is ready to receive the next block or, in Write mode, to receive a Write, Write, File Mark, or Write N File Marks, from host. 4. - In Write File Mark mode, a Write File Mark, or Write N File Marks is completed. 5. - Drive is ready to send next block or, in Read mode, receive a Read, Read N File Marks, or Read File Marks command from the host. 6 - Drive is ready to receive a new command.
40	EXC-	H	Exception - Drive generates this signal when an exception condition exists in the drive. Host must issue a Status command or perform a Status input to determine the cause, and clear the exception.
42	DIR-	H	Direction - Drive generates the signal that, when false, causes the host data bus drivers to assert their data bus levels and drive data bus drivers to assume a high impedance state. If true, the host assumes the high impedance state and the drive asserts its bus level.
44	RES	X	Reserved - Kept for test I/O.
46	RES	X	
48	RES	X	
50	N/U-	X	Not Used - Unconnected signal line.

Functional Interface

The interface signals ONL-, REQ-, AND RST- can, in most cases, be easily generated by the host program, and output to the interface adapter register latches and drivers. Similarly, the drive formatter generated RDY- and EXC- should be input, through receivers, to the host.

Commands are transferred by simply loading each command into a register that is connected, through drivers, to the bi-directional data bus, and implanting the required

control signal protocol with the host program. Status input is similarly implemented by the host. In order to avoid prolonged waits by the host for the formatter to complete a command, the RDY- and EXC- lines are necessary. However, the bi-directional bus control signal DIR- should only be used by the host interface adaptor to enable the host's bus drivers.

540 INSTRUCTION SET

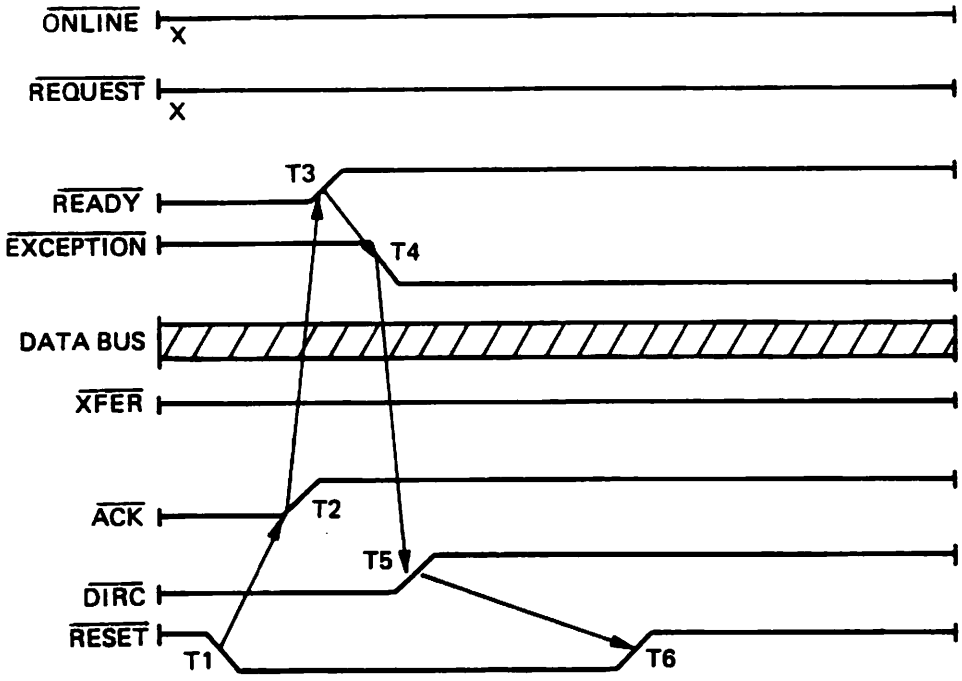
The host and 540 formatter communicate through the 8-bit bi-directional data bus. All transfers are asynchronous and eight bits wide.

The Power On/Reset sequence provides the host with the device-oriented power-on procedure. It also provides a convenient method of initializing the drive during hardware or software debugging of the host's interface.

When the power-on Reset times out, or the RES- pulse terminates; the operating parameters of the 540 initialize. The parameters default to Drive 0 and the QIC-24 format for subsequent commands. Then, Drive 0 becomes active, asserting EXC-, which makes the host issue a Read Status command. Drive 0 reponds with six status bytes, following the Request/Ready handshake illustrated in Figure 17. Bit 0 of byte 1 is set to indicate a power-up or reset.

If there is no Drive 0 on the host/drive interface, all drive-to-host signal drivers should be in the high impedence state, waiting for a Select command for a drive number other than 0.

Following the Reset, the physical drive recalibrates the Read/Write head positioner to Track 0, which causes a delay of approximately three seconds before the execution of any motion command. Read/Write commands, following the reset, begin execution from BOT. Timing for the Reset sequence is illustrated in Figure 10.



Activity	Critical Timing
T1-Host asserts RESET	N/A
T2-Controller disables ACK	T2 < T6 + 100 NSec
T3-Controller disables READY	T1→T3 < 1 uS
T4-Controller asserts EXCEPTION	T1→T4 < 10 uS
T5-Controller disables DIRC	T1→T5 < 10 uS
T6-Host disables RESET	T1→T6 > 25 uS

NOTE: The drive may assert ACK when reset is asserted.

X-Don't Care

Figure 10. Reset Timing Diagram

Table 3, which follows, lists the 540 instruction set grouped in three categories: S for standard commands, O for optional commands, and V for vendor unique commands. Within these categories, the commands are listed according to ascending MSB/LSB numbers.

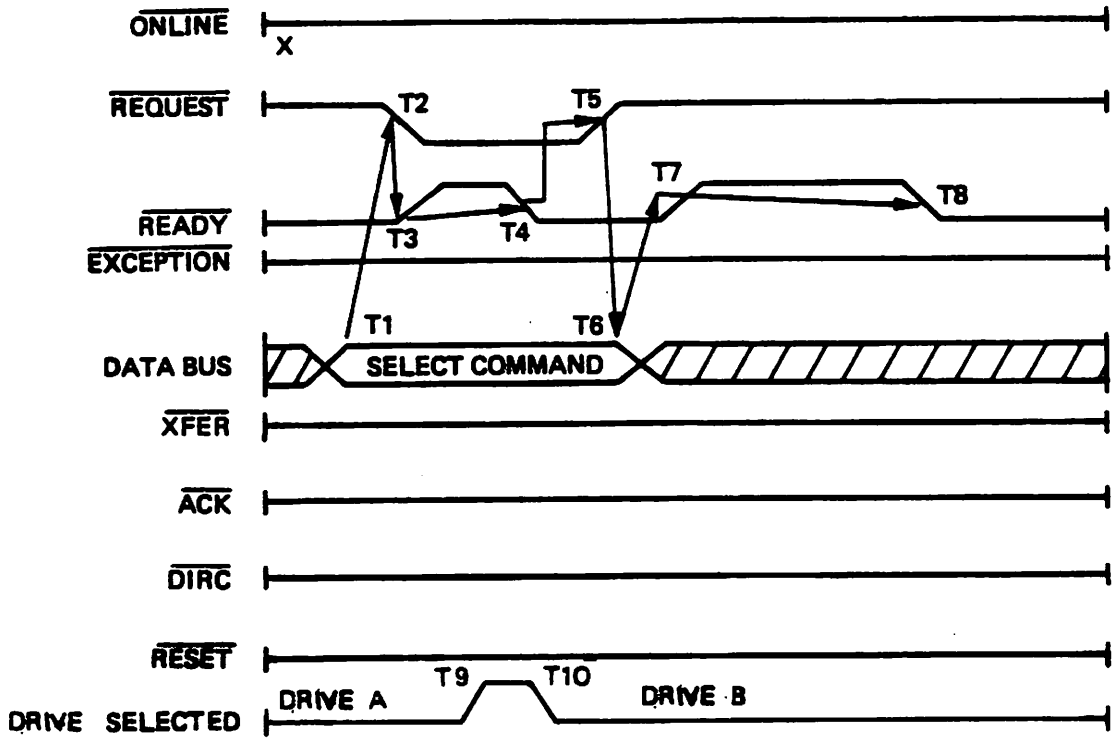
Table 3. 540 Commands

Command	Hex	Bit Pattern MSB - LSB	OIC-02
Select (1 of 4) Formatted Drives	0 (N)	0000 - NNNN	S
Position To BOT	21	0010 - 0001	S
Erase Tape	22	0010 - 0010	S
Retension	24	0010 - 0100	S
Write Data	40	0100 - 0000	S
Write File Mark	60	0110 - 0000	S
Read Data	80	1000 - 0000	S
Read File Mark	A0	1010 - 0000	S
Read Status	C0	1100 - 0000	S
Select Drive/Lock Cartridge	1 (Drive)	0001 NNNN	O
Write Without Underrun	41	0100 - 0001	O
Write N File Marks	7 (N)	0111 - NNNN	O
Space Reverse	89	1000 - 1001	O
Seek End Of Recorded Data	A3	1010 - 0011	O
Read N File Marks	B (N)	1011 - NNNN	O
Run Self-Test 1	C2	1100 - 0010	O
Read Extended Status	E0	1110 - 0000	O
Read Quarterback Format	49	0100 - 1001	V
Select Lock	D (N)	1101 NNNN	V

Select Command (0000-NNNN)

This command allows the host to select one of up to four available drives, uniquely numbered from 1 to 4 as shown below. When the Select command is initiated, the formatter saves the tape drive address, selects the addressed drive, and alerts the host at the completion of the command sequence. A LED on the front panel of the selected 540 is illuminated during command execution. The drive remains selected until another Select command is initiated. Unit select jumpers W8 and W9 are provided on the formatter. The timing diagram for the Select command is provided in Figure 11.

NNNN	W8	W9	Select
0001	In	In	Drive 0
0010	Out	In	Drive 1
0100	In	Out	Drive 2
1000	Out	Out	Drive 3



Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets REQUEST	T1→T2 > 0 uS
T3-Controller resets READY	T2→T3 < 1 uS
T4-Controller sets READY	T3→T4 >20 uS (500 uS nominal)
T5-Host resets REQUEST	T4→T5 > 0 uS
T6-Bus data invalid	T4→T6 > 0 uS
T7-Controller resets READY	20<T5→T7<100 uS
T8-Controller sets READY	T7→T8 >20 uS
T9-Drive A Deselected	T2→T9 < 170 uS
T10-Drive B Selected	T9→T10 >20 uS

X-Don't Care

*If more than one drive is daisy chained, Drive A is the previously selected drive and Drive B is the drive addressed in the new Select command.

Figure 11. Select Timing Diagram

Position to BOT Command (0010-0001)

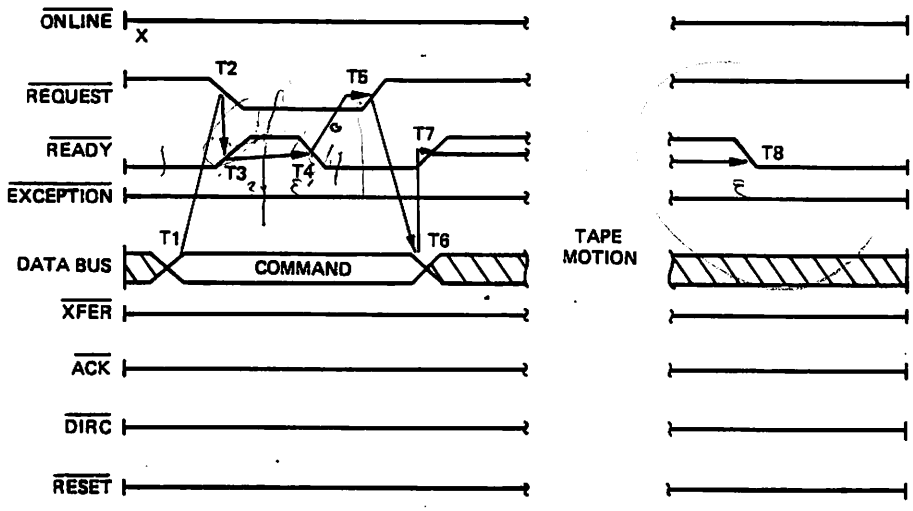
This command positions the tape in the selected drive to the Beginning Of Tape (BOT). The timing diagram for this command is illustrated in Figure 12.

Erase Tape Command (0010-0010)

This command erases all the tape tracks from BOT to EOT, then deactivates the Erase bar and returns to BOT. This command fulfills the requirements of initialization. Timing for Erase Tape is the same as for the BOT command. (See Figure 12)

Retension Command (0010-0100)

This command retensions the tape by returning to BOT; going from BOT to EOT; then returning to BOT. This command also fulfills the requirements of initialization. Timing for Retension is the same as for the BOT command. (See Figure 12)



Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets REQUEST	T1→T2 > 0 uS
T3-Controller resets READY	T2→T3 < 1 uS
T4-Controller sets READY	T3→T4 >20 uS (500 uS nominal)
T5-Host resets REQUEST	T4→T5 > 0 uS
T6-Bus data invalid	T4→T6 > 0 uS
T7-Controller resets READY	20<T5→T7< 100 uS
T8-Controller sets READY	T7→T8 >20 uS

X-Don't Care

Figure 12. BOT, Erase & Retension Timing Diagram

Write Data Command (0100-0000)

The Write command can only be issued by the host after an ONL- is asserted. When the drive is ready for a data block transfer, the RDY- line is activated. However, if the host asserts a XFER- between blocks before RDY- has been asserted, the Ready line may not be asserted.

When Ready has been asserted to indicate a data block boundary, the host can terminate the Write command by issuing a Write File Mark or Write N File Mark command. Either command will stop tape motion and the drive will maintain the present tape position until another command is issued.

When RDY- is active, the host can terminate the Write command by de-activating ONL-. This action will write a file mark and rewind the tape to BOT.

If the Write command is issued after the insertion of a cartridge, or a RST- pulse, writing starts at BOT. Otherwise, writing begins at the current tape position.

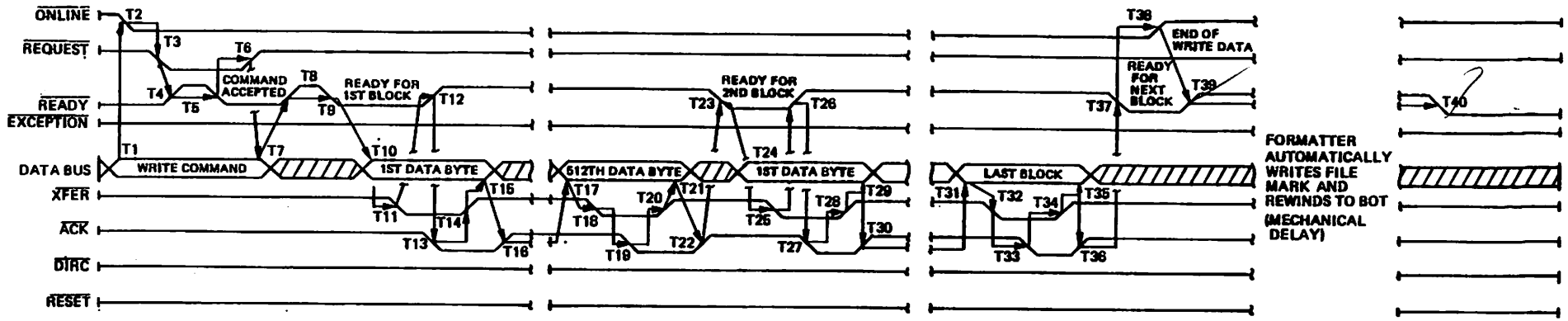
If the drive attempts, unsuccessfully, to write a data block 16 times, the Write command is terminated, an EXC- is set, and the tape is rewound.

When the drive detects the Early Warning hole on the last track, the drive stops accepting data blocks from the host, terminates the Write command, and uses an EXC- and Read status sequence to report an End-Of-Media condition. Then, if another Write command is issued, a final data transfer of 1,024 bytes can be made. A timing diagram for the Write command is provided in Figure 13.

Write Mode Option

An optional bus parity check can be enabled by installing jumper W6 on the formatter pcb with this option:

- Data bytes, not commands, are checked for parity.
- Up to 50 nanoseconds are allowed between XFR- and HBP- valid.
- EXC- is set to parity error detected and a data block with a parity error is not written to tape.
- Valid data buffers are written to tape and the buffer in error is cleared.
- Recovery from a parity error is accomplished by the host reading status, then issuing another Write command. If this is not done, it causes a rewind abort with illegal command status.



Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets ONLINE	N/A
T3-Host sets REQUEST	T2→T3 > 0 uS
T4-Controller resets READY	T3→T4 < 1 uS
T5-Controller sets READY	T4→T5 > 20 uS (500 uS nominal)
T6-Host resets REQUEST	T5→T6 > 0 uS
T7-Bus data invalid	T5→T7 > 0 uS
T8-Controller resets READY	20< T6→T8< 100 uS
T9-Controller sets READY	T8→T9 > 20 uS
T10-Host data to bus	N/A
T11-Host sets XFER	T10→T11 > −40 nS*
T12-Controller resets READY	T11→T12 1 uS
T13-Controller sets ACK	0.5< T11→T13< 100 uS
T14-Host rests XFER	T11→T14 > 0 uS
T15-Bus data invalid	T13→T15 > 0 uS
T16-Formatter resets ACK	0<T14-T16< 3 uS
T17-Host data to bus	N/A
T18-Same as T11*	Same as T11
T19-Same as T13	Same as T13
T20-Same as T14	Same as T14

Activity	Critical Timing
T21-Same as T15	Same as T15
T22-Same as T16	Same as T16
T23-Controller sets READY	T22→T23 > 100 uS
T24-Host data to bus	N/A
T25-Host sets XFER	Same as T11*
T26-Controller resets READY	Same as T12
T27-Controller sets ACK	Same as T13
T28-Host resets XFER	Same as T14
T29-Bus data invalid	Same as T15
T30-Controller resets ACK	Same as T16
T31-Host data to bus	N/A
T32-Host sets XFER	Same as T18
T33-Controller sets ACK	Same as T19
T34-Host resets XFER	Same as T20
T35-Bus data invalid	N/A
T36-Controller resets ACK	Same as T22
T37-Controller sets READY	Same as T23
T38-Host resets ONLINE	N/A
T39-Controller resets READY	N/A
T40-Controller set READY	N/A

* T11 may precede T10 by up to 40 nS

Figure 13. Write Data Timing Diagram

Read Data Command (1000-0000)

The Read command can only be issued by the host after an ONL- is asserted. When the drive is ready for a data block transfer, the RDY- line is asserted. However, if the host begins transferring between blocks by asserting ACK- before RDY- is asserted, the RDY- line may not be asserted.

When a file mark is read, the Read command is terminated by the drive. This action stops the tape, and asserts EXC-. Then, the host must issue a Read Status command to clear the exception.

The Read command can also be terminated by issuing a Read File Mark or Read N File Mark command when RDY- is asserted. With either of these commands, the drive reads to the designated file mark, sets EXC-, and stops tape motion.

The Read command can be terminated by de-activating ONL-, when Ready has been asserted. This sequence rewinds the tape to BOT.

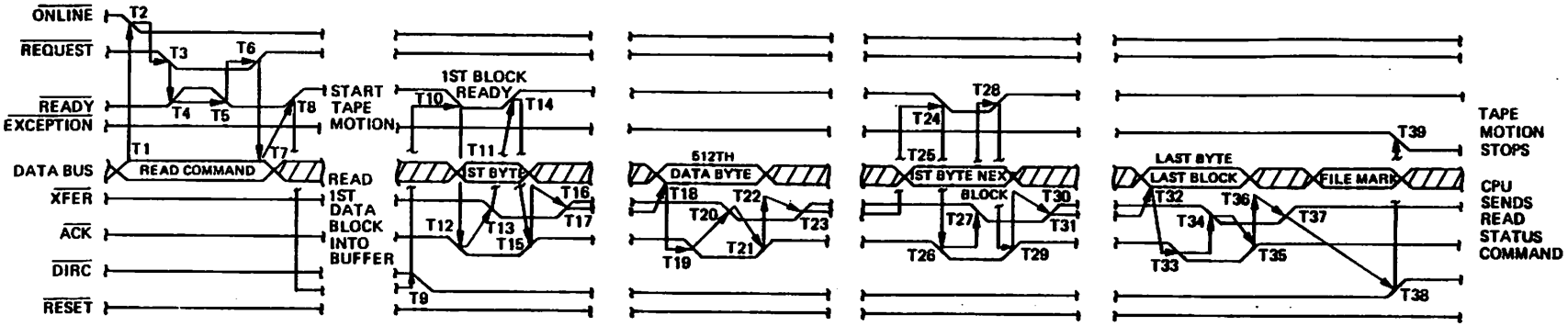
If the drive is unable to read a data bloack after 16 attempts, EXC- is asserted, and the drive stops at the present tape position.

A Read command following a cartridge insertion, or RST- pulse, starts at BOT. Otherwise, the Read starts at the current tape position. The timing diagram for the Read command is illustrated in Figure 14.

Read Mode Option

A Parity option enables the bus parity generator by installing jumper W6 on the formatter pcb. With this option:

- The 540 generates the parity bit with 50 nanoseconds maximum delay from ACK- to HBP- valid.
- The 540 accepts a backspace command while in a Read sequence to recover from a Read parity error. Any other command will cause a rewind abort with illegal command status.



Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets ONLINE	N/A
T3-Host sets REQUEST	T2→T3 > 0 uS
T4-Controller resets READY	T3→T4 < 1 uS
T5-Controller sets READY	T4→T5 > 20 uS (500 uS nominal)
T6-Host resets REQUEST	T5→T6 > 0 uS
T7-Bus data invalid	T5→T7 > 0 uS
T8-Controller resets READY	20 < T6→T8 < 100 uS
T9-Controller changes DIRC	N/A
T10-First data byte to bus	N/A
T11-Controller sets READY	N/A
T12-Controller sets ACK	T11→T12 > - 40 nS*
T13-Host sets XFER	T12→T13 > 0 uS
T14-Controller resets READY	T13→T14 < 1 uS
T15-Formatter resets ACK	0.5 < T13→T15 < 3 uS
T16-Host data to bus	T13→T16 > 0 uS
T17-Host resets XFER	T15→T17 > 0 uS
T18-Bus data valid	N/A
T19-Formatter sets ACK	Same as T12*
T20-Host sets XFER	Same as T13

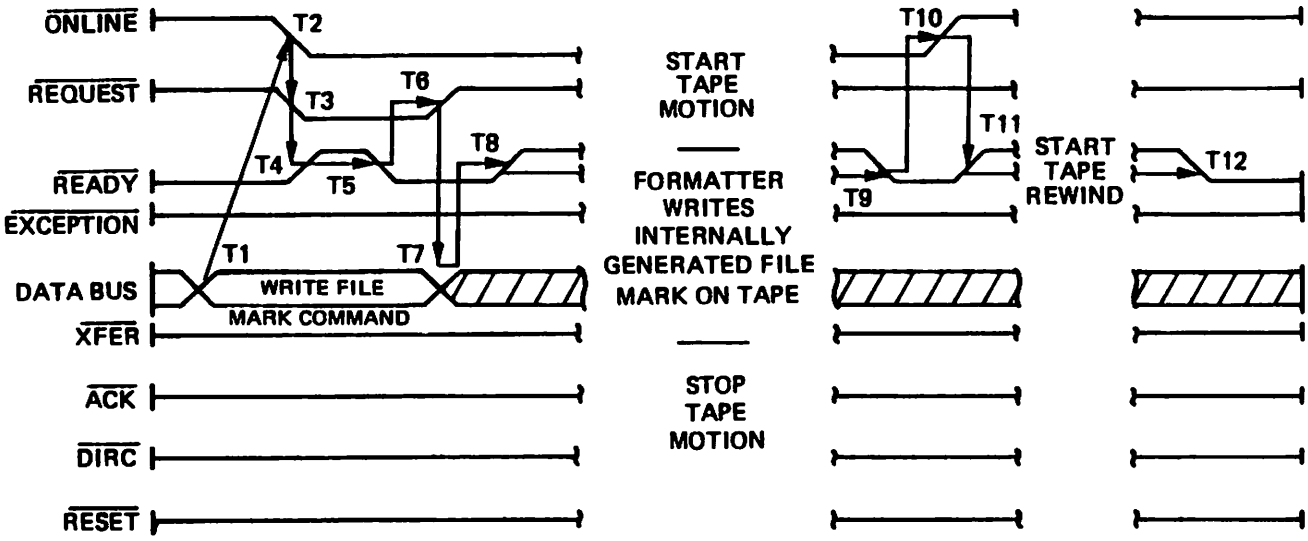
Activity	Critical Timing
T21-Controller resets ACK	Same as T15
T22-Bus data invalid	Same as T16
T23-Host resets XFER	Same as T17
T24-Controller sets READY	N/A
T25-First byte to bus	N/A
T26-Controller sets ACK	Same as T12*
T27-Host sets XFER	Same as T13
T28-Controller resets XFER	Same as T14
T29-Controller resets ACK	Same as T15
T30-Bus data invalid	Same as T16
T31-Host resets XFER	Same as T17
T32-Last byte to bus	N/A
T33-Controller sets ACK	Same as T12*
T34-Host sets XFER	Same as T13
T35-Controller resets ACK	Same as T15
T36-Bus data invalid	Same as T16
T37-Host resets XFER	Same as T17
T38-Controller sets EXCEPTION	N/A
T39-Change bus direction	N/A

* T12 may precede T11 by up to 40 nS

Figure 14. Read Data Timing Diagram

Write File Mark Command (0110-0000)

This command writes a file mark on the tape in the selected drive. A Write File Mark (WFM) command, following a cartridge insertion or RST- pulse, writes the mark at the BOT. Otherwise, the mark is written at the current tape position. The timing diagram for the WFM command is illustrated in Figure 15.

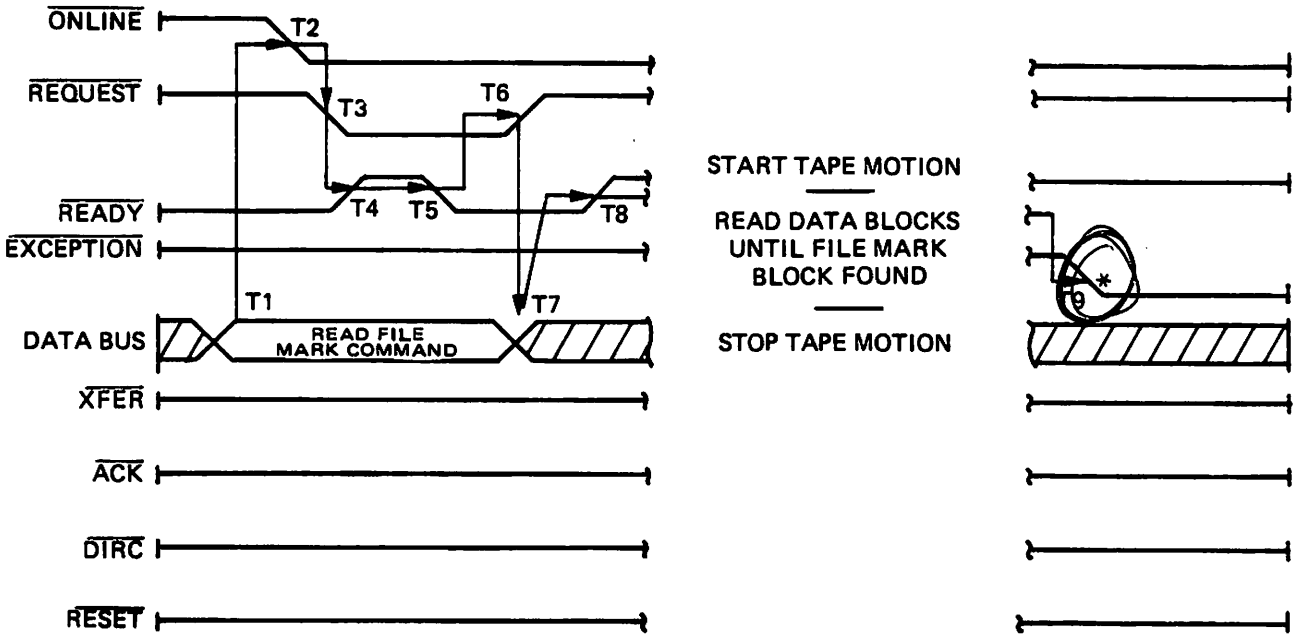


Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets ONLINE	T1→T2 > 0 uS
T3-Host sets REQUEST	T2→T3 > 0 us
T4-Controller resets READY	T3→T4 < 1 uS
T5-Controller sets READY	T4→T5 > 20 uS (500 uS nominal)
T6-Host resets REQUEST	T5→T6 > 0 uS
T7-Bus data invalid	T5→T7 > 0 uS
T8-Controller resets READY	T20<T6→T8<100 uS
T9-Controller sets READY	N/A
T10-Host resets ONLINE	T9→T10>0 uS
T11-Controller resets READY	N/A
T12-Controller sets READY (at BOT)	N/A

Figure 15. Write File Mark Timing Diagram

Read File Mark Command (1010-0000)

This command moves the tape on the selected drive to the next file mark. A Read File Mark (RFM) command, following a cartridge insertion or RST- pulse, starts reading at the BOT. Otherwise, reading starts at the current tape position. The timing diagram for the RFM command is illustrated in Figure 16.



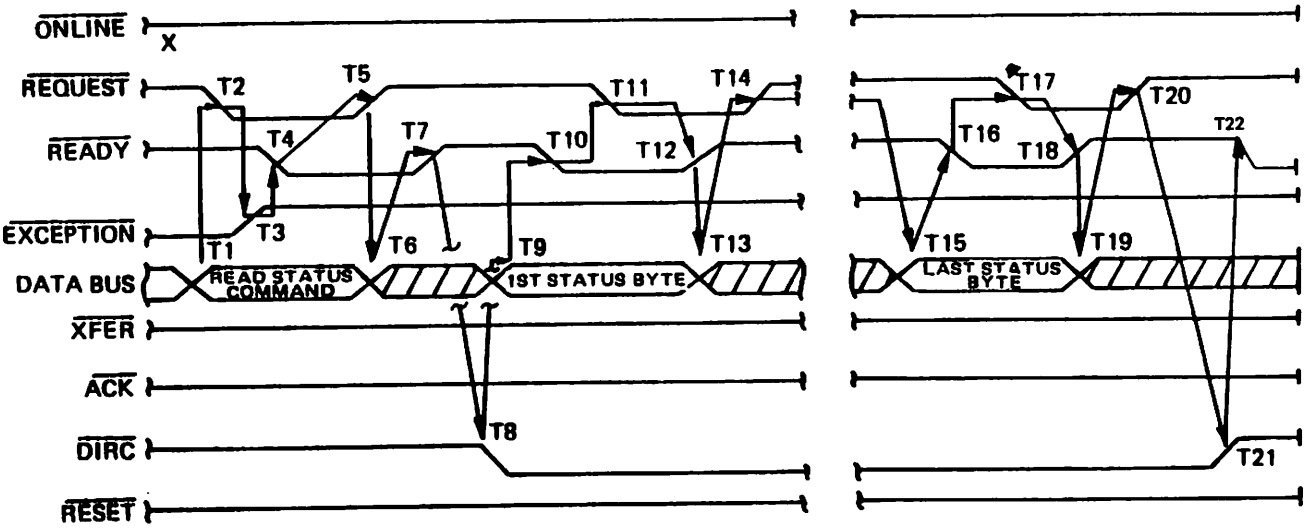
Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets ONLINE	T1→T2 > 0 uS
T3-Host sets REQUEST	T2→T3 > 0 uS
T4-Controller resets READY	T3→T4 < 1 uS
T5-Controller sets READY	T4→T5 >20 uS (500 uS nominal)
T6-Host resets REQUEST	T5→T6 > 0 uS
T7-Bus data invalid	T4→T7 > 0 uS
T8-Controller resets READY	20< T6→T8 < 100 uS
T9-Controller sets EXCEPTION	N/A

* System must issue READ STATUS command

Figure 16. Read File Mark Timing Diagram

Read Status Command (1100-0000)

This command, originated by the host, provides the host with information about the selected drive. This information is transferred from the drive in the standard QIC-02 six status bytes. The timing diagram is provided in Figure 17.

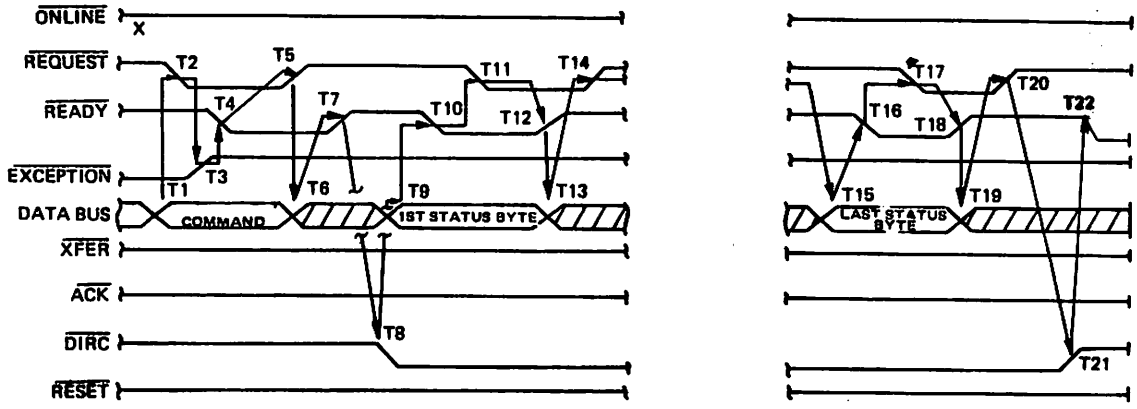


Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets REQUEST	T1→T2 > 0 uS
T3-Controller resets EXCEPTION	T3→T4 >10 uS
T4-Controller sets READY	T2→T4 >20 uS (500 uS nom.)
T5-Hosts resets REQUEST	T4→T5 > 0 uS
T6-Bus data invalid	T4→T6 > 0 uS
T7-Controller resets READY	20< T5→T7< 100 uS
T8-Controller changes bus DIRC	N/A
T9-First status byte to bus	N/A
T10-Controller sets READY	T7-T10 >20 uS
T11-Host sets REQUEST	N/A
T12-Controller resets READY	T11→T12 < 1 uS
T13-Bus data invalid	T11→T13 > 0 uS
T14-Host resets REQUEST	T11→T14 >20 uS
T15-Last status byte to bus	N/A
T16-Same as T10	Same as T10
T17-Same as T11	Same as T11
T18-Same as T12	Same as T12
T19-Same as T13	Same as T13
T20-Same as T14	Same as T14
T21-Controller changes bus DIRC	N/A
T22-Controller sets READY	T20→T21 > 0 uS
X-Don't Care	T21→T22 > 0 uS

Figure 17. Read Status Timing Diagram

Read Extended Status Command (1110-0000)

This optional command, issued by the host, provides the host with information for fault isolation of the selected drive. This information is provided by the drive in 64 bytes of vendor unique status data. The timing diagram for this command is provided in Figure 18.

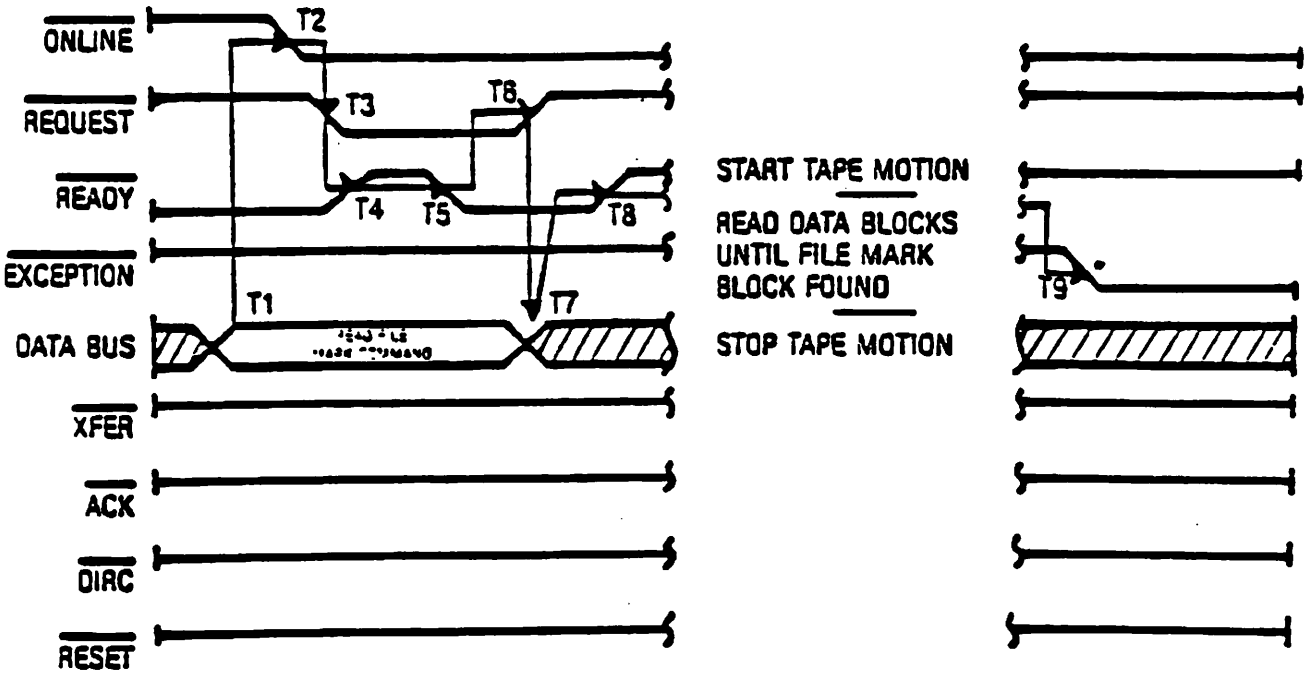


Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets REQUEST	T1→T2 > 0 uS
T3-Controller resets EXCEPTION	T3→T4 > 10 uS
T4-Controller sets READY	20 < T2→T4 < 500 uS
T5-Host resets REQUEST	T4→T5 > 0 uS
T6-Bus data invalid	T4→T6 > 0 uS
T7-Controller resets READY	20 < T5→T7 < 100 uS
T8-Controller changes bus DIRC	N/A
T9-First status byte to bus	N/A
T10-Controller sets READY	T7→T10 > 20 uS
T11-Host sets REQUEST	N/A
T12-Controller resets READY	T11→T12 > 20 uS
T13-Bus data invalid	T11→T13 > 0 uS
T14-Host resets REQUEST	T11→T14 > 20 uS
T15-Last status byte to bus	N/A
T16-Same as T10	Same as T10
T17-Same as T11	Same as T14
T18-Same as T12	Same as T12
T19-Same as T13	Same as T13
T20-Same as T14	Same as T14
T21-Controller changes bus direction	T20→T21 > 0 uS
T22-Controller sets READY	T21→T22 > 0 uS
X-Don't care	

Figure 18. Read Extended Status Timing Diagram

Read N File Marks Command (1011-NNNN)

This optional command is identical to the RFM, except the number of file marks to be read is specified by the binary value of NNNN. If NNNN is made equal to 0, the operation is not performed. The timing diagram for this command is illustrated in Figure 19.



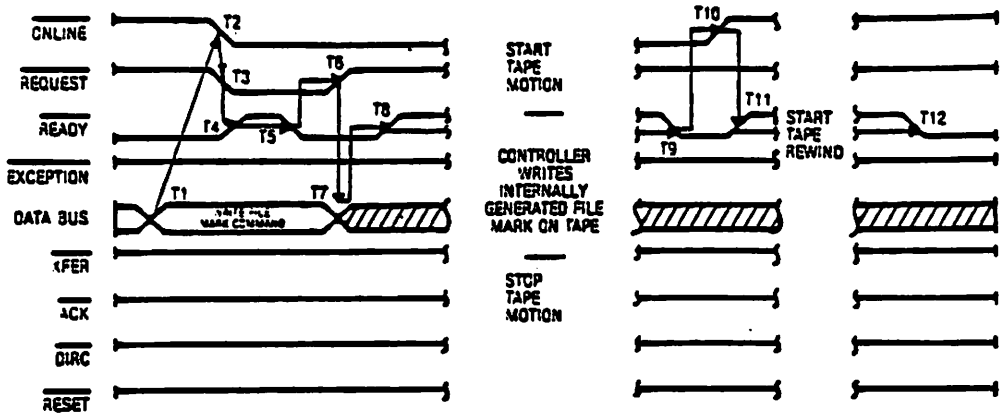
Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets ONLINE	T1→T2 > 0 uS
T3-Host sets REQUEST	T2→T3 > 0 uS
T4-Controller resets READY	T3→T4 < 1 uS
T5-Controller sets READY	T4→T5 > 20 uS (500 uS nom.)
T6-Host resets REQUEST	T5→T6 > 0 uS
T7-Bus data invalid	T4→T7 > 0 uS
T8-Controller resets READY	20 < T6→T8 < 100 uS
T9-Controller sets EXCEPTION	N/A

*System must issue READ STATUS command

Figure 19. Read N File Marks Timing Diagram

Write N File Marks Command (0111-NNNN)

This optional command is identical to the WFM, except the number of file marks to be written is specified by the binary value of NNNN. If NNNN is made equal to 0, the operation is not performed. The timing diagram for this command is illustrated in Figure 20.

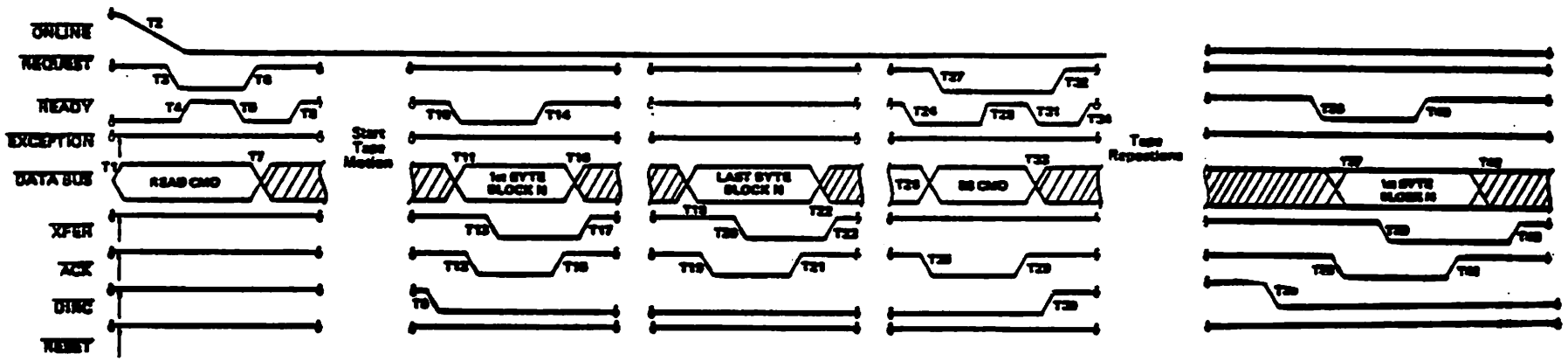


Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets ONLINE	T1→T2 > 0 uS
T3-Host sets REQUEST	T2→T3 > 0 uS
T4-Controller resets READY	T3→T4 < 1 uS
T5-Controller sets READY	T4→T5 > 20 uS (500 uS nom.)
T6-Host resets REQUEST	T5→T6 > 0 uS
T7-Bus data invalid	T5→T7 > 0 uS
T8-Controller resets READY	20 < T6→T8 < 100 uS
T9-Controller sets READY	N/A
T10-Host resets ONLINE	T9→T10 > 0 uS
T11-Controller resets READY	N/A
T12-Controller sets READY (at BOT)	N/A

Figure 20. Write N File Marks Timing Diagram

Space Reverse Command (1000-1001)

The Space Reverse command can only be issued when nested in a Read sequence, and is actually a backspace plus a Read command. The first data byte of the previous data block is presented to the data bus. If a file mark is read, the Read command is terminated. The timing for the Space Reverse command is illustrated in Figure 12.



Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets ONLINE	N/A
T3-Host sets REQUEST	T2→T3 > 0 uS
T4-Controller resets READY	T3→T4 < 1 uS
T5-Controller sets READY	T4→T5 > 20 uS
T6-Host resets REQUEST	T5→T6 > 0 uS
T7-Bus data invalid	T5→T7 > 0 uS
T8-Controller resets READY	20 uS < T8→T9 < 100 uS
T9-Controller changes DIRC	N/A
T10-First data byte to bus	N/A
T11-Controller resets READY	N/A
T12-Controller sets ACK	T11→T12 > -40 uS
T13-Controller sets XFER	N/A
T14-Controller resets READY	T13→T14 < 1 uS
T15-Controller resets ACK	0 T15→T16 < 3 uS
T16-Bus data invalid	T13→T16 > 0 uS
T17-Host resets XFER	T16→T17 > 0 uS
T18-Bus data invalid	N/A
T19-Controller sets ACK	Same at T12
T20-Host sets XFER	Same as T13
T21-Controller resets ACK	Same as T15
T22-Data bus invalid	Same as T16

Activity	Critical Timing
T23-Host resets XFER	Same as T17
T24-Controller sets READY	N/A
T25-Controller sets ACK	Same as T12
T26-Host command to bus	N/A
T27-Host sets REQUEST	T24→T27 > 0 uS
T28-Controller resets READY	T27→T28 < 1 uS
T29-Controller resets ACK	T28→T29 > 0 uS
T30-Controller resets DIRC	T28→T31 > 20 uS
T31-Controller sets READY	T28→T31 > 20 uS
T32-Host resets REQUEST	T31→T32 > 0 uS
T33-Bus data invalid	T31→T33 > 0 uS
T34-Controller resets READY	20 uS < T8→T9 < 100 uS
T35-Controller set DIRC	T34→T35 > 0 uS
T36-Controller sets READY	N/A
T37-First byte to bus	N/A
T38-Controller sets ACK	Same as T12
T39-Host resets XFER	Same as T13
T40-Controller resets READY	Same as T14
T41-Controller resets ACK	Same as T15
T42-Bus data invalid	Same as T16
T43-Host resets XFER	Same as T17

* BACKSPACE is a nested command, so it must be preceded by a READ command

Figure 21. Space Reverse Timing Diagram

Seek End of Recorded Data Command (1010-0011)

This optional command instruct the drive to find the end of the recorded data. Once found, new data may be appended by another Write command. The timing for this command is essentially the same as for a Read File Mark command. (See Figure 16.) No data is transferred, and the completion of the command is indicated by an Exception signal and the End of Recorded Media status bit.

Run Self Test 1 Command (1100-0010)

This optional command activates the drive to perform a number of self-test operations. This command prevents writing on the tape in the recordable area. The coded results of the test are stored in Status Register 3. The code 0000-0000 indicates that the self-test operation may not have been performed. The following codes indicate test results:

Status Byte	Description
11 Hex	Self test complete. No error
12 Hex	Basic drive microprocessor error
13 Hex	I/O error
14 Hex	EOT/BOT sensor error
15 Hex	Head positioner error
22 Hex	R/W error
23 Hex	Capstan motor error
24 Hex	Formatter checksum error
25 Hex	Data buffer error

00 - Test not Performed

Select Drive/Lock Cartridge Command (0001-NNNN)

This optional comand performs the functions of a Select command, except the LED is illuminated and remains on until a standard Select command is issued or the drive is reset. The timing for this command is the same as for a standard Select command. (See Figure 11.)

Write Without Underruns Command (0100-0001)

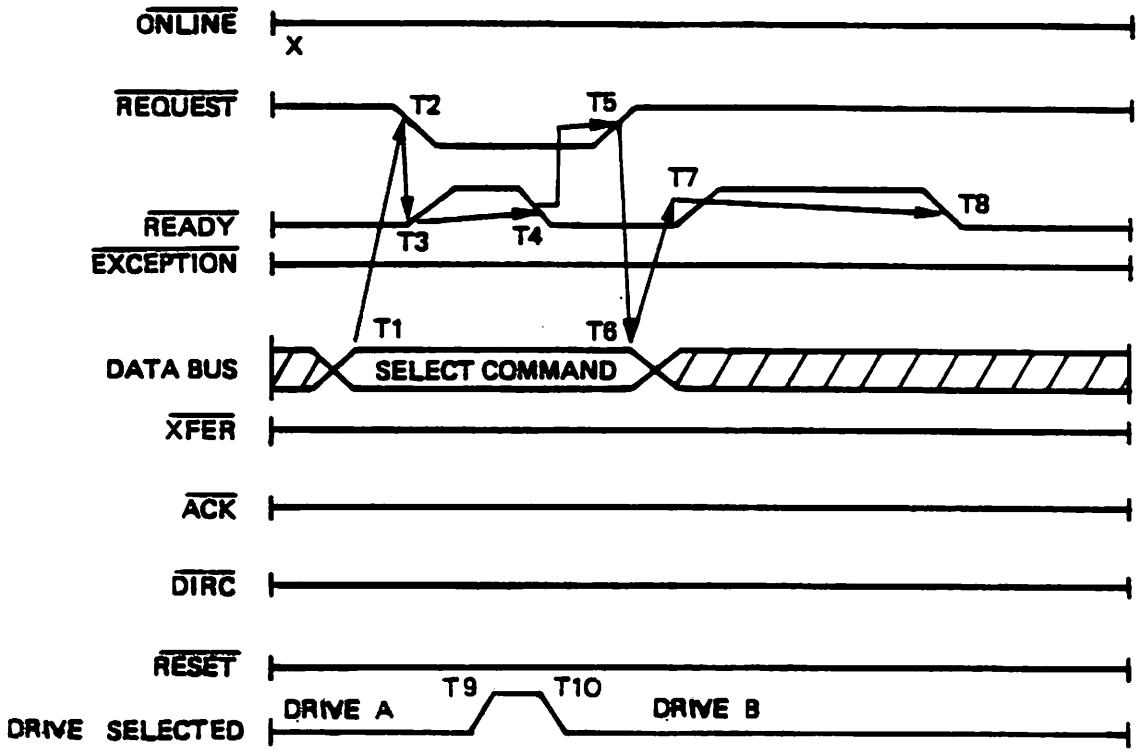
This optional command keeps the tape running when there is no data available in the Write mode. This is accomplished by writing an elongated preamble and/or redundant blocks until data becomes available or the end of the tape is reached. The timing for this command is the same as for a standard Write command. (See Figure 13)

Read Quarterback Format Command (0100-1001)

This vendor unique command changes the 540 parameter logic to read the format of the Cipher Quarterback™ 4-track tape. All 540 commands, except the Write operations, may be used in this mode. A Power-On or RST-pulse restores the drive to the QIC-24 configuration.

Select Lock Command (1101-NNNN)

This optional command is used with daisy chained formatted drives. It performs the functions of a Select command, except the tapes in both the selected and deselected drives are not rewound to BOT. Because these tapes stay at the current position, one 540 can copy from another 540 without rewinding to BOT or seeking the end-of-data position. The timing for this command is illustrated in Figure 22.



Activity	Critical Timing
T1-Host command to bus	N/A
T2-Host sets REQUEST	T1→T2 > 0 uS
T3-Controller resets READY	T2→T3 < 1 uS
T4-Controller sets READY	50 < T3→T4 < 500 uS
T5-Host resets REQUEST	T4→T5 > 0 uS
T6-Bus data invalid	T3→T6 > 0 uS
T7-Controller resets READY	20 < T5→T7 < 100 uS
T8-Controller sets READY	T7→T8 > 20 uS
T9-Drive A De-Selected	T2→T9 < 170 uS
T10-Drive B Selected	T9→T10 < 20 uS
X-Don't care	

*If more than one formatted drive is daisy chained, Drive A is the previously selected drive, and Drive B is the drive addressed in the new Select command.

Figure 22. Select Lock Timing Diagram

SECTION 4

ERROR PROCESSING & RECOVERY

INTRODUCTION

The 540 formatter provides extensive error processing and recovery sequences which greatly reduce the software effort required to interface the formatter with the host. The information in this Section is only intended to be an introduction to the basic principles of error processing and error recovery for the 540.

The formatter provides statistical information on the number of errors it has automatically processed. When determining system performance, during the evaluation phase, these statistics can be very useful. Table 4 summarizes the Exception Status bytes provided by the formatter in accordance with QIC-02.

Table 4. Exception Status Bytes

Byte 0	Byte 1	Status	Description	Result
1110X0000	00000000	No Cartridge	Drive selected has no cartridge when BOT, RET, Erase, Write, WFM, Read, or RFM was issued, or cartridge was removed while selected.	Fatal
11110000	00000000	No Drive	Tape drive selected not present when BOT, RET, Erase, Write, WFM, Read, or RFM was issued.	Fatal
10010000	X000X000	Write Protected	Tape drive selected contains safe (write protected) cartridge when Erase, Write, or WFM was issued.	Fatal
10001000	00000000	End of Media	Tape passed early warning hole of last track during Write command.	Continuable
100X0100	10001000	Read or Write Abort	Same block rewritten 16 times during Write or WFM command, or unrecoverable reposition error occurred during Write, WFM, Read, or RFM command. Tape returns to BOT.	Fatal

Table 4 (Continued)

Byte 0	Byte 1	Status	Description	Result
100X0100	00000000	Read Error, Bad Block transfer	Same block retried 16 times to recover block without CRC error; last transfer contained data from erroneous data block for off-line reconstruction.	Continuable
100X0110	00000000	Read Error, Filler Block	Same block with 16 retries failed to recover block without CRC error; last block transferred contained filler data to keep total block count correct.	Continuable
100X0110	10100000	Read Error, No Data	No recorded data detected on the tape.	Continuable
100X1110	10100000	Read Error, No Data & EOM	No recorded data detected on the tape; logical EOT holes on last track encountered.	Continuable
100X0110	101X1XX0	Read Error, No Data & BOM	No data detected; failed to recover next or subsequent blocks; during reverse reposition, BOT holes in first track encountered.	
100X0001	00000000	File Mark Read	File Mark block is read during Read or RFM command.	Continuable
XXXX0000	1100X000	Illegal Command	One of six attempts were made: a. To select multiple drives b. To change Drive Select during a Read/Write with tape not at BOT. c. To request BOT, Retension, or Erase simultaneously.	Fatal

Table 4 (Continued)

Byte 0	Byte 1	Status	Description	Result
			d. To request Write, WFM, Read, or RFM with On-line off. e. To issue command, other than Write or WFM during Write command. f. To issue command, other than Read or RFM during Read command. g. To issue any non-implemented command.	
XXXX0000	1000X001	Power On Reset	Power On Reset or a Reset by host occurred.	Fatal

NOTE: Bytes 2 and 3 (DEC) are the data error counter. Bytes 4 and 5 (URC) are the underrun counter

WRITE BUFFER UNDERRUN

A Write buffer underrun should be avoided, because it lowers the capacity of the tape by an amount of data that is proportional to the tape speed. It also terminates the tape motion.

Tape streaming implies continuing tape motion with small gaps between data blocks. Therefore, the host must maintain an uninterrupted transfer of data blocks to the 540 formatter. If a full Write buffer is not available to the Write channel when it is required by the formatter, a Write buffer underrun condition occurs and is logged in the statistical counters of the formatter. The formatter then initiates a last block sequence by rewriting the last data block. If a full Write Buffer is not available before the Read data channel finishes checking the last data block, the last block sequence is completed, tape motion is stopped, and a Write Reposition is initiated.

A complete last block sequence requires 0.528-inches to rewrite the last block, plus 0.300-inches for the extended gap. The data throughput decrease that results from a Write buffer underrun at 90 ips is 0.98-inch per 1.76 blocks.

Read-After-Write Errors

It requires a density of 10,000 flux changes per inch (fci) to provide the 540 with its high-capacity storage. With this density it would be ideal for all recording conditions to be perfect. However, this state is seldom achieved. Therefore, the 540 formatter is designed to accommodate occasional data errors. To ensure that data is written correctly, a Read-After-Write check is made on each block of data immediately after it is written. If an error is found, the block is rewritten. In order to support this Read-After-Write check, the three Write data buffers are allocated in this sequence:

- Buffer one stores the block that is being written.
- Buffer two stores the block being checked by the Read-After-Write, so data remains available for rewriting.
- Buffer three stores the next data block transferred by the host.

To perform Read-After-Write checking, the tape drive head is designed with two gaps, one for writing and one for reading. These gaps are separated by a distance of 0.3-inch. For tape streaming, the inter-record gap length is only 0.013-inch; therefore, the formatter must begin writing the next record before the previous record has been completely verified by the Read-After-Write.

Read-After-Write error recovery is automatically processed by the formatter. Because this process is invisible to the host, a statistical counter is provided to inform the host of the number of blocks automatically rewritten by the formatter. Each rewritten block subtracts one block from the total capacity of the tape. Because each Error Recovery sequence normally rewrites two data blocks, the statistical counter normally contains an even number which usually represents one half the number of soft errors.

READ BUFFER UNDERRUN

In normal Read operations, the formatter locates a block of data, transfers it to the buffer memory in the formatter, and performs a CRC check for errors. If no error occurs, the block of data is transferred to the host. The formatter contains three buffer memories. One is allocated to the Read channel, one to the host, and one is held in reserve to be used if the host system temporarily gets behind the transfer throughput rate of the Read channel. This buffer memory configuration provides a 1-block buffer that allows short-term host system contentions before the Read operation overruns the buffer memories in the formatter.

If the host system, with the three buffer memories, fails to stay ahead of the Read channel, a Read buffer underrun occurs. This condition arises when the Read channel has located the next block of data and none of the three buffer memories in the formatter are available for data storage. To prevent the loss of that block, the formatter must stop the tape. The formatter then performs a Read reposition sequence and then resumes the normal Read operation sequence. A statistical counter is provided in the formatter to keep track of the number of Read buffer underrun occurences.

Read Data Errors

The formatter verifies Write data with a Read-After-Write check, because there are a large number of variables associated with reading data that can result in temporary Read data errors. The error recovery, process in the formatter rereads the Block-In-Error

(BIE) up to 16 times during error recovery before informing the host that an unrecoverable Read error has been detected. The process of rereading a BIE is referred to as a Soft Error Retry (SER) sequence. This process stops the tape, performs a Read reposition sequence, then continues the normal Read sequence.

If the error in a BIE is not recovered after 16 tries, the formatter transfers the BIE, if it can be located, terminates the Read operation, and alerts the host that the transferred BIE has an unrecoverable Read error. Unless aborted, an available data block is always transferred. If another block, rather than the BIE is transferred, the host is alerted to this fact.

Each SER sequence increments, by one, a statistical counter in the formatter. During a Read operation, data blocks with CRC errors that were rewritten during the Write operation, are ignored.

Read Sequence Errors

The formatter appends a block address byte to each data block written on the tape. Blocks rewritten because of a Read-After-Write detected error, alter the normal sequence of the blocks written on tape.

During Read operations, a block sequence error can be caused by encountering a block that was read from tape without a CRC error, but with an unexpected address. Block sequence errors cause the formatter to perform an SER sequence. The SER sequence for a Read sequence error is the same as for a Read data error. If the limit of 16 SER sequences is exceeded without re-establishing the proper block address, the formatter transfers the BIE, if it can be located; terminates the Read operation; and alerts the host that the transferred BIE has an unrecoverable Read error. Unless aborted, an available data block is always transferred. If another block, rather than the BIE is transferred, the host is alerted to this fact.

READ OR WRITE ABORT ERRORS

A Read abort or Write abort prevents a Read or Write sequence from being completed. An abort is done when, after 16 rewrites of the same block, there is an unrecoverable reposition error.

NO DATA DETECTED ERRORS

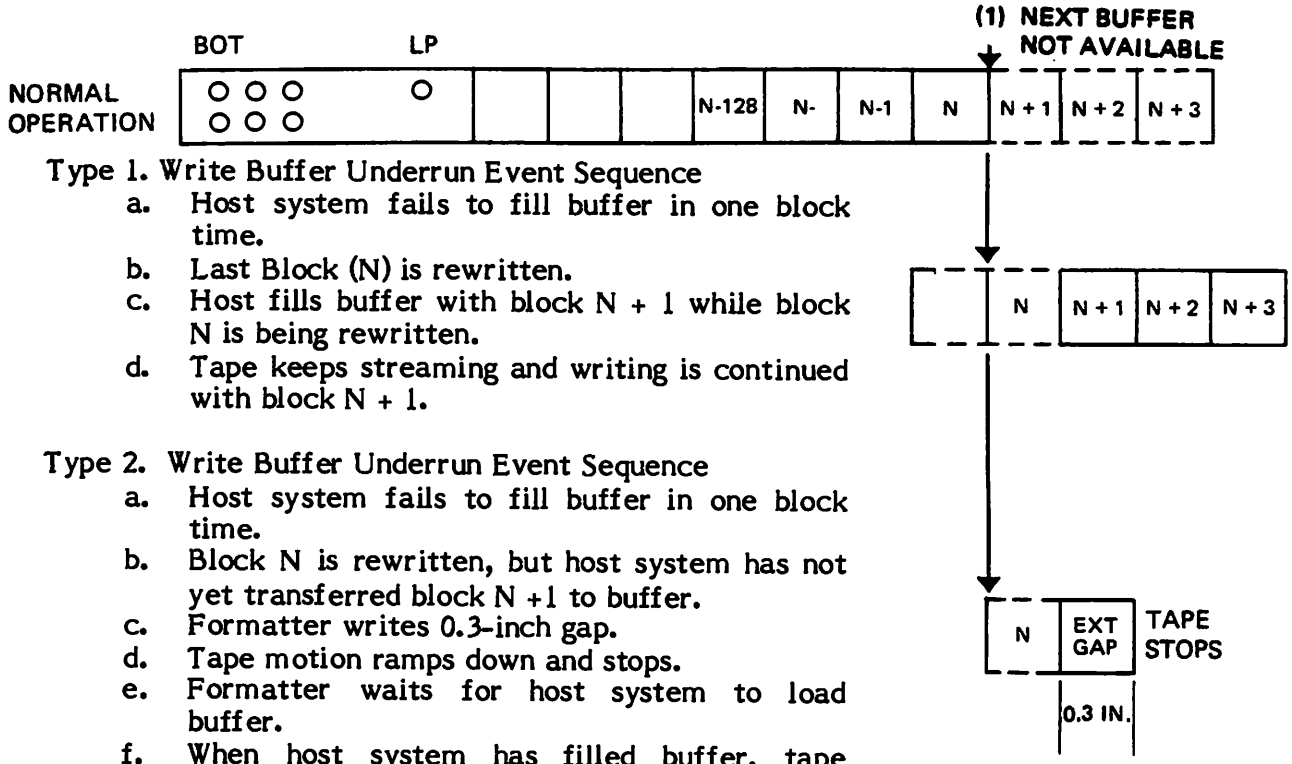
The formatter searches a length of tape, equal to approximately 128 block times, for a specific block on the Read channel. If the block is not found, the formatter performs a Read reposition sequence and repeats the search up to two times. If the block is still lost, the formatter alerts the host that there is an unrecoverable data error due to no data being detected, and does not transfer a block of data.

SECTION 5

REPOSITION TIMING

INTRODUCTION

There are two types of Write buffer underruns. Type 1 allows continuation of the streaming mode. Type 2 is followed by a reposition operation, which is conducted by a Write buffer underrun handling routine. A normal Write operation and the two types of Write buffer underrun conditions are shown and described in Figure 23. A flow chart of a Write buffer underrun routine is shown in Figure 24.



Type 1. Write Buffer Underrun Event Sequence

a. Host system fails to fill buffer in one block time.
b. Last Block (N) is rewritten.
c. Host fills buffer with block N + 1 while block N is being rewritten.
d. Tape keeps streaming and writing is continued with block N + 1.

Type 2. Write Buffer Underrun Event Sequence

a. Host system fails to fill buffer in one block time.
b. Block N is rewritten, but host system has not yet transferred block N +1 to buffer.
c. Formatter writes 0.3-inch gap.
d. Tape motion ramps down and stops.
e. Formatter waits for host system to load buffer.
f. When host system has filled buffer, tape motion begins in opposite direction and tape is run back approximately 10 blocks.
g. Tape motion stops briefly, then is reversed to original direction of tape motion during Write operation.
h. Formatter scans incoming bit stream from Read logic for block address of last block written.
i. When block addresss is found, formatter searches for extended gap.
j. When extended gap is found, formatter appends another 1 ms of gap, followed by standard 528.5-byte block format (512 user data bytes), which contains block N + 1

Figure 23. Write Buffer Underrun Events

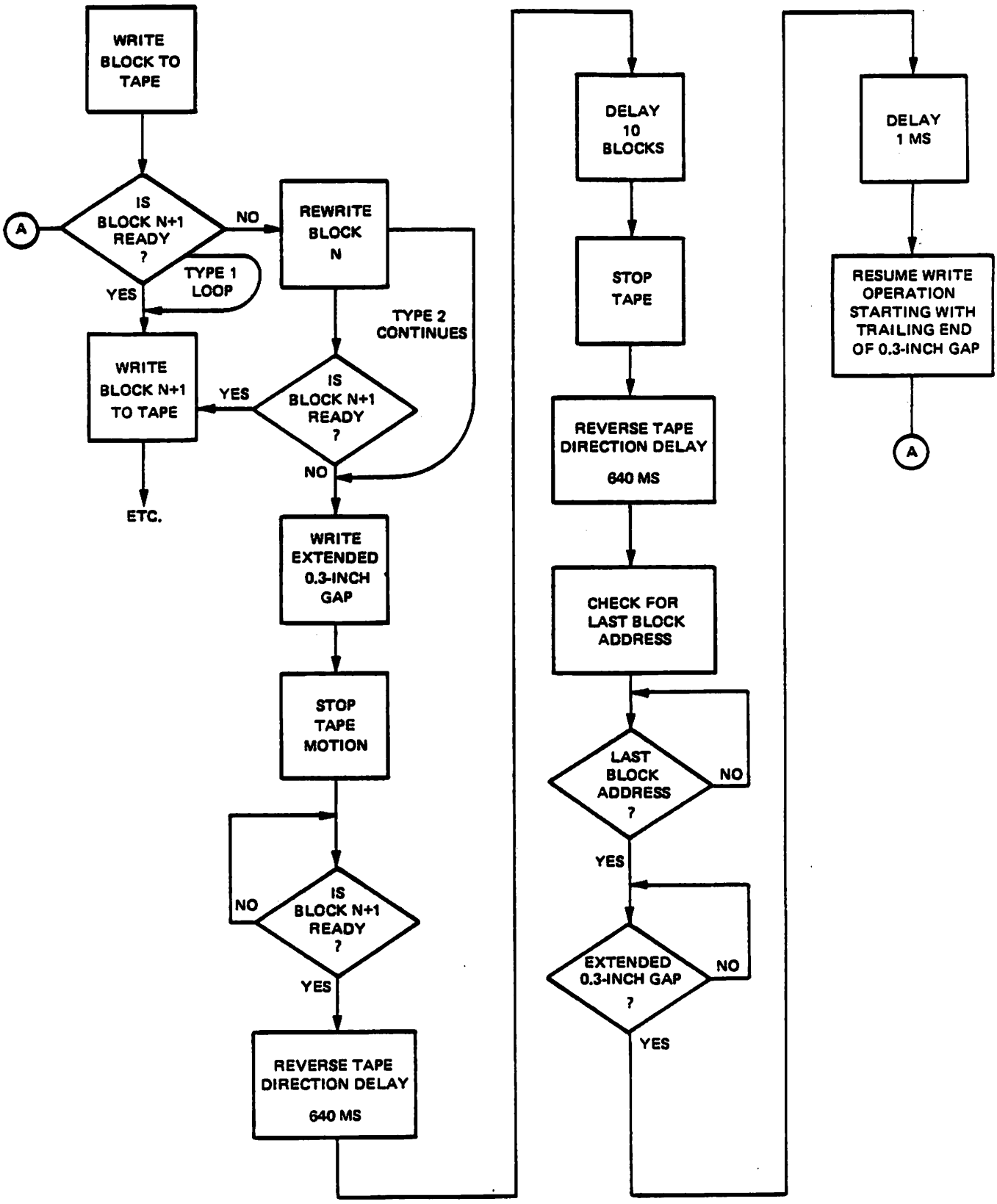


Figure 24. Write Buffer Underrun Flowchart

WRITE BUFFER CRITICAL TIMING

To maintain tape drive operation in a streaming mode without logging a Write buffer underrun on the statistical counter, a complete 512-byte transfer of user data must be accomplished with 5.8 ms.

If the host fails to respond within one block time, the formatter rewrites the last block from the host. The host then has an additional block of Write time to fill a Write buffer, before the formatter drops out of the streaming mode. The critical time elements are shown in Figure 25.

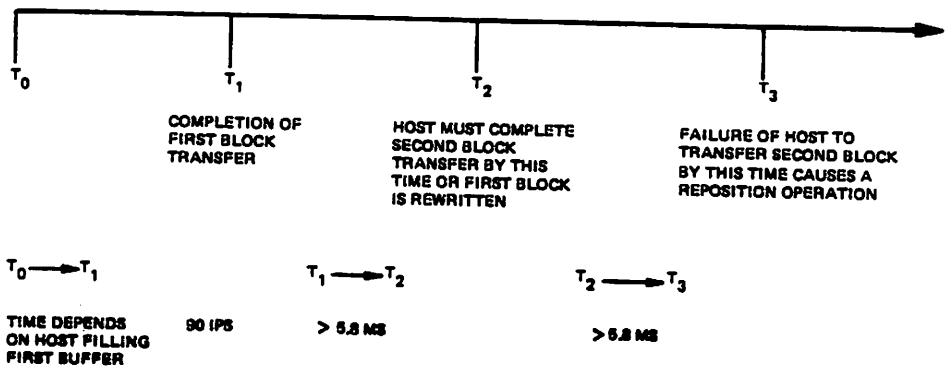


Figure 25. Critical Write Timing Elements

Write Reposition

The timing sequence of a Reposition operation is shown in Figure 26.

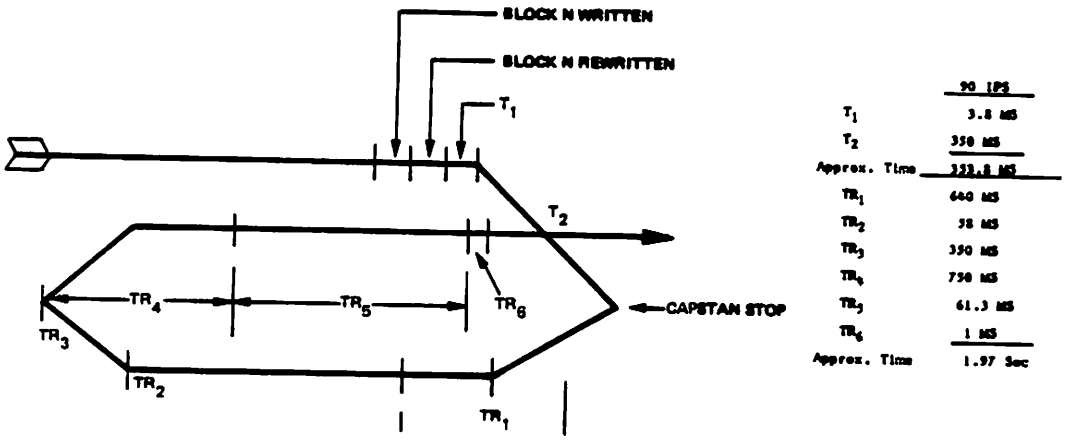


Figure 26. Reposition Timing Sequence

SECTION 6

INSTALLATION

INTRODUCTION

This Section describes the required physical mounting of the 540 and 440 drives, ambient conditions for operating the drives, cartridge loading and unloading, and recommended methods of cleaning the drives.

MOUNTING THE DRIVE

The 540 and the 440 can be mounted horizontally or vertically, but not in an upright (on end) position. When mounted horizontally, the electronic circuit board must be on top.

Figures 27 through 30 illustrate the 540. Four 6-32 tapped mounting holes are provided on the base of the drive to secure it to the complementary surface of the cabinet, rack, or other enclosure. For alternative mounting, two 6-32 tapped mounting holes are provided on each side surface of the drive. If side mounting is required, all four mounting holes must be used. The mounting screws should not penetrate the surface by more than 0.22-inch (0.56 cm) or less than 0.125-inch (0.318 cm).

Figure 31 through 34 illustrate the 440. The same tapped holes are provided as for the 540. As previously noted, side mounting must be made with all four holes.

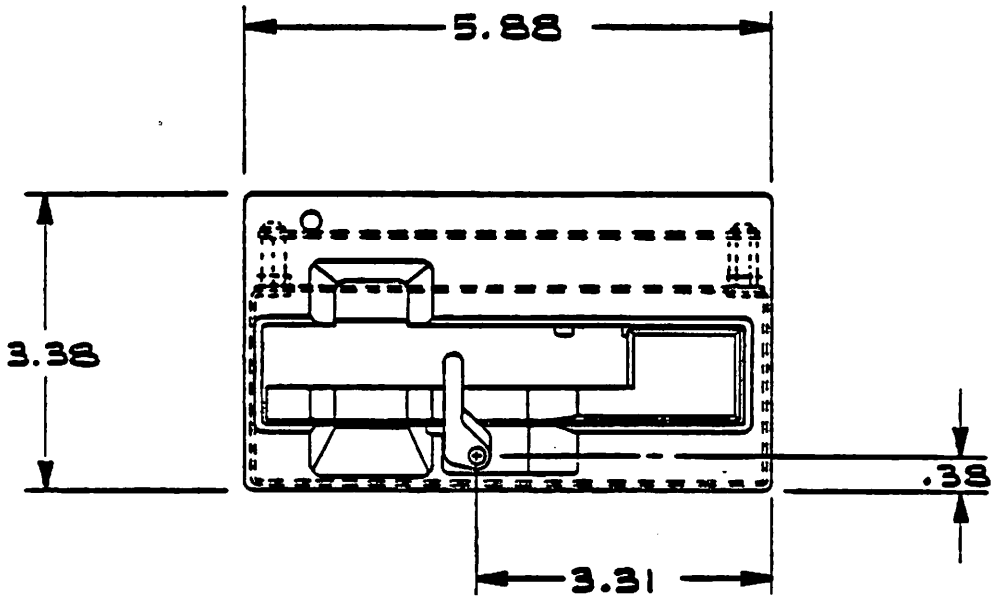


Figure 27. Front View of the 540

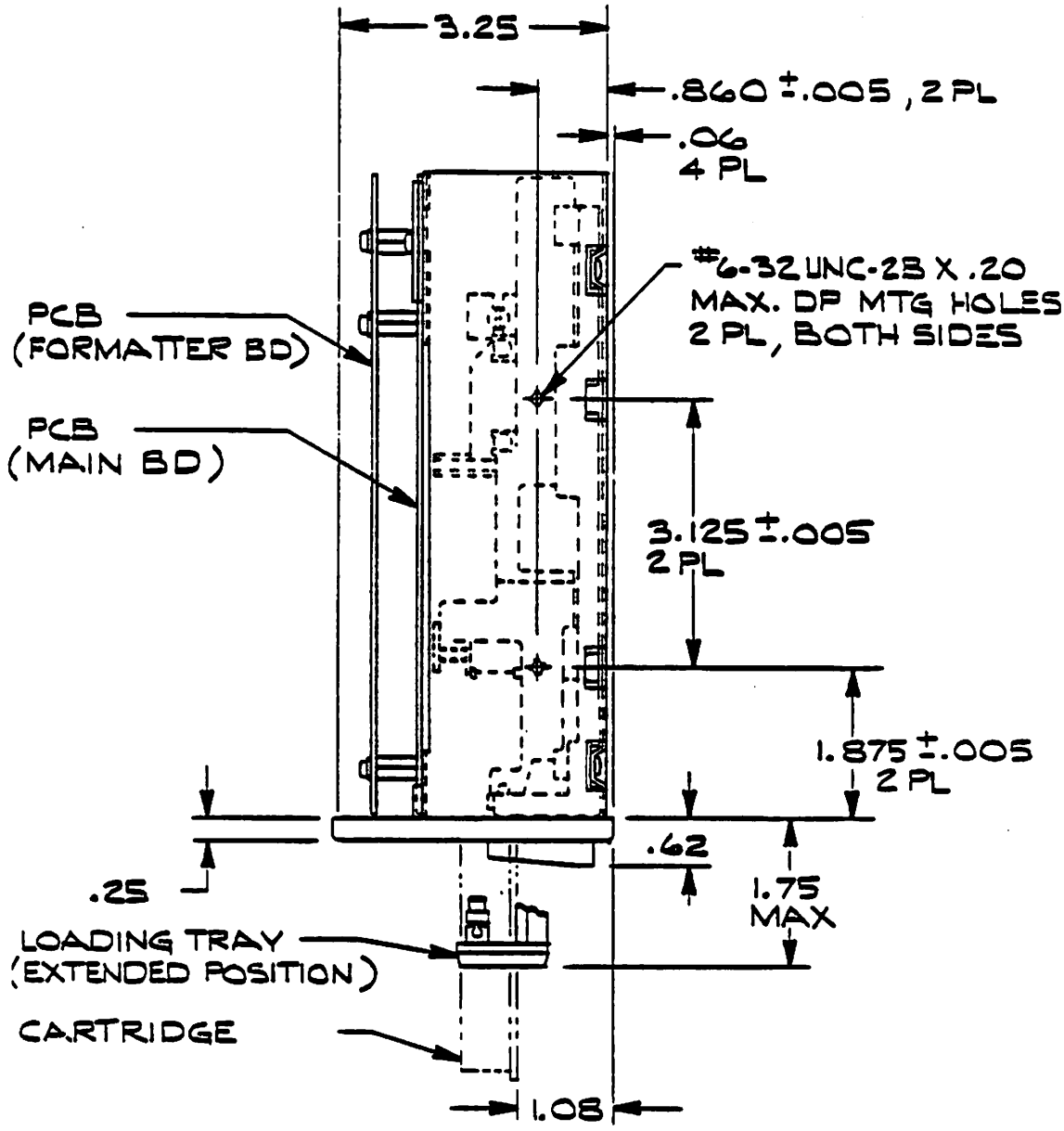


Figure 28. Right Hand Side View of the 540

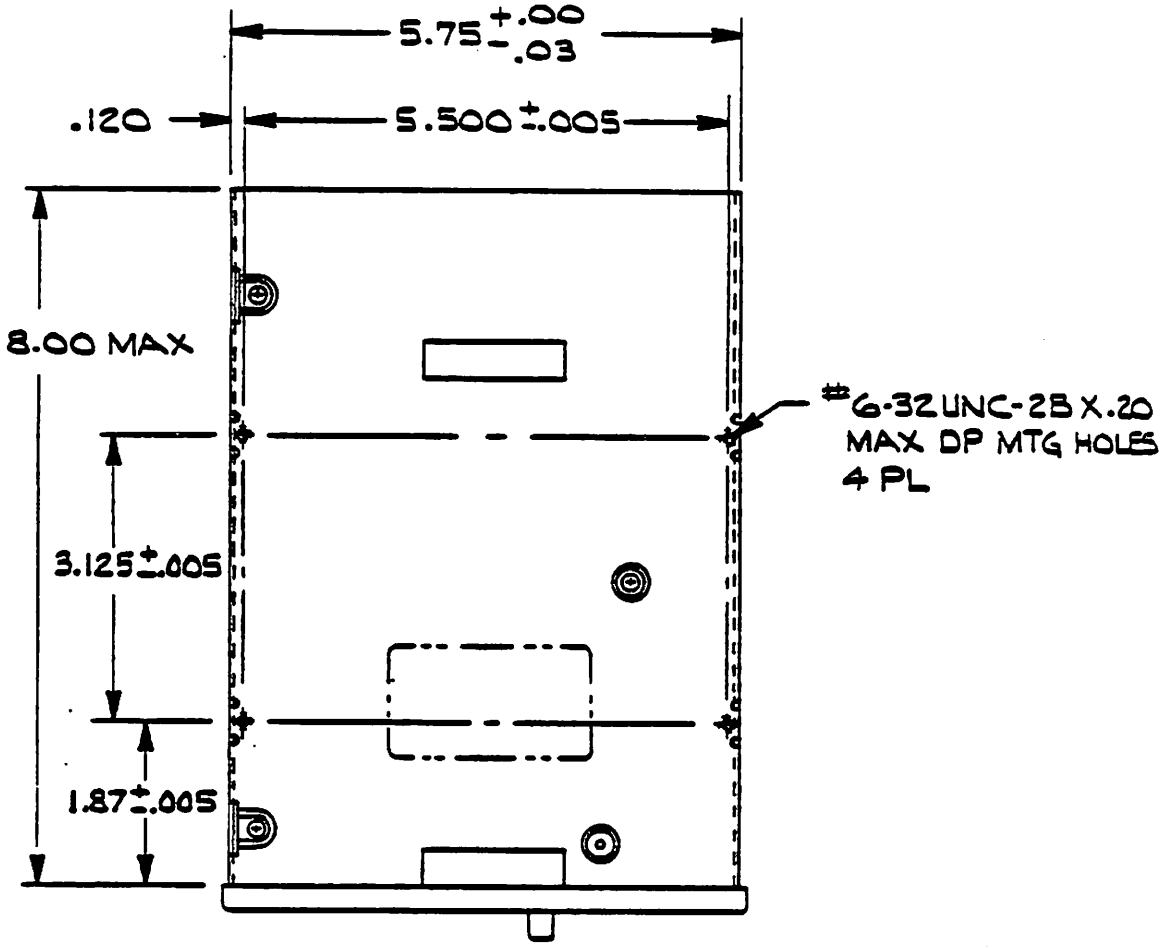


Figure 29. Bottom View of the 540

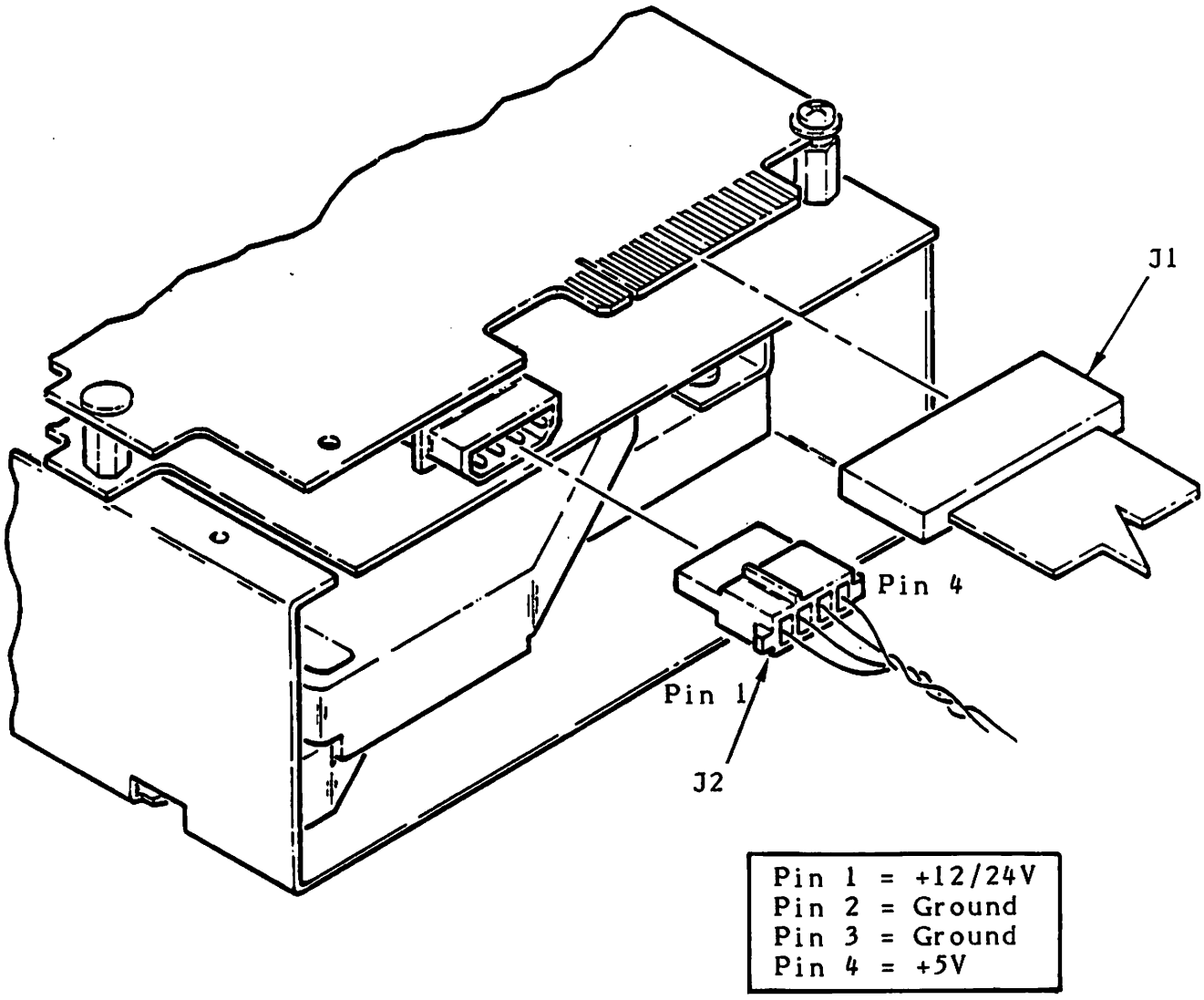


Figure 30. Partial View of the 540

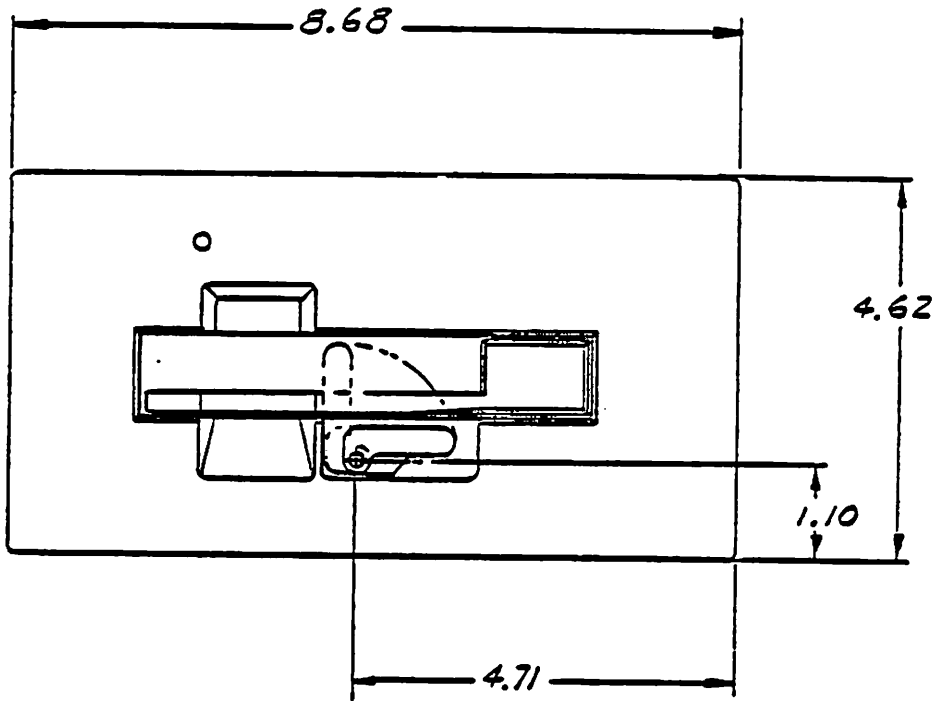


Figure 31. Front View of the 440

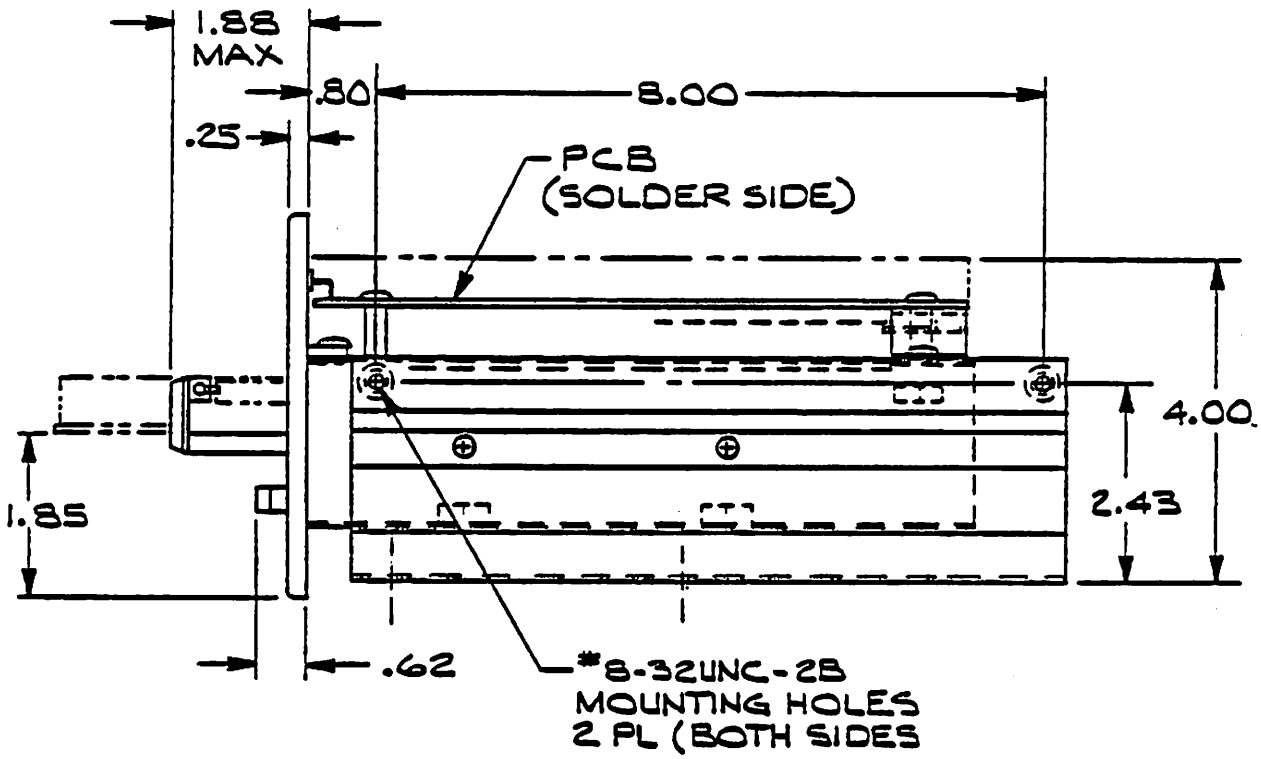


Figure 32. Right Hand View of the 440

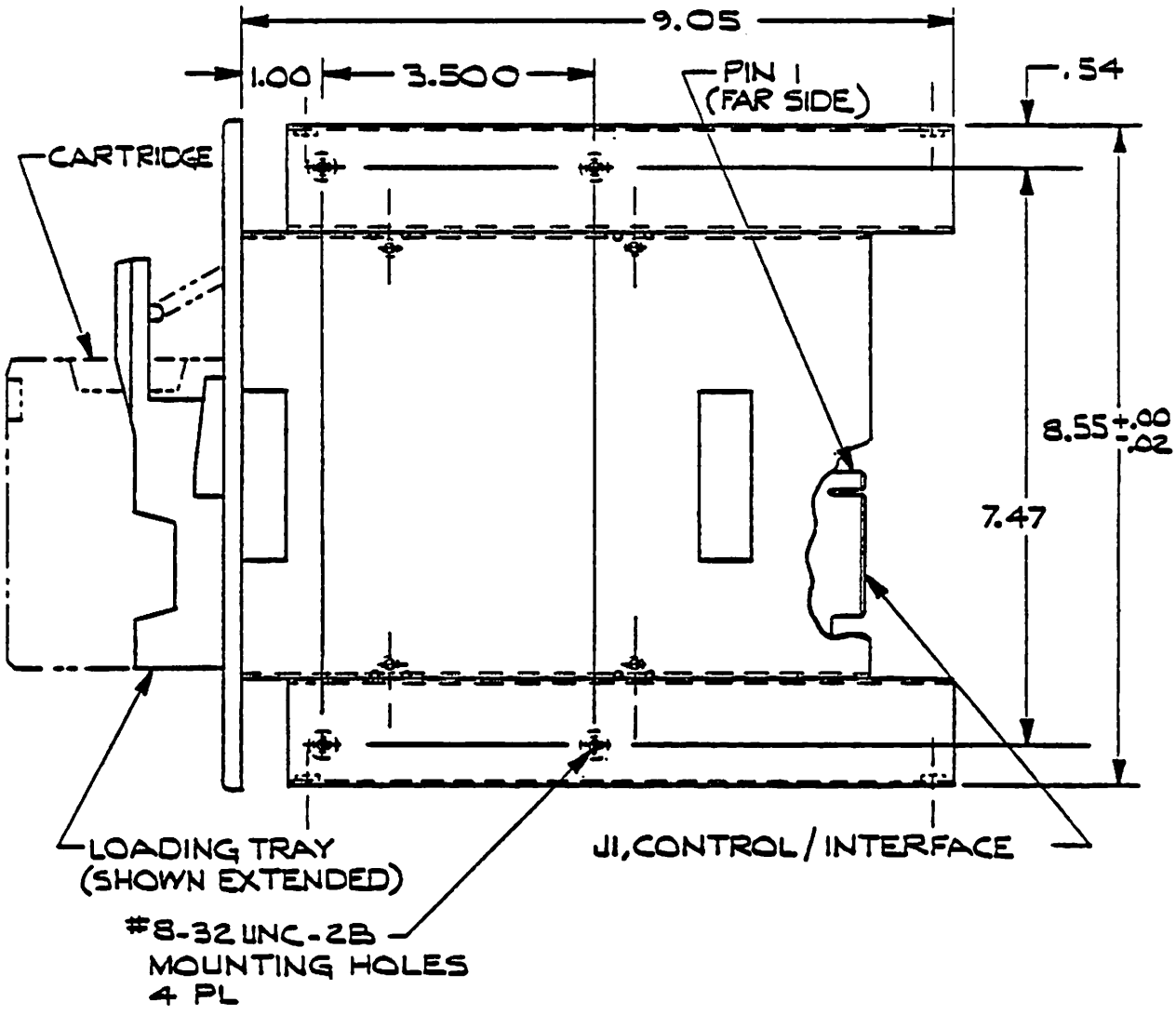


Figure 33. Bottom View of the 440

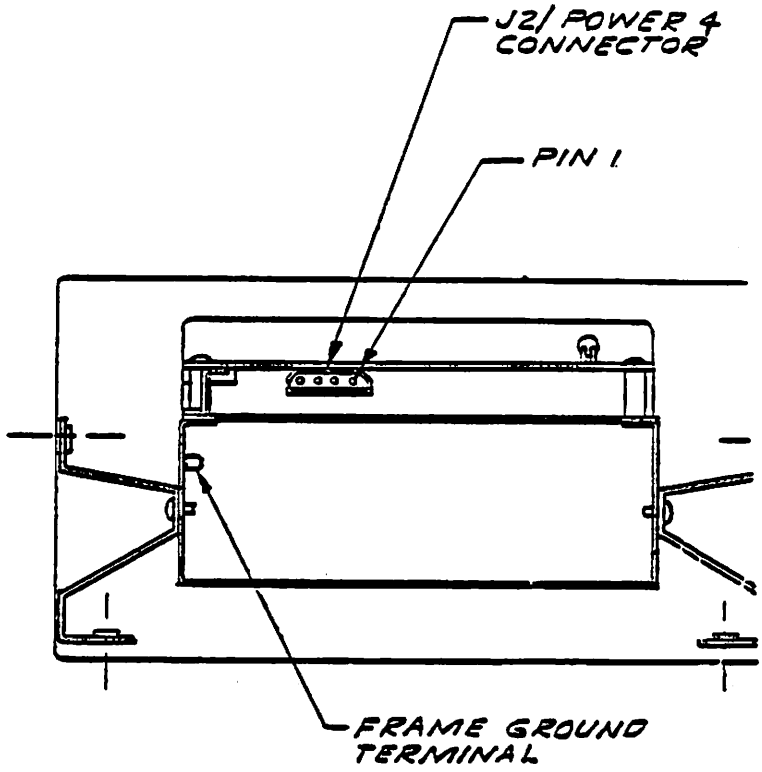


Figure 34. Partial View of the 440

Operating Temperature

A free air flow is required around the tape drive to prevent the ambient operating temperature of the drive from rising above 113° F (45° C). If this maximum ambient operating temperature cannot be maintained, forced air cooling should be used in the environment to maintain the cartridge base plate at the specified operating temperature of 45°C.

Cartridge Loading/Unloading

The cartridge tray loading mechanism is actuated by a front-mounted lever. This lever can be manually rotated a full 90 degrees. In the vertical position, the lever locks the inserted cartridge in the operational position. When the lever is horizontal, the cartridge tray is released and ready for cartridge insertion or removal.

As shown in Figure 35, the cartridge is loaded by inserting it into the tray and pushing it into the drive until it reaches the rear edge of the tray. This action automatically aligns the outer edge of the cartridge with the front of the tray. With a continuing push, the tray and cartridge moves to the rear stop, automatically opening the cartridge-protect door. Once the cartridge is fully inserted, it is automatically locked in place and seated correctly, relative to the Read/Write head.

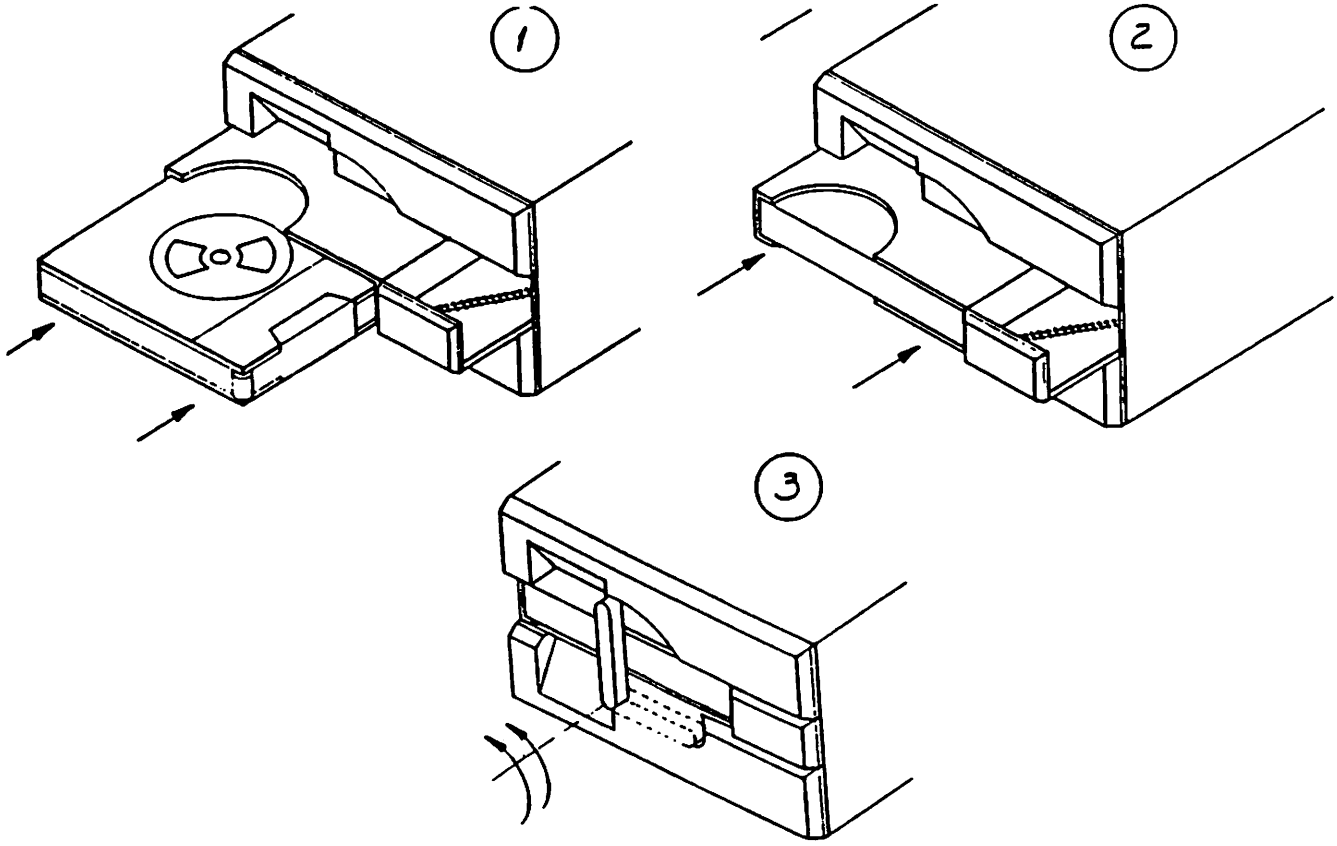


Figure 35. Tape Cartridge Loading Procedure

The cartridge is unloaded by moving the lever to the horizontal position.

Cleaning the Heads

The Read/Write heads can be swabbed gently with a lint-free swab moistened with Freon TF. After the heads have been cleaned, they should be allowed to dry thoroughly before the unit is used. It is not usually necessary to clean the heads more than once every 20 hours of actual tape movement.

APPENDIX A

SPECIFICATIONS

INTRODUCTION

The applicable specifications have been ascertained using a cartridge certified by Cipher in a 540 with a formatter PCB.

In the specifications for errors, it is understood that a recoverable error is one that can be overcome in no more that 16 retries.

Data Handling

Capacity (formatted)	
450-ft Cartridge	45 mb
555-ft Cartridge	55 mb
Recording Tracks:	9
Density	8,000 bpi
Transfer Rates	
90 ips	86.7 kbs
Maximum Burst	200 kbs
Recording Form	9-track, serpentine
Data Buffering	3 x 512 bytes
Recording Code	(0,2) Run Length Limited
Head Type	2-channel Read-After-Write with full-width AC Erase bar

Maximum Error Rate:*			
Soft Write	1×10^7		
Soft Read	1×10^8		
Hard Read	1×10^{10}		
Mean Time Between Failures	18,000 hours with 20% workload		

*Soft errors recoverable in 16, or fewer, tries

Power Requirements

DC Voltage			
Control	12V $\pm$ 0.6 Or 24V $\pm$ 2.4		
Logic	5V $\pm$ 0.25		
Maximum P-P Ripple (included in tolerance)	+12V +5V	200MV 50MV	
Standby Current:	+5V	+12V	+24V
Intelligent	1.0 Amps	200 MA	200 MA
Basic	0.8 Amps	200 MA	200 MA
Operating Current:			
Intelligent	2.2 Amps	1.8 Amps	0.9 Amps
Basic	0.8 Amps	1.8 Amps	0.9 Amps
Maximum Motor Startup Surge	2.6 A for 350 ms at +12V 1.3 A for 350 ms at +24V		
Power Dissipation			
Intelligent	30 Watts		42 Watts surge
Basic	28.1 Watts		37.7 Watts surge
Heat Dissipation			
Intelligent Normal Maximum	 66 BTU/hr (approx.) 143 BTU/hr (approx.)		

Dimensions & Weights

The hole spacing for the rack mounting is the same as a standard disk drive having the equivalent form factor.

540 (5 1/4-inch Form Factor)

Height	3.38 inches (8.59 cm)
Width	5.88 inches (14.94 cm)
Depth	8 inches (20.32 cm)
Weight	4.5 lbs (2.04 kg)
Maximum Shipping Weight	5 lbs (2.27 kg)

440 (8-inch Form Factor)

Height	4.62 inches (11.73 cm)
Width	8.68 inches (22.05 cm)
Depth	9.5 inches (24.13 cm)
Weight	5 lbs. (2.27 kg)
Maximum Shipping Weight	5 lbs. (2.27 kg)

Environmental Requirements

Temperature Range

Operating	+41° to +113°F (+ 5 to +45°C)
Non-Operating	-22° to +140°F (-30 to +60°C)

Relative Humidity*

Operating	20 to 80%, non-condensing
Non-Operating	1 to 90%, non-condensing

*at 26°C max, wet bulb (tape cartridge specification)

Altitude

Operating	Sea level to 10,000 feet (3 km)
Non-Operating	Sea level to 49,000 feet (15 km)

Temperature Gradient

Operating	1°C minute maximum

Shock (1/2 sine, 10 ms long)

Operating	2.5 G, 1/2 sine wave, 11 ms
Non-Operating	30 G*

* Shipping and short term storage (in Cipher shipping container which meets NSTA specifications)

Maximum Acoustic Output:

Open Frame	55 dba at one meter

Vibration

Frequency Range	5 to 500 Hz
Peak Acceleration	1G
Applicaton	3 orthogonal axes

APPENDIX B

540 BASIC DRIVE

INTRODUCTION

The 540 without the formatter pcb is called a basic drive. The block diagram for the basic drive is illustrated in Figure 36.

POWER REQUIREMENTS

Performance Specification

The surge current, caused by bringing the cartridge up to speed, lasts for 350ms.

	+5	VDC ± 5% @	1.3	Amp maximum		
	+12	VDC ± 5% @	1.8	Amps nominal,	2.6	Amps surge maximum
or	+24	VDC ± 10% @	0.9	Amp nominal,	1.3	Amps surge maximum

Power Dissipation

(5V X 1.3 Amp) + (12V X 1.8) = 28.1 Watts operational

(5V X 1.3 Amp) + (12V X 2.6 amps) = 37.7 Watts surge

INTERFACING

The basic drive has a streaming cartridge tape drive device level interface. It is designed to be connected to a compatible formatter in a separate electronics device. Signals are standard TTL voltage levels.

This interface is to be QIC-36 compatible. The 50-pin connector is to be compatible with the 3M 3415-0001, or equivalent. The signal cable is a 50-connector flat ribbon type; a 3M 3365/50 or equivalent is recommended.

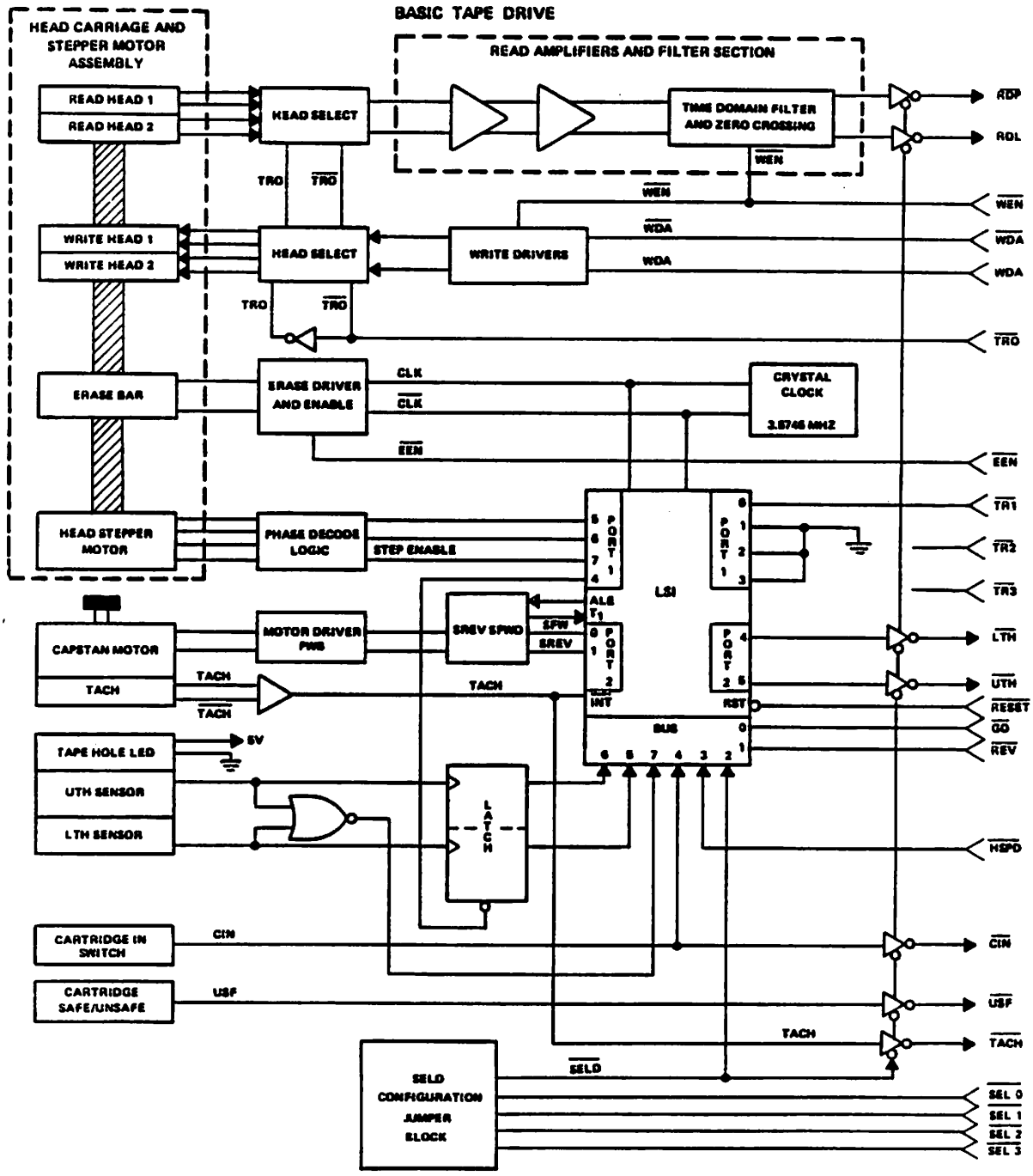


Figure 36. Basic Drive Interconnect Diagram

Connector Pin Assignments

There is a 34-pin I/O connector that connects the basic drive to the 50-pin basic adapter which replaces the formatter pcb.

The pin assignments for the 34-pin connector are listed in Table 5, except for pin numbers 8, 11, 12, 14, 22, 24, 26, 28, 30, and 32 which are connected to ground at the drive and should also be connected to ground at the formatter. Also unlisted are pin numbers 15, 16, 17, 18, and 21 which are connected to 5 volts at the drive.

Table 5. Formatter To Main PCB Connector

Pin Number	Name	In/Out	True	Description
19	TR0	In	High	Track Select bit 0
23	TR1	In	High	Track Select bit 1
20	TR2	In	High	Track Select bit 2
33	TR3	In	High	Track Select bit 3
9	WDA-	In	See Write & Erase Channels	Inverse Write Data signal
10	WDA	In	See above	Write Data Signal
1	RST-	In	Low	Reset Drive
29	WEN	In	High	Write Enable control
25	EEN	In	High	Erase Enable control
27	REV	In	High	Direction control for capstan servo
31	GO	In	High	Go control for capstan servo
7	KEY			Connector key
3	TACH-	Out	Low	Tachometer signal
34	NUS			Not used
2	LTH-	Out	Low	Lower Tape position code
4	UTH-	Out	Low	Upper Tape position code
5	USF-	Out	Low	Unsafe-cartridges safe plug in UNSAFE Position
6	CIN	Out	Low	Cartridge in pulse
13	RDP	Out	See Read Channel	Read Data pulse output

The pin assignments for the 50-pin basic drive interface are provided in Table 6. The odd numbered pins are connected to signal ground at the drive and should also be connected to signal ground at the host. In the "To" column of Table 6, D designates the drive and C the controller.

Table 6. Basic Drive Interface Connector

Pin Number	Name	To	Description
02	GO-	D	Go Control for Capstan Servo
04	REV-	D	Direction Control for Capstan Servo
06	TR3-	D	Track Select bit 3
08	TR2-	D	Track Select bit 2
10	TR1-	D	Track Select bit 1
12	TR0-	D	Track Select bit 0
14	RST-	D	Reset
16	DS3-	D	Drive 3 Select control
18	DS2-	D	Drive 2 Select control
20	DS1-	D	Drive 1 Select control
22	DS0-	D	Drive 0 Select control
24	RDL-	C	Read Level output - a digitized derivative of the analog read signal
26	RDP-	C	Read Pulse output - a pulse per flux transition
28	UTH-	C	Upper Tape position code
30	LTH-	C	Lower Tape position code
32	SLD-	C	Selected Response from selected drive
34	CIN-	C	Cartridge In Place
36	USF-	C	Unsafe - cartridge safe plug is in "unsafe" position (i.e. writing is enabled)
38	TCH-	C	Capstan Tachometer pulses - each pulse approximately equals 120 mils of tape movement
40	WDA-	D	Write Data signal
42	WDA+	D	Inverse Write Data signal
44	RES	D	Reserved
46	RES		Reserved
48	WEN-	D	Write Enable control
50	EEN-	D	Erase Enable control

Signal Explanations

The following paragraphs explain the functions of the more complex I/O signals.

TR0 - TR3 — The nine tracks are selected by a 4-bit binary number with a range of 00 to 08 (Hex).

RST- — On receiving this signal from the formatter, the LSI control device performs a power-up initialization and recalibrates the stepper motor positioner to the recalibrated reference position. The RST- must be asserted after a power-up sequence to assure the calibration of the head position.

TR1
REV
GO
CIN — These formatter control signals, with the drive tape hole pulse, are scanned at 1.7 ms intervals, after the RST- has been asserted. When found by the scan, the following drive functions are performed in the listed sequence: track position, tape hole responses, and motion control. Host control signals are also scanned at the 1.7 ms rate, unless the LSI control device is positioning, starting, or stopping the tape.

When found by the scan, TR1 causes a track position sequence to be performed in order to position the recording head on the required track. (For typical tape motion control timing, see Figure 37.)

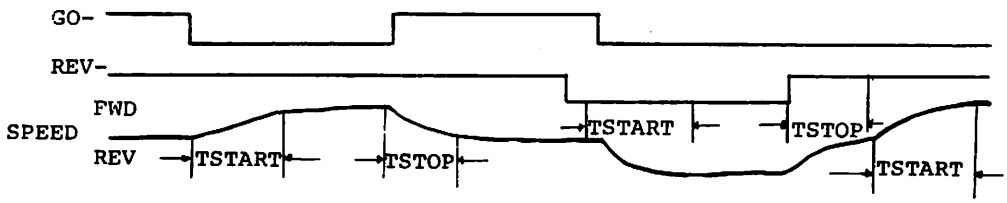


Figure 37. Typical Motion Control Timing

In this Figure, the approximate time for TSTART or TSTOP is 350 ms.

GO — When this pulse is scanned, it causes the tape to start in the direction specified by the state of REV. However, the state of TR1 or REV can be changed while GO is asserted. Changing the state of TR1 causes a Stop sequence, a track position sequence, and a Start sequence. Changing the state of REV causes a Stop sequence and a Start sequence in the opposite direction.

Tape Position Codes

Tape position code signals: Upper Tape Hole (UTH) and Lower Tape Hole (LTH) are generated by the LSI control device. These signals are defined in Table 7.

Table 7. Tape Position Codes

UTH-	LTH-	Description
True	True	Beginning Of Tape position - BOT holes nearest recording area just to the right of tape hole sensor
False	True	End of tape (EOT) position - EOT hole nearest recording area just to the left of tape hole sensor
True	False	Warning Zone - between BOT tape holes and Load Point hole or between Early Warning hole and EOT hole
False	False	Recording Zone - between Load Point hole and Early Warning hole if BOT or EOT position has occurred since the last cartridge insertion (CIN). Otherwise this code means that the tape position is unknown.

When a cartridge is inserted, the tape position is unknown. Therefore, the host should move the tape to BOT or EOT in order to have a known position. The host can move the tape to BOT by asserting REV and GO.

When the BOT is recognized by the LSI control device, UTH- and LTH- are asserted; the tape is stopped; and the control lines are scanned for GO and FWD, the reverse of GO. If the pulse is not found, the tape is moved forward to BOT and stopped. UTH- and LTH- continue to be asserted, if the host reverses the tape or does not move it.

When FWD and GO are found by the scan, the LSI control device asserts the Warning Zone indication, prior to initiating the tape start sequence. When the Load Point hole is seen by the LSI control device, Recording Zone is asserted. As forward motion continues, the Early Warning hole crosses the sensors and Warning Zone is asserted. When the EOT hole is seen by the LSI control device, the EOT position code is asserted, a tape stop sequence occurs, and the control lines are scanned for REV and GO. If REV and GO are not found, the tape is moved in reverse until the EOT hole is again seen, and then stopped. The EOT position code continues to be asserted as long as the host commands Forward, or there is no tape movement. When REV and GO are asserted, the LSI control device asserts the Warning Zone indication prior to initiating the tape start sequence. Further events in the reverse direction are analogous to the forward events.

Write & Erase Channels

The Write and Erase driver circuitry is illustrated in Figure 38.

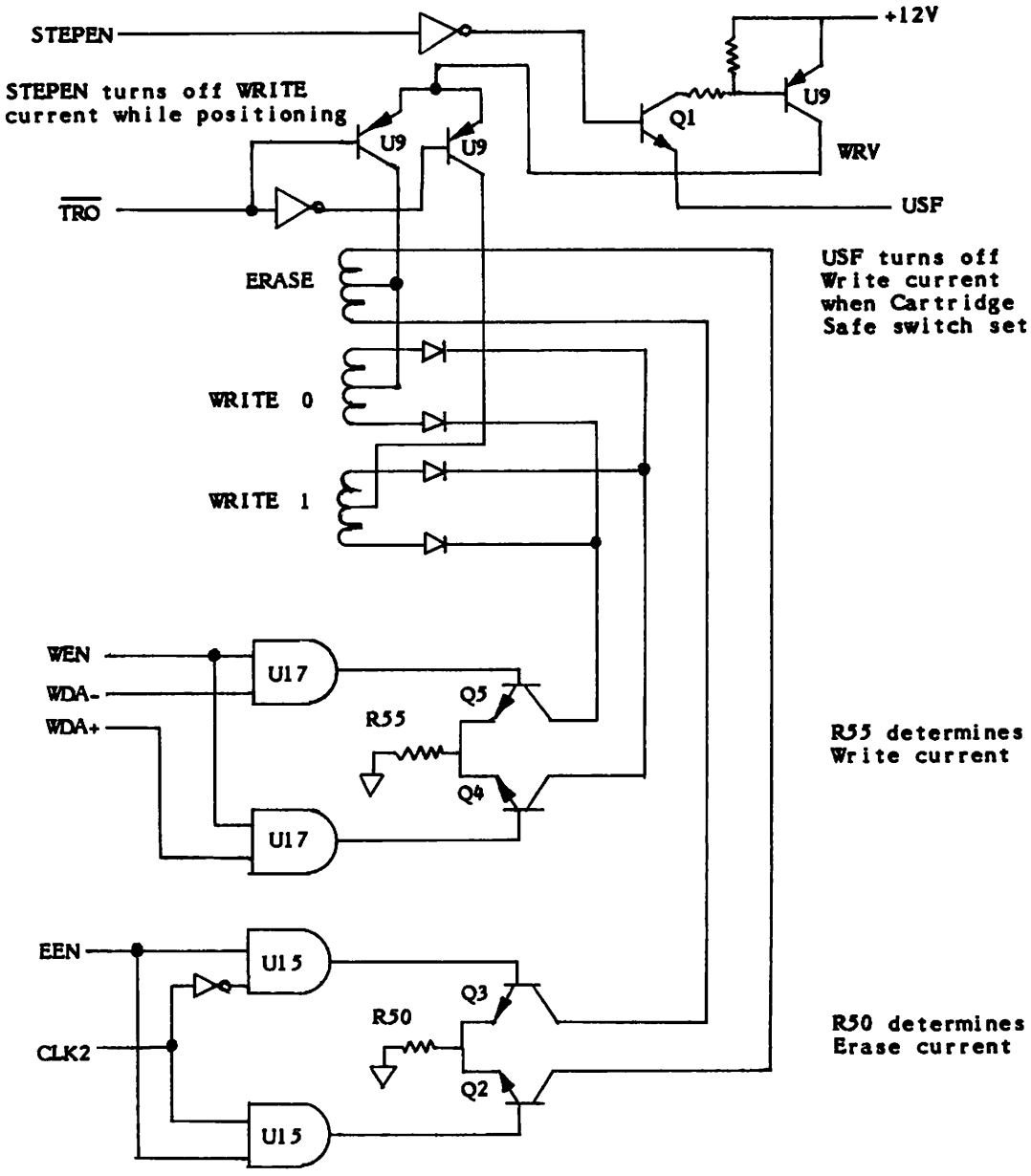


Figure 38. Write & Erase Drivers

The Write driver is enabled when the drive has been selected and the WEN line asserted. The enabled Write driver sends current to the selected Write head. When WDA+ is true and WDA- is false, it supplies negative current. When the signs are reversed, the supplied current is positive.

The other two combinations of WDA+ and WDA- are not allowed when Write is enabled. The maximum pause between WDA+ and WDA- is 15 nanoseconds.

Write head selection is controlled by TR0 and the Write driver which can only send current through the head connected to the Write Voltage. When TR0 is false, head 0 and the Erase Head are connected to the Write Voltage. When TR0 is true, head 1 is connected. The Erase driver is enabled when the drive is selected and EEN is asserted. The Erase clock is generated internally by the 540.

The Write channel is disconnected when the Safe switch is open, or during a power-up or power-down of the 5V DC. The Write, and Read, channels are designed for high-density digital recording and, therefore, low-density recording is not allowed. The recording code, when Write is enabled, must have data transitions occurring only at 1.11, 2.22, or 3.33 uS $\pm$ 1% intervals.

Selection of the Read head is controlled by TRO, as illustrated in Figure 39.

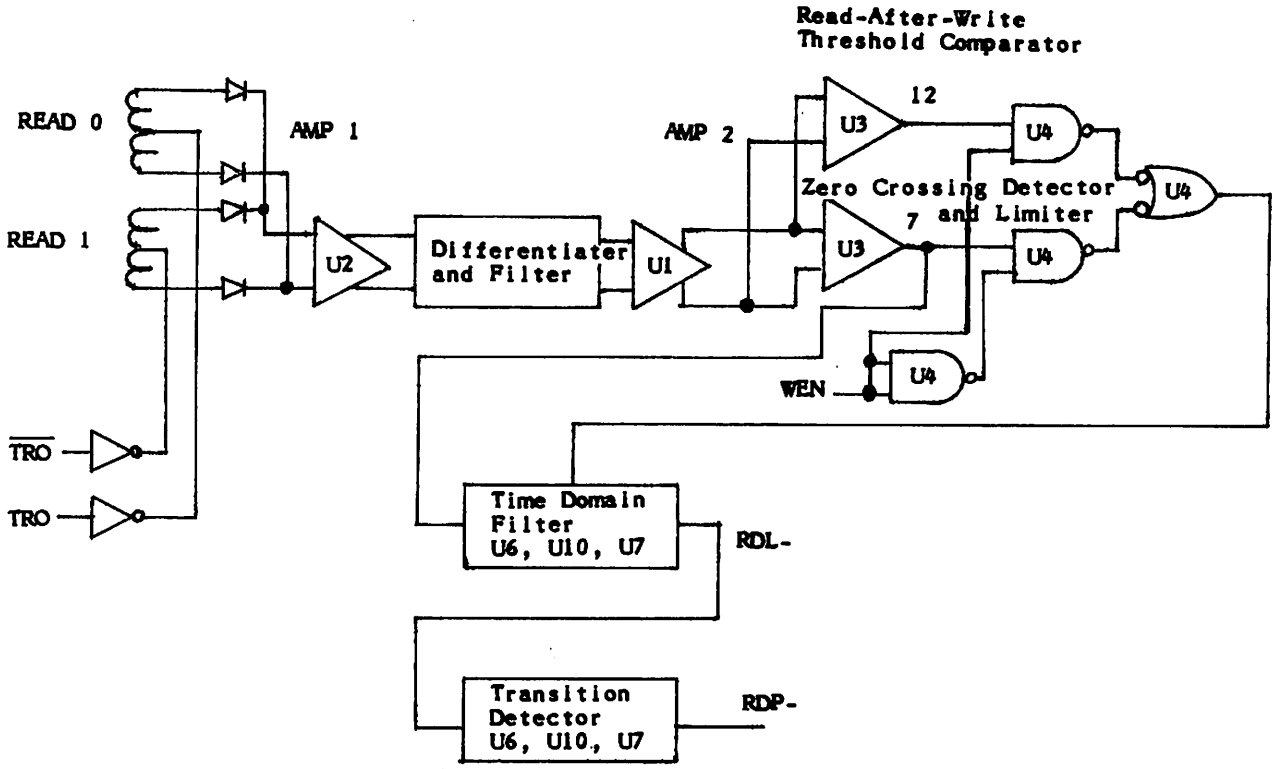


Figure 39. Read Channel

Head 0 is selected when TR0 is false, while Head 1 is selected when TR0 is true. For Read Only operations, the signal from the selected Read head is amplified, differentiated and filtered, amplified again, and converted to the logic level by a comparator and limiter. Transitions of less than half a data transition period are removed by the time-domain filter from the Read Data Level signal (RDL). The RDL, signal resembles the Write data (WDA-), Read Data Pulses (RDP) are generated at each transition of RDL, as shown in Figure 40.

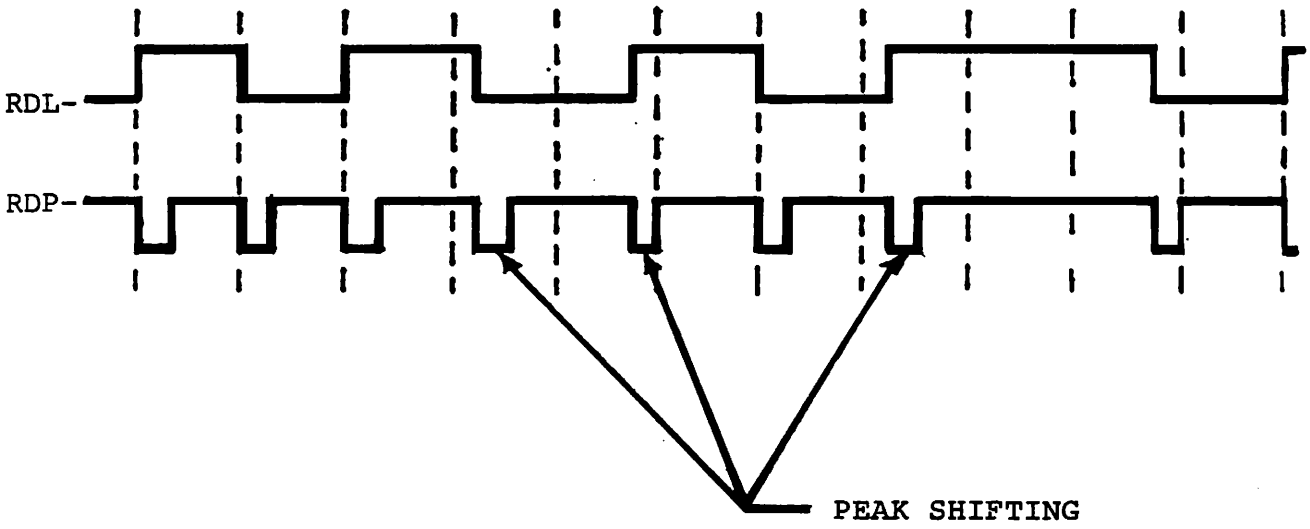


Figure 40. Read Signals

For Read-After-Write operations, 50% of nominal signal amplitude threshold is invoked to eliminate marginal recording areas from the tape.

The format should allow peak shifts (deviations of read level transitions) of up to $\pm$ 0.41 uS for tape recording areas in which the signal amplitude is not less than 25% of nominal. Peak shifts of up to $\pm$ 1/2 a data transition period, or greater, can occur in recording areas in which the signal amplitude is less than 25% of nominal.

Tape Media

It is recommeded that only 10,000 fci certified media be used in order to maintain the integrity of the 540 at its maximum recording density. Either the DC300XL or the 555 ft. cartridge can be used, depending on capacity requirements.

Drive Selection

Four Drives can be daisy chained to a single controller, as long as each has a different unit number. The maximum total cable length is ten feet, and only the last drive should have the U5 and U6 termination resistor packs. The drive select jumpers on the basic I/O adapter are shown in Table 8.

Table 8. Jumpers For Daisy Chaining

Drive	Jumper
0	W0
1	W1
2	W2
3	W3

If a jumper is not installed, that drive is always unselected.

DESIGN IMPLEMENTATION

The following information should be reviewed before installing a basic 540 tape drive.

VCO & Phase-Lock Loop

A Voltage Controlled Oscillator (VCO) and phase-lock loop are required to synthesize an adequate Read clock. This clock must be able to track the Instantaneous Speed Variations (ISV) of the tape and allow reliable recovery of high density data. The wide-band phase-lock loop filter allows the clock to track ISV frequencies as high as 20 KHz.

Retension

Tension between reels of the cartridge tape is required to maintain proper tape head contact for reliable recording. This requirement is achieved by maintaining the take-up reel at a higher tension than the supply reel with an iso-elastic band. Because the tape must be run both forward and backward, a reel is always being unwound at less tension than it was wound. Should "tape slip" occur, tape tension required for good head -to-media contact may be lost, resulting in data errors.

Cartridge tape manufacturers recommend a retension pass to correct this problem. A retension pass consists of continuous forward tape motion beginning at BOT and ending at EOT, followed by continuous reverse tape motion from EOT to BOT. The controller designer should provide a means by which the user can institute a retension pass when necessary. A retension pass takes two minutes. A retension pass is required more often when a cartridge is used in a continuous non-streaming mode.

Erase Action

An Erase pass on the cartridge tape removes all previously written data. This assures the user that there will be no old data on Track 0. An Erase pass takes two minutes, and the Erase frequency is greater than 1.7 mHz.

Overwriting

The basic 540 is not designed to allow overwriting.

Tape Repositioning

Identification is essential to rewrite data blocks inadvertently written in dropout regions of the tape; to reposition the tape during Read retries; and to resume a Read or Write operation after a tape stop. The drives long start/stop time and short gaps between records to achieve high capacity, are both inconsistent with block counting. Therefore, blocks must be identified with an address field which allows the host (formatter) to identify them. The recommendation is a 4-byte block address consistent with the QIC-24 specifications which allows each data block to have a unique address. Tape repositioning can then consist of stopping, backing up behind the desired block, and then running in the original direction. If the Read head is still not behind the desired block, the process can be repeated.

When repositioning to the last block to resume a halted Write operation, it should be kept in mind that the Write head is 0.300 inches ahead of the Read head and that this amount of recording length is lost each time the streaming operation is halted.

Read-After-Write Check

In order to avoid hard Read errors, user data must not be recorded in marginal recording areas of the tape. Blocks in these areas are usually detected by the formatter's Read-After-Write check and, if in error, rewritten in different recording areas. This technique is made much more effective if stringent requirements are placed on the Read-After-Write check. Although this may cause more blocks to be rewritten, it is possible that by writing a slightly larger percentage of the blocks, a tape could have no hard errors throughput in up to 5,000 passes (normal life of a tape).

More stringent Read-After-Write requirements are provided by the 540's 50% threshold capability. Additional stringency can be provided by use of a 75% window in the formatter that is centered on the expected data position. Then, data transitions occurring outside the window during the Read-After-Write check are not acceptable. For Read Only operations, a full 100% window should be used.

Further Information

For further information, please contact the 540 Product Manager, Cipher Data Products, Inc. 7301 Orangewood Avenue, Garden Grove, California 92641, (714) 891-3711 (TWX: 910-596-1870)

APPENDIX C

ENHANCED 540 DRIVE

INTRODUCTION

The Enhanced 540 is form, fit, and functionally compatible with the existing 540 product series. A number of mechanical enhancements have been incorporated along with added electronics and firmware functions. This combination of mechanical and electronics changes has made the Enhanced 540 one of the most functionally versatile and reliable 1/4" cartridge tape drives available.

The mechanical changes have been introduced to ensure reliability by reducing the total parts count in the unit, and to improve the functional cartridge load mechanism. The mechanical parts count has been reduced by 30%, by using alternative design methods, and combining multiple part sub-assemblies into single-piece sub-assemblies. These methods have virtually eliminated multiple moving parts that perform single functions, increasing manufacturing consistency. Another area of design improvement is the use of lower friction, higher lubricity materials in mechanisms that that require friction contact parts. These changes are detailed on the following pages.

In the area of electronics, changes made have also been implemented to improve performance and reliability. In the performance area, functionality has been increased, without diminishing any of the features of the Standard 540. A series of short command driven self test-routines, including read/write testing, have been added which verify many functions of the 540.

Additional Read-On-The-Fly and Write-Filemark-On-The-Fly commands increase performance and throughput, by adding the capability to maintain streaming with multiple files; not possible in standard QIC-02 products. Cipher has also added a unique Search Command that offers direct data block accessibility, instead of file accessibility. This is done with an internal algorithm that does not require sequential streaming to locate the desired target block, saving minutes in locating a particular area on the tape.

Another major enhancement to cartridge interchange and reliability has been added with the implementation of track offset data recovery. This change automatically positions the 540 head vertically during read recovery, adding a greater margin in recovering recorded data, even under the most extreme conditions. This function is transparent to the QIC-02 interface.

The Enhanced 540 can be identified by the assembly number series. The Standard 540 has a 960273-0xx number series placed on the bottom of the drive, while the Enhanced 540 products are number 960273-6xx on the side of the drive; the xx being the consecutive numbering series for either product line.

MAJOR MECHANICAL ENHANCEMENTS

The Enhanced 540 has been designed with 10 major mechanical improvements to improve and simplify its power and usefulness.

1 Reliability improved, by reducing the number of mechanical parts by 30%. This includes a 40% reduction in positioner drive parts (see #2), and a 45% reduction in total parts in the cartridge registration lifters (see #6).

2. Friction and gear backlash reduced, by replacing the gear-to-gear positioner drive with a coupled drive. This enhancement also reduces, to almost zero, the noise usually produced by the positioner gear drive.

3. Cartridge loading/unloading operation improved, by adding spring action to actuator rod. This provides the cartridge loading lever with over-travel when it is moved from the horizontal to the vertical locking position, providing a more positive detent. The lever is also spring assisted when moved from the vertical to horizontal position to facilitate unloading.

4. Reliability improved, by eliminating the two moving parts that make up the switch arm extension. This extension is replaced by direct activation of cartridge-in-place and write- protect switches.

5. Air flow increased, by eliminating the bottom cover.

6. Reliability, tolerances, and precision improved by the new zinc die-cast construction of cartridge registration lifters which eliminates moving parts, and increases the registration accuracy of this critical component.

7. Cartridge stability increased, by redesigning the cartridge hold-down clamp. The clamp now has a spring loaded trigger to help guide the cartridge past the read/write head during loading; then release the clamp. This design also helps protect the drive, if the cartridge is inserted at an angle, and increases the reliability of the opening action of the cartridge door.

8. Load lever operation simplified and made more precise, by replacing the formed curved rod with a square shaft actuator rod.

9. Head positioner life lengthened, by increasing lubricity through the use of high lead brass and high nickel stainless steel.

10. Mechanical stress diminished without loss of tolerances, by using a 3-point mounting suspension design for the deck casting.

IMPROVED MAIN BOARD ELECTRONICS

The new main board electronics in the Enhanced 540 include three important design enhancements that greatly increase the functionality of the drive.

1 Automatic write current selection, by redesigning firmware and hardware to include the detection of DC300XL or DC600A type cartridges. (The actual DC600A cartridge is not recommended, because its abrasiveness can cause excessive head wear.) Media identification is made by sensing the distance between BOT and load point, and enabling the appropriate write current and read amplifier levels in the switch circuitry. This detection is done only at BOT, following a reset or a cartridge change.

2 More efficient drive circuitry, by redesigning the capstan motor drive circuit to improve switching efficiency for better thermal operating characteristics.

3 Simpler +12V To +24V conversions with a single jumper. (Refer also to paragraphs on Enhanced Jumper Configuration.)

4. Addition of a device ready line from the main board to the formatter (J8, Pin 34) to allow communications between boards. Used with the new track-offset read recovery feature that is in the firmware of both boards, this jumper permits the passage of track offset commands on track address lines. The device ready line acts as a ready/busy line from the main board to the formatter, when in track offset mode.

ENHANCED FORMATTER ELECTRONICS

The enhanced command set includes all QIC-02 standard and optional commands listed in Table 3 of the Cipher 540 Product Description Manual, with the additions listed in Table 9 and a change in Run Self Test I:

Table 9. Additional QIC-02 Commands

Command	Hex	Bit Pattern MSB	LSB	QIC-02
Run Self Test II	CA	1100	1010	0
Write Filemark On The Fly	62	0110	0010	Vendor Unique
Read On The Fly	82	1000	0010	Vendor Unique
Block Search	AD	1010	1101	Vendor Unique
Disable Track Offset	29	0010	1001	Vendor Unique
Enable Track Offset	2A	0010	1010	Vendor Unique
Disable Offset Append	2B	0010	1011	Vendor Unique
Enable Offset Append	2C	0010	1100	Vendor Unique
Reserved*	CB	1100	1011	
Reserved*	C4	1100	0100	

*Reserved commands are not defined, but are accepted by the 540. Therefore, they do not cause an illegal command status exception.

Explanations of Command Additions

Run Self Test I (C2) - The changed command performs a check sum test. Following completion, a Read Status Command should be issued to verify results in Status Byte 3, as shown below. Command timing is illustrated in Figure 41.

Status Byte 3:
00 = Self Test not performed
11 = Self Test complete. No error.
24 = Self Test failed. Check sum error.

Run Self Test II (CA) - This command performs the following sequential tests and reports status in Bytes 3, 4 and 5. After each test has passed, the next test is automatically run. Following completion, a Read Status Command should be issued to verify results. Command timing is illustrated in Figure 41.

Caution: Self Test II writes to the cartridge. Ensure only a scratch tape cartridge is installed.

1. Speed Test - Monitors tachometer pulses to verify tape speed.
   Fail = Status Byte 3 = 23 = Speed error.
   Status Byte 4 = 01 = Test 01.

2. Sensor Test - Rewinds the tape, detects BOT, and moves forward to ensure that the sensors detect when the load point is passed.
   Fail = Status Byte 3 = 23 = Sensor error.
   Status Byte 4 = 02 = Test 02.

3. Write Test - This test writes 16 data blocks followed by 16 filemarks, and verifies internal write completion for each block.
   Fail = Status Byte 3 = 22 = Write/Read error.
   Status Byte 4 = 03 = Test 03.
   Status Byte 5 = 01 = Speed or sensor error.
   = 03 = Write timeout error.

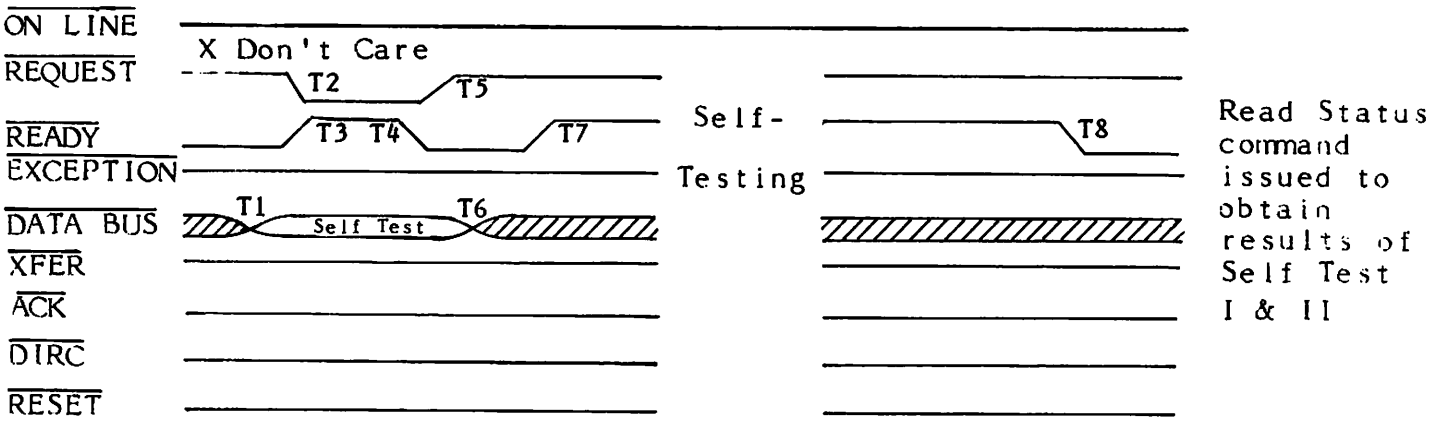
4. Read Test - This test verifies read data, read filemark, and gap detect
   Fail = Status Byte 3 = 22 = Read error.
   Status Byte 4 = 04 = Test 04.
   Status Byte 5 = 01 = Sensor or speed error.
   = 02 = Overrun detector error.
   = 03 = Read timeout*.
   = 04 = Unable to read*.
   = 05 = Unable to read filemark.
   = 06 = Gap detect failure.

byte 4 = Test ID of Test last executed

byte 3 = Test Function ID

byte 5 = Error Code

*If write protected cartridge is used with Self Test II, Test 4 will fail here, and status Byte 0 will indicate write protect status.



	ACTIVITY	TIMING
T1	Host command to bus	N/A
T2	Host sets REQUEST	T1→T2>0 uS
T3	Controller resets READY	T2→T3<1 uS
T4	Controller sets READY	T3→T4>20 uS (500 uS nom.)
T5	Host resets REQUEST	T4→T5>0 uS
T6	Bus data invalid	T4→T6>0 uS
T7	Controller resets READY	20 uS<T5→T7< 100 uS
T8	Controller sets READY	T7→T8>20 uS

Figure 41. Run Self Test I & II

5. Erase Test - This test erases a portion of tape from BOT, and verifies that it is erased.

Fail =	Status Byte 3	= 22	= Write/Read error.
	Status Byte 4	= 05	= Test 05.
	Status Byte 5	= 01	= Speed or sensor error.
		= 03	= Erase error.

6. Write Test - This test verifies single block write function.

Fail =	Status Byte 3	= 22	= Write/Read error.
	Status Byte 4	= 06	= Test 06.
	Status Byte 5	= 01	= Speed or sensor error.
		= 03	= Write timeout.

7. CRC Test - This test verifies the CRC check function, and performs a positioning test.

Fail =	Status Byte 3	= 22	= Write/Read error.
	Status Byte 4	= 07	= Test 07.
	Status Byte 5	= 01	= Speed or sensor error.
		= 02	= Position error.
		= 03	= CRC failed.
Pass =	Status Byte 3	= 11	= Self Test complete. No error.
	Status Byte 4	= 07	= Test 07.
	Status Byte 5	= 00	

This concludes Self Test II. If all the tests are passed, the tape is erased and rewound to BOT, and the Self Test complete status can be found by issuing a Read Status command. If an error occurred, the test is stopped at that point, and the error status defined, as shown above.

Self Test II is a functional verification of the 540, and may be used as an incoming test or as an isolation test of a specific drive failure. It allows the system to verify quickly that the 540 drive is functioning.

Write Filemark On The Fly (62) - The WFOTF command has all the attributes of a Write Filemark command, except tape motion is not terminated immediately after writing the filemark. Instead, the 540 writes an elongated postamble, waiting for the host to respond with a new Write command. If the host fails to respond with a new Write command within 7.0 msec., the 540 terminates the Write Command and stops tape motion. If the host reinstructs the 540 with a new Write command within the allowed 7.0 msec., then an additional 3.5 msec. is allowed to complete the data block transfer from the host to the 540. If the 540 is reinstructed within the 7.0 msec., but a 512 byte data block is not transferred within the 10.5 msec. time allowed, the 540 will perform a write underrun sequence and stop tape motion. If the data block transfer is completed after the underrun, the 540 will reposition and continue writing as if following a normal underrun.

Proper termination of a Write command can be accomplished in one of two ways. First, after issuing a WFTOF, the host can force a write underrun condition. In this case, tape motion is terminated and the 540 exits the write mode. Second, the host can inactivate Online. In this case, a filemark is written and the tape is rewound. If Online is inactivated following a Write Filemark Command, then the tape is rewound. (Timing for WFOTF is shown in Figure 42)

Read On The Fly (82) - The ROTF command has all the attributes of a Read command, except tape motion is not terminated immediately after reading the filemark. This allows the host to maintain streaming, when reading cartridges written with a large number of short files.

When the host issues a ROTF command, the 540 starts reading. If a filemark is detected, the 540 will set an Exception. To maintain streaming, the host must issue a Read Status command, complete a read status sequence, and reinstruct the 540 with a new ROTF command within 8 msec. If the host is unable to meet these requirements, a read overrun will occur, tape motion will be stopped, and the read will be terminated. (Timing for ROTF is shown in Figure 43.)

Block Search Command (AD) - This command allows the host to search for a specific block on tape without streaming sequentially through the entire tape. The sequence for this command is:

1. The host issues the Block Search command followed by a 4-byte block, using the request/ready handshake. The most significant block address byte is issued first.

2. The 540 calculates a track position and motor direction.

3. The 540 enables the capstan motor, and updates the track position.

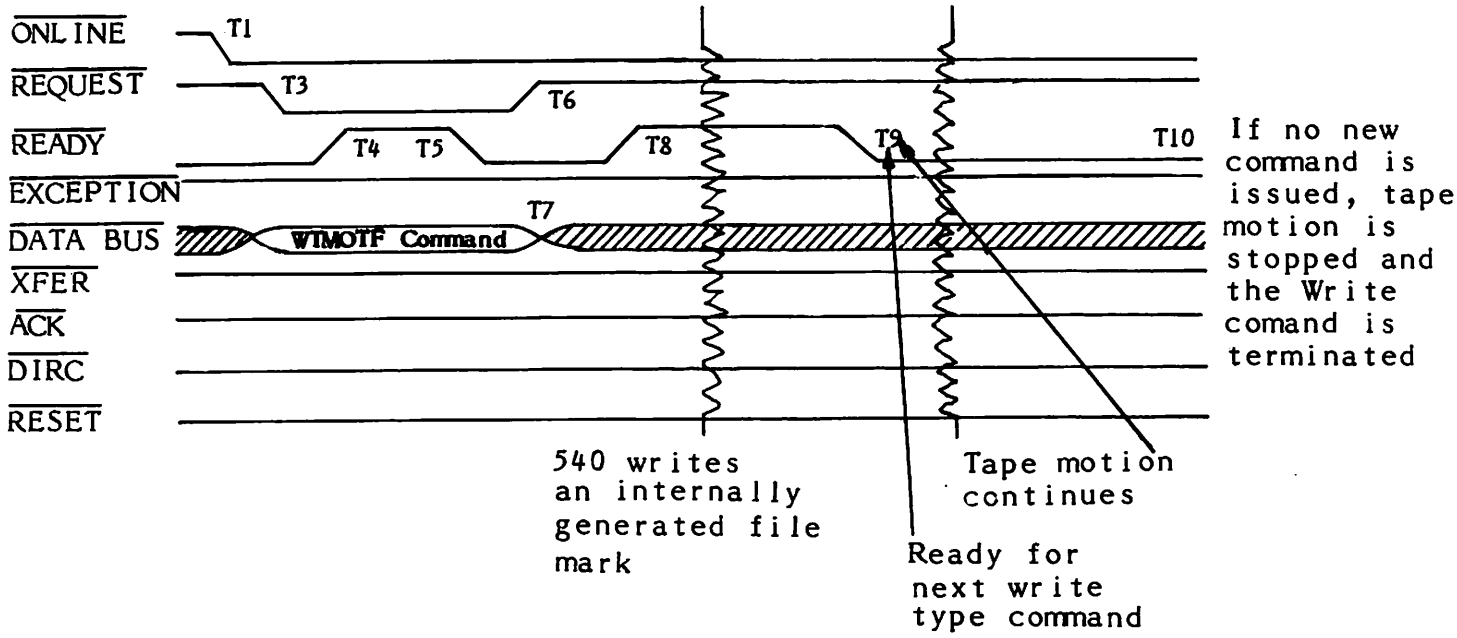
4. The 540 searches for the target block, minus one.

5. When found, the 540 enables Ready.

6. If the block search was nested in a Read command, the host may resume reading. If not, tape motion stops, the 540 terminates the search, and waits for another command.

7. If the 540 fails to locate the target block, it will reposition, and try again. If the 540 again fails to locate the target block, the tape is rewound, Exception is set, and the command aborted. Following an abort, the following read status will show the following in Status Bytes 0 and 1, indicating an unrecoverable data error and BOT:

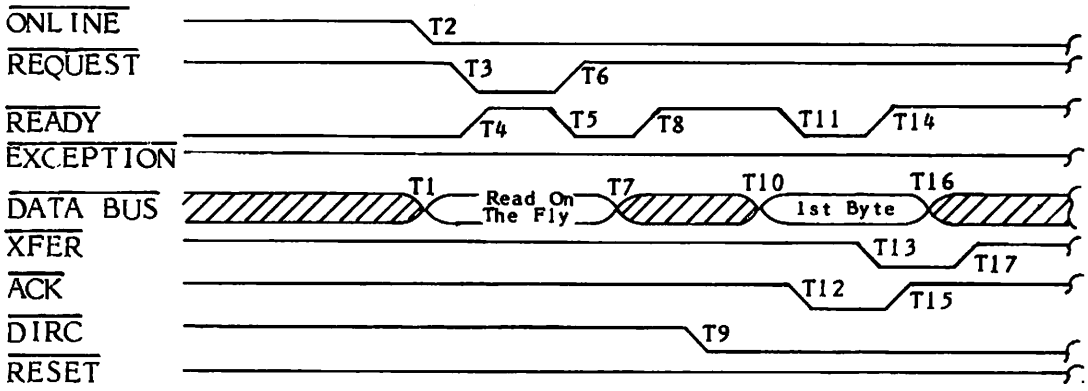
Byte 0	**Byte 1**
100X0100	10001000

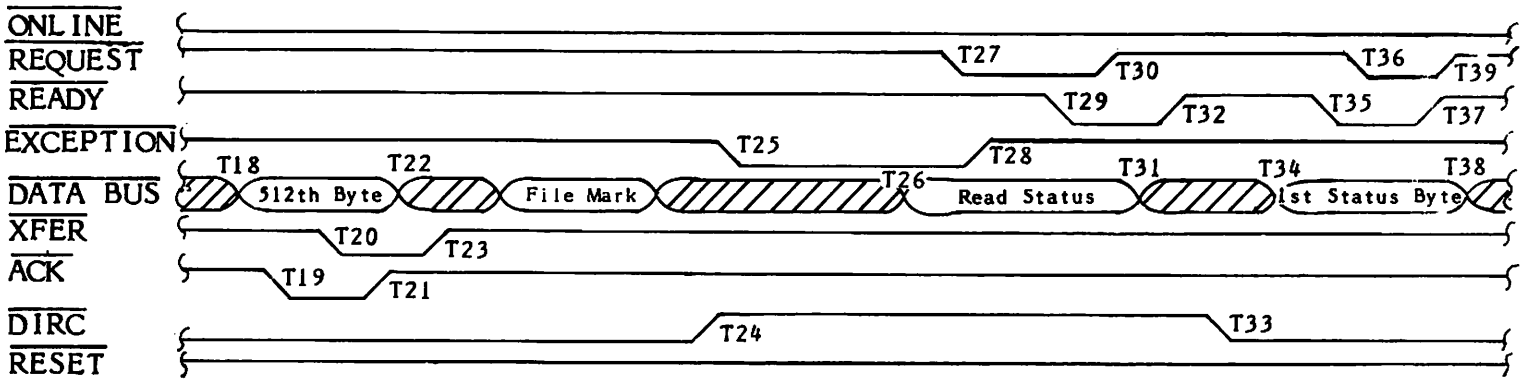


Write Filemark on the Fly

	ACTIVITY	TIMING
T1	Host sets ONLINE	N/A
T2	Host command to bus	T1→T2 >0 uS
T3	Host sets REQUEST	T2→T3 >0 uS
T4	Controller resets READY	T3→T4 <1 uS
T5	Controller sets READY	T4→T5 >20 uS (500 uS nom.)
T6	Host resets REQUEST	T5→T6 >0 uS
T7	Bus data invalid	T5→T7 >0 uS
T8	Controller resets READY	20 uS< T6 –T8< 100 uS
T9	Controller sets READY	N/A
T10	No command issued Write terminated	T9→T10>7 mS

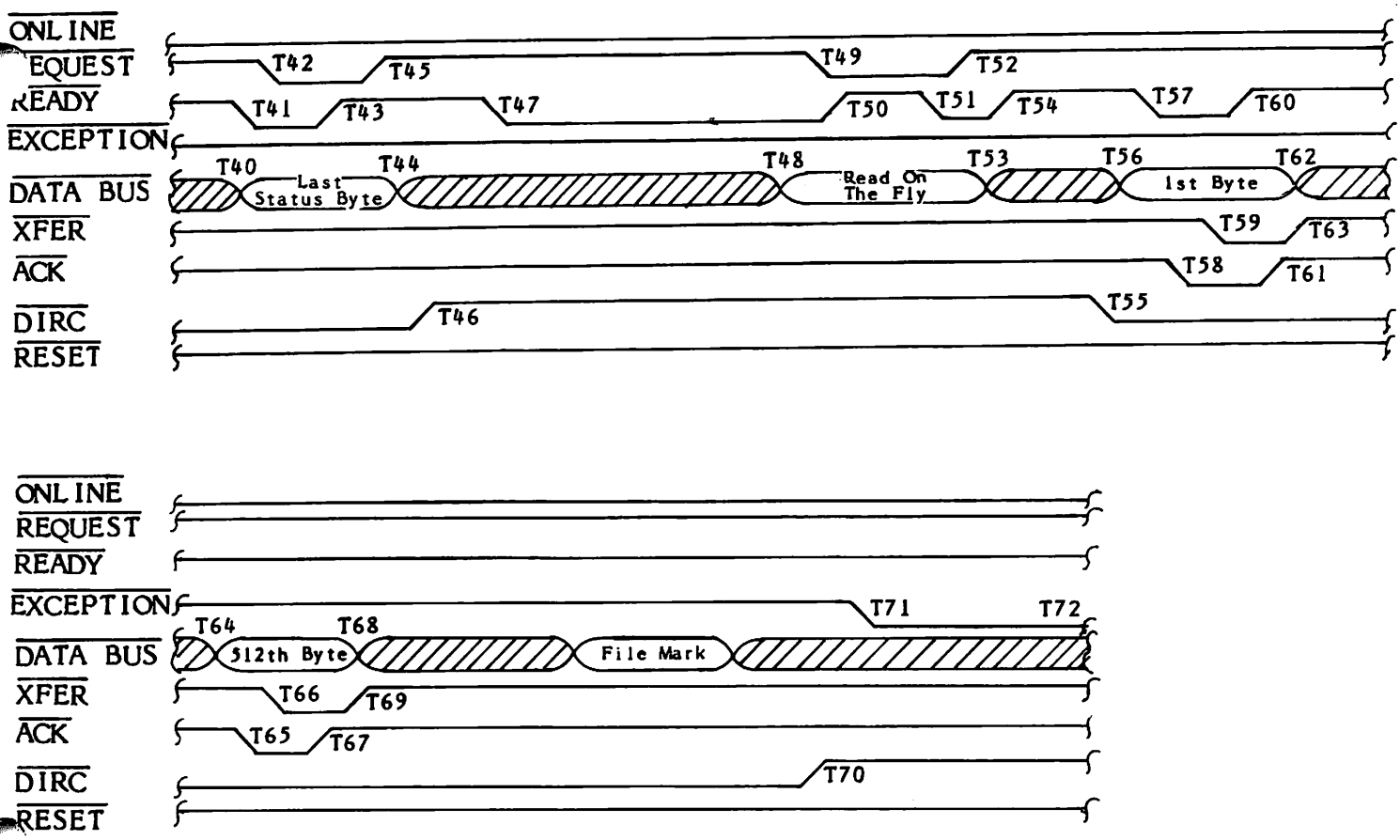
Figure 42. Write Filemark On The Fly (WFTOF)





T1	CPU command to bus	N/A
T2	CPU sets ONLINE	N/A
T3	CPU set REQUEST	T2→T3>Ø uS
T4	Formatter resets READY	T3→T4<1 uS
T5	Formatter sets READY	T4→T5>20 uS (500 uS nom.)
T6	CPU resets REQUEST	T5→T6>Ø uS
T7	Bus data invalid	T5→T7>Ø uS
T8	Formatter resets READY	20 uS<T6-T8<100 uS
T9	Formatter changes DIRC	N/A
T10	Data byte to bus	N/A
T11	Formatter sets READY	N/A
T12	Formatter sets ACK	T11→T12>-40 nS
T13	CPU sets XFER	T12→T113>Ø uS
T14	Formatter resets READY	T13→T14<1 uS
T15	Formatter reset ACK	0.5 uS<T13→T15<3 uS
T16	Bus data invalid	T13→T16>Ø uS
T17	CPU resets XFER	T15→T17>Ø uS
T18	Data to bus	N/A
T19	Formatter sets ACK	T18→T19>Ø uS
T20	CPU sets XFER	T19→T20>Ø uS
T21	Formatter resets ACK	0.5 uS<T20→T21<3 uS
T22	Bus data invalid	T20→T22 Ø uS
T23	CPU resets XFER	T21→T23 Ø uS
T24	Changes bus DIRC	T23→T24 Ø uS
T25	Formatter sets exception	T24→T25 Ø uS
T26	CPU command to bus	N/A
T27	CPU sets REQUEST	T26→T27>Ø uS
T28	Formatter resets exception	T27→T28>Ø uS
T29	Formatter sets READY	T27→T29>20 uS (500 uS nom.)
T30	CPU resets REQUEST	T29→T30>Ø uS
T31	Bus data invalid	T29→T31>Ø uS
T32	Formatter resets READY	20 uS<T30-T32<100 uS
T33	Formatter changes bus DIRC	N/A
T34	First status byte to bus	N/A
T35	Formatter sets ready	T32→T35>20 uS
T36	CPU sets REQUEST	N/A
T37	Formatter resets READY	T36→T37<2 uS
T38	Bus data invalid	T36→T38>Ø uS
T39	CPU resets REQUEST	T36→T39>20 uS

Figure 43. Read On The Fly (ROTF) (1 of 2)



	ACTIVITY	TIMING
T40	Last status byte to bus	N/A
T41	Formatter sets READY	Same as T35
T42	CPU sets request	Same as T36
T43	Formatter resets READY	Same as T37
T44	Bus data invalid	Same as T38
T45	CPU resets REQUEST	Same as T39
T46	Formatter changes bus DIRC	T45→T46>Ø uS
T47	Formatter sets READY	T46→T47>Ø uS
T48	CPU command to bus	N/A
T49	CPU sets REQUEST	N/A
T50	Formatter resets READY	T49→T50<1 uS
T51	Formatter sets READY	T50→T51>20 uS (500 uS nom.)
T52	CPU resets REQUEST	T25→T52<8 mS
T53	Bus data invalid	T51→T53 Ø uS
T54	Formatter resets READY	20 uS<T52→T54<200 uS
T55	Formatter changes DIRC	N/A
T56	Data byte to bus	N/A
T57	Formatter sets READY	N/A
T58	Formatter sets ACK	T57→T58>-40 nS
T59	CPU sets XFER	T58→T59>Ø uS
T60	Formatter resets READY	T59→T60<1 uS
T61	Formatter resets ACK	0.5 uS<T59→T61<3 uS
T62	Bus data invalid	T59→T62>Ø uS
T63	CPU resets XFER	T61→T63>Ø uS
T64	Data to bus	N/A
T65	Formatter sets ACK	T64→T65>Ø uS
T66	CPU sets XFER	T65→T66>Ø uS
T67	Formatter resets ACK	0.5 uS<T66→T67<3 uS
T68	Bus data invalid	T66→T68>Ø uS
T69	CPU resets XFER	T67→T69>Ø uS
T70	Changes bus DIRC	T69→T70>Ø uS
T71	Formatter sets exception	T70→T71>Ø uS
T72	Read terminated	T71→T72>8 mS

Figure 43. Read On The Fly (ROTF) (2 of 2)

Before using the Search command, it is necessary to know how many data blocks are recorded on a cartridge. Tape block addresses are sequential and the first block address at BOT Track 0 is 0001. Filemarks are sequential with data block addresses. A convenient method of identifying block addresses is to write a label block in the data field as either the first or last block in a file. This block can then be used as a reference, prior to using the Search command. (Timing for Block Search command is shown in Figure 44.)

Backspace (89) - This command is an enhanced version of the Space Reverse command, shown in Figure 21 in the Product Description manual. When nested in a read sequence, it is actually a Backspace Read which physically repositions and rereads the previous data block. Once the data block is read, the command returns the tape to the original position. If the data block is not read by the host, multiple nested backspaces will position tape reverse, a block at a time.

The 540 presents the first data byte of the previous data bloack command to the bus, and maintains the read sequence. This is a particularly useful way to recover from a read parity error. The read sequence is terminated if a filemark is read, and the 540 must be reinstructed with a new Read command to continue reading.

In the enhanced version, the Backspace command can also be a stand-alone instruction. In this case, it positions the tape, but does not present data to the bus. Multiple commands will position tape reverse, a block at a time.

A Backspace command issued at BOT results in an Exception.

Disable/Enable Track Offset (29/2A)
Disable/Enable Offset Append (2B/2C) - These four enhanced mode select commands can be used to modify the 540 track offset recovery method, as explained below.

When powered on or reset, the Standard 540 defaults with the offset enabled for read mode operation and disabled for the write append operation. This allows track offset head positioning in ± 4 mil and ± 8 mil increments from the mechanical nominal position during read retry recovery sequence. Data can only be appended to prerecorded data at the mechanical nominal track position, even if a previous read required a ± 4-mil offset to recover the prerecorded data. If a previous read required an ± 8-mil offset to recover prerecorded data, the Write Append will not be allowed. In this case, the 540 will flag a hard write error with Exception, abort the write operation, and rewind the tape.

The track offset read recovery sequence invokes a 20-reposition/read retry algorithm in the normal error recovery process. If the 540 is at the mechanical nominal position, the read retries are done in the sequence and amount shown in Table 10.

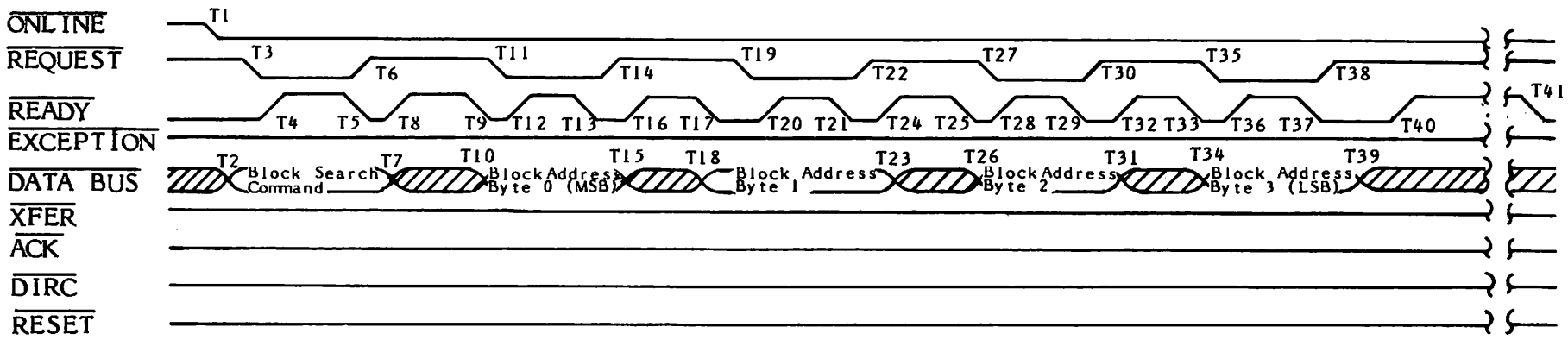


Figure 44. Block Search Command

	ACTIVITY	TIMING
T1	Host sets ONLINE	N/A
T2	Host command to bus	N/A
T3	Host sets REQUEST	T2→T3>0 uS
T4	Controller resets READY	T3→T4<1 uS
T5	Controller sets READY	T4→T5>20 uS (500 uS nom.)
T6	Host resets REQUEST	T5→T6>0 uS
T7	Bus data invalid	T5→T7>0 uS
T8	Controller resets READY	20 T6→T8 100 uS
T9	Controller sets READY	20<T8→T9<100 uS
T10	Bus data valid byte 0 (MSB)	N/A
T11	Host sets REQUEST	T9→T11>0 uS
T12	Controller resets READY	T11→T12<1 uS
T13	Controller sets READY	T12→T13>20 uS (500 uS nom.)
T14	Host resets REQUEST	T13→T14>0 uS
T15	Bus data invalid	T13→T15>0 uS
T16	Controller resets READY	20<T14→T16<100 uS
T17	Controller sets READY	20<T16→T17<100 uS
T18	Bus data valid byte 1	N/A
T19	Host sets REQUEST	T17→T19>0 uS
T20	Controller resets READY	T19→T20<1 uS
T21	Controller sets READY	T20→T21>20 uS (500 nom.)

	ACTIVITY	TIMING
T22	Host resets REQUEST	T21→T22>0 uS
T23	Bus data invalid	T21→T23>0 uS
T24	Controller resets READY	20<T22→T24<100 uS
T25	Controller sets READY	20<T24→T25<100 uS
T26	Bus data valid byte 2	N/A
T27	Host sets REQUEST	T25→T27>0 uS
T28	Controller resets READY	T27→T28<1 uS
T29	Controller sets READY	T28→T29>20 uS (500 nom.)
T30	Host resets REQUEST	T29→T30>0 uS
T31	Bus data invalid	N/A
T32	Controller resets READY	20<T30→T32<100 uS
T33	Controller sets READY	20<T32→T33<100 uS
T34	Bus data valid byte 3 (LSB)	N/A
T35	Host sets REQUEST	T33→T35>0 uS
T36	Controller resets READY	T35→T36<1 uS
T37	Controller sets READY	T36→T37>20 uS (500 nom.)
T38	Host resets REQUEST	T37→T38>0 uS
T39	Bus data invalid	T37→T39>0 uS
T40	Controller resets READY	20<T38→T40<100 uS
T41	Controller sets READY, search complete, target block found	T40→T41 (5-90 sec.)

Table 10. Twenty Reposition/Read Retries

Amount	Position
6	Mechanical nominal
1	-4 mils
1	+4 mils
1	-8 mils
1	+8 mils
2	-4 mils
2	+4 mils
2	-8 mils
2	+8 mils
2	Mechanical nominal

If the tape is not at the mechanical nominal position when read error occurs, the method is the same, but the last eight retries are at the mechanical nominal position.

When a successful read occurs at any position, the 540 continues reading at that position. But, if after 20 retries the data is not recovered, a hard read error is reported with an Exception and error status, and tape motion is stopped.

If the read sequence is normally terminated by reading a filemark, and the 540 is currently at either $\pm$4 mil or $\pm$8 mil offset position, the Marginal Block Detected (MBD) status bit will be set with the file mark detected status bit.

Enhanced Mode Selection

The four mode select commands can be used to modify the initial 540 default condition for track offset or enable original conditions, following a mode change.

When Enable Write Append Offset is invoked, the 540 will step the positioner up and down in 2-mil increments to locate the upper and lower boundaries of the recorded data. Once the boundaries are established, the head is positioned to the mid-point between the upper and lower edge, and write data is appended at that point. If the difference between the upper and lower edge is greater than four mils, the 540 flags a hard write error with an Exception, aborts the write operation, and rewinds the tape. When this occurs, Extended Status Byte 49 contains the append-up count and 50 contains the append-down count. If the difference between Bytes 49 and 50 is greater than four, an abort occurs.

These status bytes are read, using the Read Extended Status III (EO) command and are valid only if the enabled Byte 47 (Append With Offset command) has been set to 1.

When reading or searching for end of recorded data in order to write append to a recorded tape, The retry sequence shown in Table 11 is used to determine that the tape has been erased, regardless of the placement of previous tracks . This results in the setting of the No Data Detected or End of Recorded Media bit being set.

Table 11 Retry Sequence for No Data Detection

Amount	Position
1	Mechanical nominal
1	-4 mils
1	+4 mils
1	-8 mils
1	+8 mils
2	Mechanical nominal

ENHANCED STATUS BYTE CONFIGURATION

A summary of the enhanced versions of Status Bytes 0 and 1 are provided in Table 12

Table 12. Enhanced Status Byte Summary

Byte No	Bit No.	Definition
0 (MSB)	7	(STO) Set, if any other bit in Byte 0 is set. If Bit 7 is set Exception may be set
	6	(CNI) Cartridge Not In. Exception set if cartridge removed, and (1) drive selected by select drive with Lock Cartridge command; (2) motion command is issued; or (3) tape moved previously from BOT
	5	(DFF) Device Fault Flag, No longer unselected drive (USL) bit. DFF sets Exception. Must be followed by a Read Status sequence to clear Exception. (Read Extended Status III contains information in Byte 25 to determine cause of fault.) DFF set when formatter detects 540 condition which prohibits further command execution. For example: 1.No tape motion (jammed cartridge) 2.Failure to recognize or exit area between BOT/load point, or early warning/EOT. 3.No tach pulses from capstan motor. 4.Failure to complete command function in specified internal time. For example: not completing rewind once formatter initiates command. DFF indicates an unrecoverable 540 or cartridge error to user
	4	(WRP) WRite Protected cartridge. Set if cartridge write protect mechanism on safe. Remains set until cartridge is write enabled. Exception set if any Write or Erase command is issued when cartridge is write protected.
	3	(EOM) End Of Media. Set when early warning hole detected on last track in write mode. Remains set while tape is at logical end of media. Not reset by Read Status. When set, Exception is set

Table 12. Enhanced Status Byte Summary (cont'd)

Byte No.	Bit No.	Definition
	2	(UDE) Unrecoverable Data Error. Set for unrecoverable data error during read or write operation. If set, Exception is set. Reset by Read Status.
	1	(BNL) Bad Block Not Located. Set to indicate drive not able to locate correct block on tape.If set, Exception is set. When set with (UDE), drive transfers filler data block or data from a different block to keep correct total block count. BNL reset by Read Status.
(LSB)	0	(FMD) FileMark Detected. Set when filemark block is read. Exception set and FMD reset by Read Status.
1 (MSB)	7	(STI) Set, if any other bit in Byte 1 is set. If set, Exception may be set
	6	(ILL) ILLegal command. Exceptions and Bit 6 set under these conditions: 1.On line not asserted when read or write type command attempted or in process. 2.Non-implemented command is issued. 3.Non-read type command issued without proper termination of read sequence. 4.Non-write type command issued without proper termination of write sequence. ILL reset by Read Status.
	5	(NDT) No data detected. Set when drive determines no data is recorded on tape. If set, Exception is set. NDT reset by Read Status.
	4	(MBD) Marginal Block Detected. Set at detection of marginal data block. Enhanced track offset read recovery uses MBD to alert host if ±4-mil or ±8-mil offset required to read recorded cartridge. Exception set only if Exception and filemark read status are indicated. A set MBD indicates track position offset, when filemark was read This status indicates to host a marginally recorded cartridge. Host may determine to write append tape, or recover data and rewrite cartridge.

Table 12. Enhanced Status Byte Summary (cont'd)

Byte No	/Bit No.	Definition
	3	(BOM) Beginning Of Medium. Bit set when drive is logically at BOT, Track 0. If set, Exception is set. Bit not reset by Read Status, but reset when tape moved away from logical BOT.
	2	(BPE) Bus Parity Error. Bit set when drive detects odd parity error on bus during data transfer to drive. If set, Exception is set. Odd parity is an odd number of active bits on bus. Parity is enabled by W8, W9, W10 jumper configuration on 540 formatter. Only data checked for parity.
	1	(ERM) End of Recorded Media. Bit set when drive detects end of recorded media, or following a Seek End of Data command. If set, Exception is set.
(LSB)	0	(POR) Power On/Reset occurred set. Bit set following power on to drive or a reset from host. If set, Exception is set. Bit reset by a Read Status.

ENHANCED FORMAT READ CAPABILITY

The enhanced 540 can read 4- or 9-track tapes recorded with the QIC-11 (Quarterback type) format.

Although QIC-11 is a non-standard format, it is defined here as similar to QIC-24, but with a 1-byte block address rather than four bytes.

QIC-11 (4-Track Format)

After issuing a Read Command at BOT, the drive automatically sets the correct format flag, and reads either 9-track QIC-24 tapes or 4-track QIC-11 tapes. No special command is required, because the drive determines the format type by reading the first data blocks on Track 0. The initial default format, following a reset or cartridge change, is QIC-24. The flag will remain set until another reset, or cartridge change, is made.

Attempting to write while in QIC-11 mode is an illegal sequence, and is flagged as an illegal command. Due to repeating block addresses in QIC-11, the Search command is illegal while in this mode. Also, Seek End of Data cannot be used, if Track 0 is not completely erased.

QIC-11 (9-Track Format)

The 9-track tapes written with the QIC-11 format can be read on the 540, by issuing the the vendor unique Read Quarterback Format command (49 Hex) to set the QIC-11 mode. This command can be issued only at BOT, and can be followed by Read and position commands. Write commands and the Search command, due to repeating block addresses, are not legal in QIC-11 mode. Also, Seek End of Data cannot be used in QIC-11 mode if Track 0 is not completely erased.

Reset must be issued to return the 540 to QIC-24 mode.

ENHANCED READ EXTENDED STATUS

The enhanced Read Extended Status (Read Extended Status III) provide additonal information. For example, Byte 25 offers information to determine the cause of a device fault. The format of this command is provided in Table 13.

Table 13. Read Extended Status III Format

Byte (Hex)	Byte & Bit Description
00 (00)	Basic Drive Control Register (bit map) 7 - Reserved 6 - Write Enable 5 - Erase Enable 4 - Reverse Enable 3 - Go Enable 2 - 0 Reserved
01 (01)	Current Track/Lock Register 7 thru 4 Bit On Current Track(MSB=7, LSB=4) 3 thru Lock Bit Set By Host If (In) Select Cmd. Used 2 thru 0 Reserved
02 (02)	Last Status (bit map) 7 - CRC Error 6 - Filemark 5 - Gap Detected 4 - 3 Reserved 2 - Write Complete 1 - Read Complete 0 - Host Complete
03 (03) thru 12 (0C)	Reserved
13 (OD)	Command Register 7 thru 0 - Reserved
4 (0E)	Status Byte 0
15 (0F)	Status Byte 1
16 (10)	Status Byte 2, Data Error Counter
17 (11)	Status Byte 3, Data Error Counter
18 (12)	Status Byte 4, Underrun Counter
19 (13)	Status Byte 5, Underrun Counter
20 (14) thru 23 (17)	Reserved

Table 13. Read Extended Status III Format (cont'd)

Byte(Hex)	Byte & Bit Description
24 (18)	Format Type (bit map) 7 - 0 6 - 0 5 - 1 4 - 0 3 - 0 2 - 0 1 - X (0 = QIC 11) 0 - X (3 = QIC 24)
25 (19)	Position Error Map for Device Fault Flag 01 = CMD = Rev. + Go + Delay Error = Still at EOT 02 = Drive in Zone With Go ON. Error = Unable to Reach EOT or BOT Within 1 Second 03 = Error = No Tach. Pulses Motor Running 30 IPS 04 = CMD = Rev + Go + Delay. Error = No BOT Within 1.5 Minutes 05 = Unable To Find Load Point or Early. Warning After Go From BOT or EOT + Timeout 06 = Unable To Exit Zone Area After Go Issued + Delay 07 = Speed Error 08 = Speed Error at Zone 09 = Acceleration Error OA = Speed 10 Percent OB = Speed Deviation 10 Percent OC = Motor Run Away OD = Main Board Is Busy Following Wait Timeout. Device Ready Line From Main To Formatter Board Did Not Go Ready

Table 13. Read Extended Status III Format (cont'd)

Byte (Hex)	Byte & Bit Description
	Position Error Map (cont'd) OE OF 10 11 12 13 Motor Not Moving When It Should Be Running 14 = Fake Zone Indication False Early Warning or Load Point Detected 17 = Consecutive Write Errors In Excess 18 = Unable To Write The Target Block 19 = Unable To Locate Elongated Gap For an Append
26 (1A) thru 29 (1D)	Reserved
30 (1E)	Last Block Address (LSB)
31 (1F)	Last Block Address
32 (20)	Last Block Address
33 (21)	Last Block Address (MSB)
34 (22)	File Mark Count (usually set to 0)
35 (23) thru 46 (2E)	Reserved
47 (2F)	Offset Status
48 (30)	Reserved
49 (31)	Append Up Count
50 (32)	Append Down Count
51 (33) & 52 (34)	Reserved
53 (35)	Number of Blocks Recovered at Current Position

Table 13. Read Extended Status III Format (cont'd)

Byte (Hex)	Byte & Bit Description
54 (36)	Number of Blocks Recovered at Last Offset Position
55 (37) & 56 (38)	Reserved
57 (39)	Vendor I.D. Cipher = 01
58 (3A)	Firmware Revision Level
59 (3B)	Select
60 (3C)	Previous Track Offset Bit Map
61 (3D)	Previous Track Offset Bit Map
62 (3F)	Previous Track Offset Bit Map
63 (3F)	Previous Track Offset Bit Map

ENHANCED JUMPER CONFIGURATION

The select drive jumper configuration with enhanced formatter board (P/N 940524) is shown below:

NNNN	W6/W7	Select
0001	In/In	Drive 0
0010	Out/In	Drive 1
0100	In/Out	Drive 2
1000	Out/Out	Drive 3

The parity jumper configuration with enhanced formatter board is shown below:

W8	W9	W10	Parity
In	Out	In	Enabled
Out	In	N/A	Disabled

With the enhanced main board (P/N 940538), the voltage select option is shown below:

+12V configuration	+24V configuration
Jumper E13 to E12	Jumper E11 to E12

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Small Computer System Interface Product Description

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CONTENTS

CONTENTS (Continued)

SECTION 1

INTRODUCTION

This publication presents the interface commands for three tape drives produced by Cipher Data Products, Inc. The three products are:

- The model 540 1/4-inch streaming cartridge tape drive, which interfaces with the Emulex MT01 SCSI Tape Controller. The tape drive can use QIC-24 or read QIC-11 data formats. (Conforms to SCSI Rev. 14A)

- Cipher 1/2-inch reel-to-reel streaming tape drives (Conforms to SCSI Rev. 15)

- Cipher 1/2-inch cartridge tape drive (Conforms to SCSI Rev. 17A)

Each command is presented along with the applicable excerpts from the Small Computer System Interface (SCSI) command specification of the American National Standards Institute (ANSI) as specified in Revision 15 produced by the X3T9.2 task group at their April 22-23, 1985 meeting. (ANSC X3T9.2/82-2 Rev.15, 4/23/85).

SCSI categorizes tape drives as sequential-access devices. The commands for such devices are governed by Section 6 of the SCSI command specification, which describes the overall SCSI command structure; Section 7, which presents command descriptions for all device types; and Section 9, which covers Group 0 commands for sequential-access devices.

> NOTE: Some of the information in Sections 2, 3 and 4 of this publication have parenthetical references, such as "(Ref. 7.1.1)". These notations are provided to show where the information was found in the SCSI specification.

SCSI commands may be mandatory, optional or vendor-unique. In addition, use of certain fields within a command descriptor block or implementation of a particular feature may be optional or vendor-unique. All tape drives described in this publication conform to all mandatory SCSI capabilities. In addition, some optional features and some vendor-unique features are implemented. Further, some items, such as the file formats for information sent or received from a device, are left to the systems integrator.

Commands for the tape drives are described in this publication by comparison with the SCSI specification and optional, vendor-unique and unspecified features are shown. In those cases where optional or vendor-unique options are not implemented, the fields are not shown.

This publication is meant for use by computer professionals with an understanding of hardware and software interface concepts. No previous knowledge of SCSI is presumed. Using the information contained here, a user should be able to integrate any of the specified tape units with any appropriate host system.

This publication has six sections and three appendices. Section 2 presents a brief overview of the SCSI architecture to show how the information in this publication fits together.

Section 3 contains the descriptions of the SCSI command structures that are used in the Cipher Data Products described. Command structures that are not used by these products are omitted.

Section 4 shows the SCSI status information structure returned by the tape drives in response to SCSI commands, errors and other conditions.

Section 5 describes the message codes sent between the initiator and target after the status phase.

Section 6 presents the SCSI command specification for each supported command, along with a discussion of each tape drive's differences, if any, from the ANSI specification.

Appendices A, B and C present the specific characteristics and specifications for the tape drives.

NOTE:
This publication uses the "H" notation to specify hexadecimal numbers. For example, to represent the hexadecimal number 8, the notation used is 8H.

SECTION 2

SCSI ARCHITECTURE OVERVIEW (Ref. Section 5)

SCSI has an eight-phase architecture:

- o BUS FREE
- o ARBITRATION
- o SELECTION
- o RESELECTION
- o COMMAND
- o DATA
- o STATUS
- o MESSAGE

The SCSI bus can never be in more than one phase at any given time. The phases are described below.

The BUS FREE phase is used to indicate that no SCSI device is actually using the SCSI bus and that it is available for subsequent users.

The ARBITRATION phase allows one SCSI device to gain control of the SCSI bus so that it can assume the role of initiator or target. If the system has only one initiator, this phase is not required.

The SELECTION phase allows an initiator to select a target for the purpose of initiating some target function (e.g., READ or WRITE command).

The RESELECTION phase is an optional phase that allows a target to reconnect to an initiator for the purpose of continuing some operation that was previously started by the initiator but was suspended by the target.

The information transfer phases are the COMMAND, DATA, STATUS and MESSAGE phases. They are all grouped together because they are all used to transfer data or control information via the data bus. The following chart shows the information transfer phases.

Phase Name	Direction of Transfer	Comment
DATA OUT	Initiator to target	Data phase
DATA IN	Initiator from target	Data phase
COMMAND	Initiator to target	
STATUS	Initiator from target	
MESSAGE OUT	Initiator to target	Message phase
MESSAGE IN	Initiator from target	Message phase

The DATA phase is a term that encompasses both the DATA IN phase and the DATA OUT phase. In these phases, data is transferred to or from the initiator.

The COMMAND phase allows the target to request command information from the initiator. Command structures are described in Section 3; actual commands are described in Section 6.

The STATUS phase allows the target to request that status information be sent from the target to the initiator. STATUS structure and information are described in Section 4.

The MESSAGE phase is a term that references either a MESSAGE IN or a MESSAGE OUT phase. The first byte transferred in either of these messages will be either a single-byte message or the first byte of a multiple-byte message. Messages are described in Section 5.

SECTION 3

SCSI COMMAND STRUCTURE (Ref. Section 6)

The command definitions assume a data structure providing the appearance at the interface of a contiguous set of logical blocks of a fixed or explicitly defined data length. The SCSI initiating device maps the physical characteristics of the attached targeted peripheral devices to one of the several logical structures defined by the device type code.

A single command may transfer one or more logical blocks of data. Multiple commands may be linked if they are sent to the same Logical Unit (LU). A target may disconnect from the SCSI bus to allow activity by other SCSI devices while a LU is being prepared to transfer data.

Upon command completion (successful or unsuccessful), the target returns a status byte to the initiator. Since many error and exception conditions cannot be adequately described with a single status byte, one status code, CHECK CONDITION, indicates that additional information is available. The initiator may issue a REQUEST SENSE command to retrieve this additional information. There are other status conditions that fully describe the reason for the incomplete command, such as the RESERVATION CONFLICT status. Section 4 describes the status byte structure.

Many of the command descriptions refer to the nonextended-sense data and the extended-sense data. These data formats are described in the REQUEST SENSE command description.

By keeping the minimum functions essential to commmunicate via this protocol, a wide range of peripheral devices of varying capability can operate in the same environment.

Command Implementation Requirements. The first byte of any SCSI command will contain an operation code as defined in this document. Three bits (bits 7 - 5) of the second byte of each SCSI command specify the LU if it is not specified using the IDENTIFY message. The last byte of all SCSI commands will contain a control byte.

Reserved. Reserved bits, bytes, fields, and code values are set aside for future standardization. A reserved bit, field, or byte will be set to zero. A target that receives a reserved bit, field or byte that is not zero or receives a reserved code value will terminate the command with a CHECK CONDITION status. If extended sense is implemented, the sense key will be set to ILLEGAL REQUEST.

Command Descriptor Block. A request to a peripheral device is performed by sending a Command Descriptor Block (CDB) to the target. For several commands, the request is accompanied by a list of parameters sent during the DATA OUT phase. See the specific commands for detailed information.

The CDB always has an operation code as the first byte of the command. This is followed by a LU number, command parameters (if any), and a control byte.

If there is an invalid parameter in the command descriptor block of any command, then the target will terminate the command without altering the medium.

Operation Code. The operation code of the CDB has a group code field and a command code field. The three-bit group code field provides for eight groups of command codes. The five-bit command code field provides for 32 command codes in each group. Thus, a total of 256 possible operation codes exist.

The group code specifies the command group. There are three group types:

Group 0 - 6-byte commands
Group 1 - 10-byte commands
Group 5 - 12-byte commands

The commands described in this publication are all group 0 commands, therefore only the 6-byte command format is shown here.

Table 1
Command Descriptor Block for 6-byte Commands

Byte	Bit 07	06	05	04	03	02	01	00
00	Operation Code							
01	Logical Unit Number			Logical Block Address (MSB)				
02	Logical Block Address							
03	Logical Block Address (LSB)							
04	Transfer Length							
05	Control Byte							

Logical Unit Number. The Logical Unit Number (LUN) addresses one of up to eight physical or virtual devices attached to a target. This method of addressing is provided for systems that do not implement the IDENTIFY message. A target that accepts an IDENTIFY message will use the LUN specified within the message. In this case, the target will ignore the LUN specified within the CDB.

Logical Block Address. The logical block address on LUs will begin with block zero and be contiguous up to the last logical block on that LU. Group 0 CDBs contain 21-bit logical block addresses.

The logical block concept implies that the initiator and target will have previously established the number of data bytes per logical block. This may be established through the use of the READ CAPACITY command or the MODE SENSE command or by prior arrangement.

Transfer Length. The transfer length specifies the amount of data to be transferred, usually the number of blocks. For several commands, the transfer length indicates the requested number of bytes to be sent as defined in the command description. For these commands, the transfer length field may be identified by a different name. (See the individual command descriptions for further information.

Commands that use one byte for transfer length allow up to 256 blocks of data to be transferred by one command. A transfer length value of 1 to 255 indicates the number of blocks that will be transferred. A value of zero indicates 256 blocks. The commands described in this publication all use 1-byte transfer lengths.

The transfer length of the commands used to send a list of parameters to a target is called the parameter list length. The parameter list length specifies the number of bytes sent during the DATA OUT phase.

The transfer length of the commands that are used to return sense data (e.g. REQUEST SENSE, INQUIRY, MODE SENSE, etc.) to an initiator is called the allocation length. The allocation length specifies the number of bytes that the initiator has allocated for returned data. The target will terminate the DATA IN phase when allocation length bytes have been transferred or when all available sense data have been transferred to the initiator, whichever is less.

Control Byte. The control byte is the last byte of every command descriptor block. A typical byte is described in Table 2.

Table 2
Control Byte

Bit	Description
7 - 6	Vendor Unique
5 - 2	Reserved
1	Flag bit - If the link bit is zero, then the flag bit will be set to zero. If the link bit is one, and if the command terminates successfully, the target will send LINKED COMMAND COMPLETE message if the flag bit is zero and will send LINKED COMMAND COMPLETE message if the flag bit is one. Typically, this bit is used to interrupt the initiator between linked commands.
0	Link bit - This bit is set to one if initiator wishes an automatic link to the next command upon successful completion of the current command. If the link bit is one, the targets that implement the linked commands will return INTERMEDIATE status upon successful termination of the command. The target will then send one of the two messages defined by the flag bit defined above. Linked commands are not implemented on the 1/2-inch reel-to-reel unit.

SECTION 4

STATUS INFORMATION (Ref. Section 14)

A status byte will be sent from the target to the initiator during the STATUS phase at the termination of each command. The following table defines the status bytes that are sent unless the command is cleared by an ABORT message, by a BUS DEVICE RESET message or by a "hard" RESET condition.

Status Byte

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	Status Byte Code				0

(Note 2)

Status Byte Code Bit Values

Bits of Status Byte 7	6	5	4	3	2	1	0	Statuses Represented
0	0	0	0	0	0	0	0	GOOD
0	0	0	0	0	0	1	0	CHECK CONDITION
0	0	0	0	0	1	0	0	CONDITION MET/GOOD (Note 3)
0	0	0	0	0	1	1	0	Reserved
0	0	0	0	1	0	0	0	BUSY
0	0	0	0	1	0	1	0	Reserved
0	0	0	0	1	1	0	0	Reserved
0	0	0	0	1	1	1	0	Reserved
0	0	0	1	0	0	0	0	INTERMEDIATE/GOOD (Note 1)
0	0	0	1	0	0	1	0	Reserved
0	0	0	1	0	1	0	0	INTERMEDIATE/CONDITION MET/GOOD (Note 1) (Note 3)
0	0	0	1	0	1	1	0	Reserved
0	0	0	1	1	0	0	0	RESERVATION CONFLICT
0	0	0	1	1	0	1	0	Reserved
0	0	0	1	1	1	0	0	Reserved
0	0	0	1	1	1	1	0	Reserved

Note 1: INTERMEDIATE/GOOD and INTERMEDIATE/CONDITION MET/GOOD are not supported by the 1/2-inch reel-to-reel unit.

Note 2: The 1/4-inch cartridge sets bit 00 to 1 to indicate that initiator selected a LUN that does not exist.

Note 3: CONDITION MET/GOOD and INTERMEDIATE/CONDITION MET/GOOD are not supported by the 1/4-inch cartridge unit.

SECTION 5

MESSAGE STRUCTURE AND DESCRIPTIONS (Ref. Section 5.5)

The message system allows communication between an initiator and target for the purpose of physical path management.

Message Protocol

All SCSI devices will implement the COMMAND COMPLETE message. A functional SCSI device can be constructed without using any of the other messages if the Logical Unit Number (LUN) is specified in the command descriptor block.

Normally the first message sent by the initiator after the SELECTION phase is the IDENTIFY message. This allows the establishment of the physical path for a particular LU specified by the initiator. It also establishes whether the initiator supports arbitration. The 1/2-inch cartridge unit uses this information to determine if it will disconnect. After the RESELECTION phase, the target's first message is also IDENTIFY. This allows the physical path to be reestablished for the target's specified LUN. Under some exceptional conditions, an initiator may send the ABORT message or the BUS DEVICE RESET message instead of the IDENTIFY message as the first message. Only one LUN will be identified for any one selection sequence; a second IDENTIFY message with new LUN will not be issued before the SCSI bus has been released (BUS FREE phase).

All of the units described in this publication implement the IDENTIFY message.

SCSI devices that implement any message other than the COMMAND COMPLETE message shall also implement the MESSAGE REJECT message. Cipher implements other messages, therefore MESSAGE REJECT is implemented.

The SCSI messages are specified in the following table, along with indicators that specify which of the Cipher tape units described in this publication use each message. The Direction column specifies IN for target-to-initiator messages and OUT for initiator-to-target messages. The next table describes each message in detail.

Code	Title	Direction		1/4" Cart	1/2" R-To-R	1/2" Cart
00H	COMMAND COMPLETE	IN		X	X	X
01H	EXTENDED MESSAGE	IN	OUT			X
02H	SAVE DATA POINTER	IN		X	X	X
03H	RESTORE POINTERS	IN			X	X
04H	DISCONNECT	IN		X	X	X
05H	INITIATOR DETECTED ERROR		OUT	X	X	X
06H	ABORT		OUT	X	X	X
07H	MESSAGE REJECT	IN	OUT	X	X	X
08H	NO OPERATION		OUT	X	X	X
09H	MESSAGE PARITY ERROR		OUT	X	X	X
OAH	LINKED COMMAND COMPLETE	IN				X
OBH	LINKED COMMAND COMPLETE (WITH FLAG)	IN				X
OCH	BUS DEVICE RESET		OUT	X	X	X
ODH-7FH	Reserved codes					
80H-FFH	IDENTIFY	IN	OUT	X	X	X

Code	Title	Description
00H	COMMAND COMPLETE	Command execution complete and a valid status sent
01H	EXTENDED MESSAGE	Multiple-byte message follows
02H	SAVE DATA POINTER	Copy present active pointers for current LU
03H	RESTORE POINTERS	Reactivate the most recently used data pointers
04H	DISCONNECT	Break present physical connection. Reconnection required to complete current operation.
05H	INITIATOR DETECTED ERROR	Error occurred (e.g. Parity error)
06H	ABORT	Clear present operation
07H	MESSAGE REJECT	Last message not appropriate or not implemented
08H	NO OPERATION	No valid response for request
09H	MESSAGE PARITY	Parity error in one or more bytes in last message
OAH	LINKED COMMAND COMPLETE	Linked command complete and status sent
OBH	LINKED COMMAND COMPLETE (WITH FLAG)	Linked command complete (with flag bit set) and status sent
OCH	BUS DEVICE RESET	Directed drive to clear all commands, go to an initial state with no initiator-pending operations

Code	Title	Description
0DH-7FH	Reserved codes	
80H-FFH	IDENTIFY	Establish connection between initiator and drive for a particular LU. The bits are interpreted as specified below.

Bit	Meaning
07	Always set to 1 to identify this message
06	Only set to 1 by initiator. Indicates initiator can accommodate disconnect and reconnect sequences.
05-03	Reserved - Set to 1.
02-00	Specifies LUN within the drive. (Should always be set to 0 for the 1/2" cartridge drive.)

Note: The 1/2 inch cartridge implements the following messages:

00H	Modify data pointer
01H	Synchronous data transfer

Note: The 1/2 inch cartridge does not implement synchronous data transfer. If the unit receives a synchronous data transfer message, it sends a synchronous data transfer message to the initiator specifying a REQ/ACK offset equal to zero. This results in asynchronous data transfer.

SECTION 6

COMMAND DESCRIPTIONS

TEST UNIT READY Command (Ref. 7.1.1)

Peripheral Device Type: All
Operation Code Type: Optional
Operation Code: 00H

TEST UNIT READY Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	0
01	Logical Unit Number			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

ANSI

The TEST UNIT READY command provides a way to find if the Logical Unit (LU) is ready. This is not a request for a self test. If the LU would accept an appropriate medium-access command without returning CHECK CONDITION status, this command will return a GOOD status.

1/4" Cartridge

Same as ANSI. The unit returns BUSY status if the auto-load operation is in progress; it returns CHECK CONDITION if the drive is not ready.

1/2" Reel-To-Reel

Same as ANSI. If the target is not loaded or is not on line, the extended sense data contains a sense key of 02. Additional sense data contains the status byte of the tape drive.

1/2" Cartridge

The status byte and sense data are as follows:

	No Error, Cartridge Loaded	Hardware Error	Not Loaded And Threaded
Status Byte			
Linked Command	INTERMEDIATE	CHECK CONDITION	CHECK CONDITION
Non-linked Cmd	GOOD	CHECK CONDITION	CHECK CONDITION
Sense Data			
Sense Byte	No Sense	INTERVENTION REQ (Value OAH)	INTERVENTION REQ (Value AH)
Sense Key	No Sense	HARDWARE ERROR (Value 4H)	HARDWARE ERROR (Value 4H)

REQUEST SENSE Command (Ref. 7.1.2)

Peripheral Device Type: All
Operation Code Type: Mandatory
Operation Code: 03H

REQUEST SENSE Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	1	1
01	Logical Unit Number			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Allocation Length							
05	Vendor Unique		0	0	0	0	Flag	Link

ANSI

The REQUEST SENSE command requests that the target transfer sense data to the initiator.

The sense data will be valid for a CHECK CONDITION status on the prior command. (This sense data will be preserved by the target for the initiator until retrieved by the REQUEST SENSE command or until any other command for the same LU is received from the same intiator that issued the command resulting in the CHECK CONDITION status.) Sense data will be cleared upon receipt of any subsequent command to the LU from the initiator receiving the CHECK CONDITION status. In the case of the single initiator option, the target will assume that the REQUEST SENSE command is from the same initiator.

The allocation length specifies the number of bytes that the initiator has allocated for returned sense data. An allocation length of zero indicates that four bytes of sense data will be transferred. Any other value indicates the maximum number of bytes that will be transferred. The target will terminate the DATA IN phase when allocation length bytes have been transferred or when all available sense data have been transferred to the initiator, whichever is less.

The REQUEST SENSE command will return the CHECK CONDITION status only to report fatal errors for the REQUEST SENSE command. For example:

(1) The target receives a non-zero reserved bit in the command descriptor block.
(2) An unrecovered parity error occurs on the data bus.
(3) A target malfunction prevents return of the sense data.

If any non-fatal error occurs during the execution of the REQUEST SENSE command, the target will return the sense data with GOOD status.

Following a fatal error on a REQUEST SENSE command, sense data may be invalid.

A target may implement the non-extended, the extended, or both sense data formats. The format of the sense data is determined by the error Class. Error Classes 0 through 6 use the non-extended sense data format. Error Class 7 uses the extended format.

Non-extended Sense.

The Error Class specifies a class of errors with Error Classes 0 through 6 being vendor unique. For these classes, the error code is vendor unique.

Table 3
Non-extended Sense Data Format

Byte	Bit 07	06	05	04	03	02	01	00
00	AdValid		Error Class			Error Code		
01	0	0	0	Logical Block Address (MSB)				
02	0	0	0	Logical Block Address				
03	0	0	0	Logical Block Address (LSB)				

The Address Valid (AdValid) bit indicates that the logical block address field contains valid information related to the error code.

Extended Sense.

Error Class 7 specifies extended sense. Error Code 0 specifies the extended sense data format. Error Code FH specifies a vendor unique data format for extended sense. Error Codes 1H through EH are reserved.

The extended sense data format is shown in Table 4.

Table 4
Extended Sense Data Format

Byte	Bit 07	06	05	04	03	02	01	00
00	AdValid	1	1	1	0	0	0	0
01	Segment Number							
02	Filemark	EOT	ILI	0	Sense Key			
03	Information Byte (MSB)							
04	Information Byte							
05	Information Byte							
06	Information Byte (LSB)							
07	Additional Sense Length (n)							
08-n+7	Additional Sense Bytes							

Bytes 03 - 05 -- Information Bytes

The information bytes are not defined if the valid bit is zero. If the valid bit is one, the information bytes contain the difference (residue) of the requested number of blocks minus the actual number of blocks copied or compared for the current segment descriptor of a COPY, COMPARE, or COPY AND VERIFY command.

Byte 01 -- Segment Number

The segment number contains the number of the current segment descriptor if the extended sense is in response to a COPY, COMPARE, or COPY AND VERIFY command. Up to 256 segments are supported, beginning with segment zero.

Byte 02

The filemark bit indicates that the current command has read a filemark. This bit is only used for sequential-access devices.

The end-of-medium (EOM) bit indicates that an EOM or Beginning-Of-Tape, etc., has occurred on a sequential access device. For sequential-access devices, this bit indicates that the unit is at or past the early-warning EOM if the direction was forward or that the command could not be completed because of Beginning-Of-Tape (BOT) was encountered if the direction was reverse.

The incorrect length indicator (ILI) bit indicates that the requested logical block length did not match the logical block of the data on the medium.

The sense keys are described in Tables 5 and 6.

The additional sense length specifies the number of additonal sense bytes to follow. 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 bytes contain command-specific, peripheral-device-specific data, or both kinds of data that further define the nature of the CHECK CONDITION status. The COPY, COMPARE, COPY and VERIFY, and SEARCH DATA commands define a standard purpose for some of these bytes. Except as described in these commands, the additional sense bytes are vendor unique.

Table 5
Sense Key (0H-7H) Descriptions

Sense Key	Description
00H	NO SENSE. Indicates that there is no specific sense key information to be reported for the designated logical unit. This would be the case for a successful command or a command that received a CHECK CONDITION status because one of the filemark, EOT, or ILI bits is set to one.
01H	RECOVERED ERROR. Indicates that the last command completed successfully with some recovery action performed by the target. Details may be determined by examining the additional sense bytes and the information bytes.
02H	NOT READY. Indicates that the LU addressed cannot be accessed. Operator intervention may be required to correct this condition.
03H	MEDIUM ERROR. Indicates that the command terminated with a non-recovered error condition that was probably caused by a flaw in the medium or an error in the recorded data.
04H	HARDWARE ERROR. Indicates that the target detected a nonrecoverable hardware failure (for example, controller failure, device failure, parity error, etc.) while performing the command or during self test.
05H	ILLEGAL REQUEST. Indicates that there was an illegal parameter in the CDB or in the additional parameters supplied as data for some commands (FORMAT UNIT, SEARCH DATA, etc.). If the target detects an invalid parameter in the CDB, it terminates the command without altering the medium. The target may have already altered the medium when it detects an invalid parameter in the data.
06H	UNIT ATTENTION. Indicates that the removable medium may have been changed or the target has been reset.
07H	DATA PROTECT. Indicates that a command that reads or writes the medium was attempted on a block that is protected from this operation. The read or write operation is not performed.

Table 6
Sense Key (8H-FH) Descriptions

Sense Key	Description
08H	BLANK CHECK. Indicates that the tape unit encountered a blank block while reading or a nonblank block while writing.
09H	VENDOR UNIQUE. This sense key is available for reporting vendor unique conditions.
0AH	COPY ABORTED. Indicates a COPY command was aborted due to an error condition on the source device, the destination device, or both.
0BH	ABORTED COMMAND. Indicates that the target aborted the command. The initiator may be able to recover by trying the command again.
0CH	This sense key is reserved.
0DH	VOLUME OVERFLOW. Indicates that a buffered peripheral device has reached the end-of-medium and data remains in the buffer that has not been written to the medium. RECOVER BUFFERED DATA commands may be issued to read the unwritten data from the buffer.
0EH	MISCOMPARE. Indicates that the source data did not match the data read from the medium. This key is supported by the 1/4"-inch cartridge unit only.
0FH	This sense key is reserved.

1/4" Cartridge

The sense information is cleared only by an I/O-type or access-type command or by the REQUEST SENSE command.

1/4" Cartridge Non-Extended Sense.

The Address-Valid (AdValid) bit specifies the interpretation of the 21-bit logical block address field. If AdValid is zero, the logical-block address field contains valid sense information. If AdValid is one, the logical-block address field contains the difference (residue) of the requested number of sense bytes and the actual number of bytes transferred.

Error Class (Byte 00, bits 06-04)

The Error Class field specifies one of the following error classes:

Bits 06	05	04	Error Class
0	0	0	Drive Errors
0	0	1	Target Errors
0	1	0	System-related Errors
0	1	1	Vendor Unique Errors

These codes, combined with the Error Code field described below, are described in Table 7.

Error Code (Byte 00, bits 03-00)

The Error Code field specifies the error. Table 7 defines all the errors in terms of the combined Error Class/Error Code fields.

Table 7
1/4" Cartridge Standard Sense Error Class/Error Code Bytes

Hex Code	Error	Description
	TAPE DRIVE ERRORS	
00	NO SENSE	No error detected
04	DRIVE NOT READY	The tape drive is not powered up and ready.
09	MEDIA NOT LOADED	The cartridge is not installed in the tape drive as indicated by a tape drive status signal.
0A	INSUFFICIENT CAPACITY	There is insufficient space on the medium to accept additional data from the initiator.
0B	DRIVE TIMEOUT	A timeout occurred during a tape drive operation.
	TARGET ERRORS	
11	UNCORRECTABLE DATA ERROR	A block could not be written or read after 16 retries.
14	BLOCK NOT FOUND	The block sequence is improper or a block is missing.

Table 7 (Continued)
1/4" Cartridge Standard Sense Error Class/Error Code Bytes

TARGET ERRORS

Hex Code	Error	Description
16	DMA TIMEOUT ERROR	System activity reached a point at which DMA service for the MT01 Controller was suspended beyond the allowable timing limits, requiring one or more retry attempts.
17	WRITE PROTECTED	The media cartridge is write protected. The outstanding WRITE command has been aborted.
18	CORRECTABLE DATA CHECK	During read operations, a block had to be read two or more times. During write operations, a block had to be written more than once.
19	BAD BLOCK FOUND	A block cannot be read correctly after 16 retry attempts.
1C	FILE MARK DETECTED	A file mark block was encountered during a read operation. The outstanding READ and VERIFY commands are terminated and the tape is repositioned just after the file mark block.
1D	COMPARE ERROR (VERIFY only)	One or more bytes did not compare when the VERIFY command was issued.

SYSTEM-RELATED ERRORS

Hex Code	Error	Description
20	INVALID COMMAND	The issued command cannot be implemented or is not applicable.

Table 7 (Continued)
1/4" Cartridge Standard Sense Error Class/Error Code Bytes

VENDOR UNIQUE ERRORS

Hex Code	Error	Description
30	UNIT ATTENTION	A Unit Attention condition occurred. The removable medium may have been changed, or the addressed LUN reset (by the BUS DEVICE RESET message), since the last command was issued to the addressed LUN. This error is reported the first time any command is issued after the condition has been detected. Then the requested command is not performed. This condition is cleared when the next I/O is issued by the same host adapter. UNIT ATTENTION is reported to all SCSI devices that will subsequently issue a command to the Target.
31	COMMAND TIMEOUT	The command execution was not completed by the MT01 before a predetermined, command-specific time limit had expired.
33	APPEND ERROR	A write operation to the tape device was attempted before the EOT was reached.
34	READ END-OF-MEDIA	A read operation to the tape device was attempted past the EOT.

The sense information depends on the value of the AdValid bit. If that bit is 0, this field contains valid device-type specifications. If the AdValid bit is set to 1, the sense information bytes specify the difference (residue) of the requested length to be accessed and the actual length accessed in blocks.

1/4" Cartridge Extended Sense

Bytes 0 through 7 of the extended sense format are the same as specified for ANSI. The extended sense format for the 1/4" cartridge uses 11 bytes; the last three are described below:

Byte	Bit 07	06	05	04	03	02	01	00
08	Error Class				Error Code			
09	Number of recoverable Errors (MSB)							
10	Number of recoverable Errors (LSB)							

Error Class (Byte 08, Bits 07-04)

Same as specified for nonextended sense.

Error Code (Byte 08, Bits 03-00)

Same as specified for non-extended sense.

Number of Recoverable Errors (Bytes 09 and 10)

A recoverable error (soft error) occurs when the unit tries to perform a READ, WRITE or VERIFY operation and must perform a retry during the operation. The unit tries up to 16 retries. The number of recoverable errors field contains the number of these errors during a series of READ, WRITE or VERIFY operations.

Sense Keys

The sense keys are the same as the ANSI sense keys, except for codes 09H and 0CH:

- o A value of 09H indicates that the Error-Class and Error-Code fields contain valid information.
- o The value of 0CH is not used.

1/2" Reel-To-Reel

The command is the same as ANSI, except that the sense keys 09H, 0CH, 0DH and 0EH are not supported. The sense data returned is the extended sense format and additional sense information described below.

The following extended sense data fields apply to all sense keys except Copy Abort (QA):

Byte	Length	Description
00	1	Extended sense ID and valid bit
01	1	Segment number (COPY command)
02	1	File mark, EOT, illegal length indicator and sense key
03	4	Residue count
07	1	Additional sense bytes (Defined below)
08	4	Zero filled
12	4	Secondary codes (Defined below)
15	1	Zero filled
16	4	FF filled
20	1	Recovery action (Defined below)
21	1	Retry count

Byte	Length	Description
22	1	FF filled
23	4	Drive status bytes
27	10	Command descriptor block
37	4	Parameter list header (COPY or MODE SELECT)
41	8	Block descriptor list for a MODE SELECT command
41	12	Segment descriptor list for a COPY command

The following extended sense data fields apply to Copy Abort (QA) sense key:

Byte	Length	Description
00	1	Extended sense ID and valid bit
01	1	Segment number
02	1	Copy abort sense key (QA)
03	4	Residue count
07	1	Additional sense bytes
08	1	Relative sense byte offset to the source device's status byte and sense data
09	1	Relative byte offset to the destination device's status and sense data

The following extended sense data fields are received from the source or destination device that detected the error:

Byte	Length	Description
10	1	Complete status byte
11	1	Sense ID and valid bit
12	1	Not used
13	1	Sense key including filemark, EOT and illegal length indicator
14	4	Information bytes
18	1	Additional sense bytes included in the source or destination sense data
19	N	Device-specific sense data

The following command descriptor block and parameter list information is available at the time of the error:

Byte	Length	Description
19+N	6	COPY CDB
19+N+6	4	Zeros
19+N+10	4	COPY parameter list header
19+N+14	12	COPY segment descriptor list

The secondary error codes included in the extended sense data is as follows:

Code	Meaning
00	No error
20	Illegal SCSI command
43	Data buffer parity error
51	Function did not complete in specified time
52	Tape position error -- BOT not indicated after REWIND, LOAD or long ERASE
53	An error occurred before the requested tape drive command was complete

Code	Meaning
54	Data buffer is not empty
55	Fixed bit is set while in variable block mode or is not set while in fixed block mode
56	Data transfer error occurred -- host to interface
57	Data transfer error occurred -- interface to host
58	VERIFY command does not support byte compare mode
59	SPACE command does not support spacing to physical end of data (EOD)
5A	Diagnostic Self Test supported
5B	Command sequence error
5C	Unit select error
5D	Variable block length 64K
5E	Unable to obtain ownership of buffer
5F	Command parameter error
60	Status error from target (COPY command)
61	COPY cannot execute -- host cannot disconnect

The recovery action codes are:

0 - No action taken
4 - Retries were performed

The drive status codes are as follows:

Byte	Description
00	Tape Status Port 1
01	Tape Status Port 2
02	Tape Status Port 3
03	DMA status

1/2" Cartridge

The sense information is only cleared by an access-type command or by a REQUEST SENSE command.

Sense Keys

The sense data is as specified in ANSI with the following exceptions in the sense key values:

09H - Not used
0CH - Not used
0EH - Not used

The Extended Sense data format is TBD.

The REQUEST SENSE command can be used to request the buffered log or tape position information.

The 2-bit vendor unique field in byte 05 contains one of the following values:

00 -- Transfer sense data
01 -- Transfer buffered log
10 -- Report position
11 -- Not used

Transfer buffered log requests usage/error information to be transmitted. The allocation length-field specifies the number of bytes transmitted.

The buffered data is TBD.

Report Position requests tape position information. The format is as follows:

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	0
01	0	0	0	0	0	0	0	0
02	Filemark	EOT	0	0	0	0	0	0
03	Track Number							
04	Logical Block Number (MSB)							
05	Logical Block Number							
06	Logical Block Number (LSB)							
07	0	0	0	0	0	0	0	0
08	0	0	0	0	0	0	0	0

Caution: This format is under review and will probably change.

INQUIRY Command (Ref. 7.1.3)

Peripheral Device Type: All
Operation Code Type: Extended
Operation Code: 12H

INQUIRY Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	0	1	0
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Allocation Length							
05	0	0	0	0	0	0	Flag	Link

ANSI

The INQUIRY command requests that information regarding parameters of the target and its attached peripheral device(s) be sent to the initiator.

Allocation Length

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 will be transferred. This condition will not be considered as an error. Any other value indicates the maximum number of bytes that will be transferred. The target will terminate the DATA IN phase when allocation length bytes have been transferred or when all available INQUIRY data have been transferred to the initiator, whichever is less.

The INQUIRY command will return a CHECK CONDITION status only when the target cannot return the requested INQUIRY data.

If an INQUIRY command is received from an initiator with a pending unit attention condition (before the target reports CHECK CONDITION status), the target will perform the INQUIRY command and will not clear the unit attention condition.

The INQUIRY data contains a 5-byte header, followed by any vendor unique parameters.

1/4" Cartridge

The 1/4" Cartridge unit uses the INQUIRY command as specified in ANSI. A 5-byte Inquiry Data Format is returned; the format always has the same bits set:

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	1
01	1	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	1
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0

1/2" Reel-To-Reel

The 1/2" Reel-To-Reel unit uses the INQUIRY command as specified in ANSI. Up to 44 bytes can be requested in the Inquiry Data Format; these bytes have the following format:

Byte	Length	Hex Value	Meaning
00	1	01	Device type (all available logical units)
	1	7F	Device type (device not present)
01	1	C5	Qualifier byte -- 1/2" Reel Tape
02	1	00	Revision level
03	1	00	Reserved
04	1	27	Additional bytes
05	1	C1	Features-commands with ECC and SLI SCSI extended commands
06	1	XX	Controller microcode change level XX = development release number
07	1	01	Controller hardware change level
08	4		Four ASCII characters
12	16	(*)	Controller identification
28	16	(**)	Unit identifier (ASCII characters)

(*) = H6210-STD1-01-46
(**) = F880 if Microstreamer drive
= M890/891 if Cache Tape drive
= M990/991 if GCR Cache Tape drive

1/2" Cartridge

The 1/2" Cartridge unit uses the INQUIRY command as specified in ANSI. A variable-length Inquiry Data Format is returned with a 5-byte header and 64 bytes of data. The header always has the same bits set:

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	1
01	1	1	1	0	0	0	0	0
02	0	0	0	0	0	0	0	1
03	0	0	0	0	0	0	0	0
04	0	1	0	0	0	0	0	0

The 64-byte vendor-unique parameters are defined below:

Byte	Length	Code	Description
0	1	01	Features Cipher commands with ECC and all SCSI Group 0 commands
1	1	xx	Drive Microcode Change Level
2	1	xx	Drive Hardware Change Level
3	7	CIPHER	Seven ASCII Characters (CIPHER<space>)
10	10	TBD	Model Number
20	10	TBD	Microcode Part Number
30	10	TBD	Drive Part Number
40	16	TBD	Drive Serial Number
56	8	mm/dd/yy	Date of Manufacture

Caution: This format is under review and will probably change.

COPY Command (Ref. 7.1.4)

Peripheral Device Type: All
Operation Code Type: Optional
Operation Code: 18H

COPY Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	0	0	0
01	0	0	0	0	0	0	0	0
02	Parameter List Length (MSB)							
03	Parameter List Length							
04	Parameter List Length (LSB)							
05	0	0	0	0	0	0	Flag	Link

ANSI

The COPY command copies data from one logical unit to another. The logical units may reside on the same SCSI device or different SCSI devices. Some SCSI devices that implement this command may not support copies to or from another SCSI device or third party copies (both logical units reside on other SCSI devices).

The parameter list length specifies the length in bytes of the parameters that will be sent during the DATA OUT phase of the command. A parameter list length of 0 indicates that no data will be transferred. This condition will not be considered as an error.

The COPY parameter list begins with a 4-byte header that contains the COPY function code and priority. Following the header is one or more segment descriptors.

COPY Parameter List

Byte	Bit 07	06	05	04	03	02	01	00
00	COPY Function Code (CFC)						Priority	
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Segment Descriptors							

Copy Function Code

The COPY function code defines a specific format for the segment descriptors. The COPY function codes are defined below:

Peripheral Device Type		COPY Function	
Source	Destination	Code	Comment
04	01	00	Direct access
04	01	00	to sequential access
01	00	01	Sequential access
01	04	01	to direct access
01	01	03	sequential access
01	02	03	to
01	03	03	Sequential access
03	01	03	
03	02	03	
03	03	03	

Peripheral Device:
00 Direct-access device
01 Sequential-access device
02 Printer device
03 Processor device
04 Write-Once Read-Multiple Device (WORMD)
05 Read-only direct-access device

Priority Field

The priority field of the COPY parameter list establishes the relative priority of this COPY command to other commands being executed by the same target. All other commands are assumed

to have a priority of 1. Priority 0 is the highest priority with increasing values indicating lower priorities.

Segment Descriptors

The segment descriptor formats are determined by the COPY function code. The segment descriptor format used for WORMDs and for read-only Direct-Access Devices (DADs) will be the same as for DADS. The segment descriptor format used for printer devices and for processor devices will be the same as for DADs. The segment descriptor format used for printer devices and for processor devices will be the same as for sequential-access devices. Thus a COPY from a WORMD to a printer device uses the same segment descriptor format as for a COPY from a DAD to a sequential-access device. The segment descriptor formats are described in Tables 8 and 9. A maximum of 256 segment descriptors are permitted. The segment descriptors are identified by ascending numbers, beginning with zero.

Errors Detected by the Managing SCSI Device. (Ref. 7.1.4.1) Two classes of unusual conditions may occur during execution of a COPY command. The first class consists of unusual conditions detected by the SCSI device that received the COPY command and is managing the execution of the command. They include parity errors while transferring the COPY command and status byte, invalid parameters in the COPY command, invalid segment descriptors, and the inability of the controlling SCSI device to continue operating. In the event of such a condition, the SCSI device managing the COPY will:

(1) Terminate the COPY command with a CHECK CONDITION status.

(2) Return the sense data in the extended sense format. The valid bit will be set to 1. The segment number will contain the number of the segment descriptor being processed at the time the unusual condition is detected. The sense key will contain the sense key code describing the condition. The information bytes will contain the difference between the number of fields of blocks in the segment descriptor being processed at the time of the failure, and the number of blocks successfully copied. This number is the residue of unprocessed blocks remaining for the segment descriptor.

Errors Detected by a Target. (Ref. 7.1.4.2) The second class of errors consists of unusual conditions detected by the SCSI device transferring data at the request of the SCSI device managing the transfer. The SCSI device managing the COPY command detects unusual conditions by receiving a CHECK CONDITION status from one of the SCSI devices it is managing. It then recovers the sense data associated with the condition.

The SCSI device managing the COPY command may also be the source or destination SCSI device (or both). It will distinguish between a failure of the management of the COPY command and a failure of the requested data transfer. It will then create the appropriate sense data internally.

After recovering the sense data associated with the detected error, the SCSI device managing the COPY command will:

(1) Terminate the COPY command with a CHECK CONDITION status.

(2) Return the sense data in the extended sense format. The valid bit is set to 1. The segment number will contain the number of the segment descriptor being processed at the time the unusual condition is detected. The sense key will be set to COPY ABORTED. The information bytes will contain the difference between the number of fields of blocks in the segment descriptor being processed at the time of the failure and the number of blocks successfully copied. This number is the residue of unprocessed blocks remaining in the segment descriptor. The additional sense length will specify the number of additional sense bytes.

The first additional sense byte will specify the byte number relative to the first byte of sense data at the beginning of the source LU's status byte and sense data. A zero value indicates that no status byte or sense data is being returned for the source LU. The first byte of the area pointed to by the first additional sense byte will contain the status byte from the source LU. The subsequent bytes will contain, unchanged, the sense data recovered from the source LU.

The second additional sense byte specifies the byte number, relative to the first byte of sense data at the beginning of the destination LU's status byte and sense data. A 0 value indicates that no status byte or sense data is being returned for the destination LU. The first byte of the area pointed to by the second additional sense byte will contain the status byte from the destination LU. Subsequent bytes will contain the unchanged sense data recovered from the destination LU.

COPY Function Code 00H and 01H. (Ref. 7.1.4.3) The format for the segment descriptors for COPY transfers between DADs and sequential-access devices is specified in Table 8. This format is required for COPY function codes 00H or 01H. The segment descriptor may be repeated up to 256 times within the parameter list length specified in the CDB.

Table 8
Segment Descriptor for COPY Function Codes 00 and 01

Byte	Bit 07	06	05	04	03	02	01	00
00	Source Address			0	0	Source LUN		
01	Destination Address			0	0	Destination LUN		
02	Sequential-Access Device Block-Length (MSB)							
03	Sequential-Access Device Block-Length (LSB)							
04	Direct-Access Device Number of Blocks (MSB)							
05	Direct-Access Device Number of Blocks							
06	Direct-Access Device Number of Blocks							
07	Direct-Access Device Number of Blocks (LSB)							
08	Direct-Access Device Logical Block Address (MSB)							
09	Direct-Access Device Logical Block Address							
10	Direct-Access Device Logical Block Address							
11	Direct-Access Device Logical Block Address (LSB)							

Source address and destination address fields in the COPY command specify the SCSI devices. The source LUN and destination LUN fields specify the logical units to use for this segment of the command. Some SCSI devices only support COPY within the SCSI device and not to other SCSI devices. If an unsupported COPY operation is requested, the command will be terminated with a CHECK CONDITION status and the sense key will be set to ILLEGAL REQUEST.

The sequential-access device block-length field specifies the block-length to be used on the sequential-access LU during this segment of the COPY command. If this block-length is known by the SCSI device managing the COPY not to be supported, the command will be terminated with a CHECK CONDITION status, and the sense key will be set to ILLEGAL REQUEST. If the block length is found to be invalid while executing a READ or WRITE operation to the sequential-access device, the command will be terminated with

a CHECK CONDITION status and the sense key will be set to COPY ABORTED.

The DAD number of fields of blocks specify the number of blocks in the current segment. A value of 0 indicates that no blocks will be transferred in this segment. The DAD logical block address specifies the starting logical block address on the LU for this segment.

COPY Function Code 03H. (Ref. 7.1.4.5) The format for the segment descriptors for COPY transfers among sequential-access devices is specified by Table 9. This format is required for COPY function 03H. The segment descriptor may be repeated up to 256 times within the parameter list length specified in the CDB.

Table 9
Segment Descriptor for COPY Function Code 03H

Byte	Bit 07	06	05	04	03	02	01	00
00	Source Address			0	0	Source LUN		
01	Destination Address			0	0	Destination LUN		
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Source Block Length (MSB)							
05	Source Block Length (LSB)							
06	Destination Block Length (MSB)							
07	Destination Block Length (LSB)							
08	Source Number of Blocks (MSB)							
09	Source Number of Blocks							
10	Source Number of Blocks							
11	Source Number of Blocks (LSB)							

Source and Destination Address

Source address and destination address fields specify the SCSI devices. The source and destination LUN fields specify the LUs to use for this segment of the COPY command. Some SCSI devices may not support "third-party" COPY in which the copying SCSI device is not the source or destination device. Some SCSI devices only support COPY within the SCSI device and not to other SCSI devices. If an unsupported COPY operation is requested, the

command will be terminated with a CHECK CONDITION status and the sense key will be set to ILLEGAL REQUEST.

Block Lengths

The source block-length field specifies the block-length of the source device for this segment of the COPY. A 0 in this field indicates variable block-length. For non-zero values, this field will match the logical unit's actual block-length. If block-length mismatches are detected by the SCSI device managing the COPY, the command will be terminated with a CHECK CONDITION status and the sense key will be set to ILLEGAL REQUEST. If the mismatches are detected during the READ operation by the COPY manager, the command will be terminated with a CHECK CONDITION status and the sense key will be set to COPY ABORTED.

The destination block-length field specifies the block length to be used on the destination LU during the COPY. Destination block-length mismatches are handled in the same manner as source block-length mismatches.

Source Number of Blocks

This field specifies the number of blocks to be transferred from the source device during this segment. A value of zero indicates that no blocks will be transferred.

1/4" Cartridge

Third-party copy operations are not supported. Block sizes of 256 and 512 bytes are supported. This unit does not support the priority field in the copy parameter list.

1/2" Reel-To-Reel

Only Copy Function Codes 00 (direct-to-sequential) and 01 (sequential-to-direct) are supported. The disk data block size is specified by issuing a READ CAPACITY command.

Tape block size can be up to 48K.

Third party data transfers are not supported.

1/2" Cartridge

Third party transfers are not supported. The parameter list is TBD.

RECEIVE DIAGNOSTIC RESULTS Command (Ref. 7.1.5)

Peripheral Device Type: All
Operation Code Type: Optional
Operation Code: 1CH

RECEIVE DIAGNOSTIC RESULTS Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	1	0	0
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	Allocation Length (MSB)							
04	Allocation Length (LSB)							
05	0	0	0	0	0	0	Flag	Link

ANSI

The RECEIVE DIAGNOSTIC RESULTS command requests analysis data to be sent to the initiator after completion of a SEND DIAGNOSTIC command.

The allocation length will specify the number of bytes that the initiator has allocated for returned diagnostic data. An allocation length of 0 indicates that no diagnostic data will be transferred. Any other value indicates the maximum number of bytes that can be transferred. The target terminates the DATA IN phase when allocation length bytes have been transferred or when all available diagnostic data have been transferred to the initiator, whichever is less.

1/4" Cartridge

The 1/4" Cartridge unit does not support the RECEIVE DIAGNOSTIC RESULTS command. If the device fails a self test initiated by the SEND DIAGNOSTIC command, it will not respond to subsequent SCSI commands until the initiator issues a SCSI bus reset command.

NOTE: If the controller self-test procedure is initiated online, the host-supplied device parameter definitions (from the MODE SELECT command) are lost. The host must re-issue the MODE SELECT command to re-establish the parameters.

1/2" Reel-To-Reel

The command is used as specified in ANSI. A diagnostic file specified by the allocation length is associated with the command; the file specifies the required diagnostic function:

Byte	Length	Description
0	1	Valid data flag. Non-zero = invalid
1	1	Reserved
2	2	Number of data bytes
4	n	Data field
4+n	1	Number of bytes in the sense field
4+n+1	m	Extended sense field

The following diagnostic functions are supported by the interface

Code	Functions
D0H	Diagnostic inquiry
D1H	Test buffer

Diagnostic Inquiry

The Diagnostic Inquiry function returns 64 bytes of information about the interface in the data field of the Receive Diagnostic file.

Because the interface supports only the test buffer function in which only the first two bytes contain valid data. These bytes are a value of 64K-1 (FFFFH), all other fields are zero filled.

Test Buffer

The Test Buffer function allows testing of the interface buffer. The logical block offset value is supported. The value is specified in Bytes 6 and 7 of the SEND DIAGNOSTIC file. (See the description of that command.) This value is multiplied by the block size to obtain the byte offset in the buffer. The block size is the one previously specified with the MODE SELECT command. On a SEND DIAGNOSTIC command, the data is transferred into the buffer at this offset. On the RECEIVE DIAGNOSTIC command, the data is then transferred from the buffer to the host.

The TEST BUFFER command may be issued only when the buffer is empty unless the device and/or unit offline bits are set (Bits 0 and 1 of Byte 1 of the command data buffer). If either of the bits is set, the data in the buffer will be destroyed.

An illegal request status is returned if the Self-Test bit is set (Bit 2 of Byte 1 of the CDB).

1/2" Cartridge

The command is used as specified in ANSI. The diagnostic data format is as described for the 1/2" Reel-To-Reel unit above.

SEND DIAGNOSTIC Command (Ref. 7.1.6)

Peripheral Device Type: All
Operation Code Type: Optional
Operation Code: 1DH

SEND DIAGNOSTIC Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	1	0	1
01	0	0	0	0	0	SelfTest	DevOfl	UnitOfl
02	0	0	0	0	0	0	0	0
03	Parameter List Length (MSB)							
04	Parameter List Length (LSB)							
05	0	0	0	0	0	0	Flag	Link

ANSI

The SEND DIAGNOSTIC command requests the target to perform diagnostic tests on itself, on the attached peripheral devices, or both. This command is usually followed by a RECEIVE DIAGNOSTIC RESULTS command, except when the self-test (SelfTest) bit is 1.

The parameter list length specifies the length in bytes of the parameter list that is transferred during the DATA OUT phase. A parameter list length of 0 indicates that no data will be transferred. This condition shall not be considered as an error. The parameter list is vendor unique.

A LU off-line (UnitOff) bit of one enables write operations on the user medium or operations that affect user visible medium positioning. If the SCSI device off-line (DevOfL) bit is 1, it enables diagnostic operations that may adversely affect operations to other LUs on the same target.

The LU off-line and SCSI device off-line bits are generally set by operating system software, while the parameter list is prepared by diagnostic application software. Thus, by preventing operations that are not enabled by these bits, the target assists the operating system in protecting its resources.

A self-test bit of 1 directs the target to complete its default self test. If the self test is requested, the parameter list length will be set to 0 and no data will be transferred. If the self test is passed, the command will be terminated with a GOOD status. Otherwise, the command will be terminated with a CHECK CONDITION status and, if extended sense is implemented, the

sense key will be set to HARDWARE ERROR.

1/4" Cartridge

The command is used as specified in ANSI but only the self-test diagnostic function is supported.

1/2" Reel-To-Reel

The command is used as specified in ANSI. A diagnostic file specified by the Parameter List field is associated with the command. This file specifies the function:

Byte	Length	Identification
0	2	Diagnostic file length (10 bytes and data)
2	1	Reserved
3	1	Diagnostic function code
4	2	Zero filled
6	2	Block offset value (0-7FH)
8	2	Number of bytes in data field
10	N	Data field for Test Buffer function

The diagnostic functions that can be selected by Byte 3 are:

Code	Functions
DOH	Diagnostic inquiry
D1H	Test buffer

Test Buffer

The Test Buffer function allows testing of the interface buffer. The logical block offset value is supported. The value is specified in Bytes 6 and 7 of the SEND DIAGNOSTIC file. This value is multiplied by the block size to obtain the byte offset into the buffer. The block size is the one previously specified by the MODE SELECT command. On a SEND DIAGNOSTIC command, the data is transferred into the buffer at this offset. On the RECEIVE DIAGNOSTIC command, the data is then transferred from the buffer to the host.

1/2" Cartridge

The command is used as specified in ANSI. The data format is as follows:

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	SelfTest	0	UnitOfl
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	Function Code							
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	0	0
06	Block Offset Value (MSB)							
07	Block Offset Value (LSB)							
08	Number of bytes in data field (MSB)							
09	Number of bytes in data field (LSB)							
10	Data field (length specified in Bytes 8 and 9)							

The Diagnostic Function Codes are as follows:

Code	Functions
DOH	DIAGNOSTIC INQUIRY - This function returns 64 bytes of information about the drive. This data is returned in the data field of the RECEIVE DIAGNOSTIC command data format.
D1H	TEST BUFFER - This function allows testing of the data buffer. The logical block offset value will be multiplied by the mode selected block size to obtain the byte offset into the buffer. On a SEND DIAGNOSTIC command, the data is transferred into the buffer at this offset. On the RECEIVE DIAGNOSTIC command, the data will be transferred from the buffer to the initiator.

EOH EXECUTE DOWN LOADED CODE - This function allows the initiator to down load code and execute it. This code is contained in the data field and cannot exceed TBD K bytes in length. The execution start address is contained in the block offset value field. Exit from the down-loaded code is accomplished by jumping to location FFFFOH, resulting in the drive performing the power-up initialization sequence. The drive completes the command prior to executing the down-loaded code.

REWIND Command (Ref. 9.1)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory
Operation Code: 01H

REWIND Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	1
01	0	0	0	0	0	0	0	Imed
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

ANSI

The REWIND command requests that the target rewind the Logical Unit to the BOT or load-point.

An immediate (Imed) bit of 1 indicates that the status will be returned as soon as the operation is initiated. An Imed bit of 0 indicates that status will be returned after the operation is completed.

1/4" Cartridge

Same as ANSI except that the Imed bit is not used.

1/2" Reel-To-Reel

Same as ANSI.

1/2" Cartridge

Same as ANSI.

READ BLOCK LIMITS Command (Ref. 9.2)

Peripheral Device Type: Sequential Access
Operation Code Type: Extended
Operation Code: 05H

READ BLOCK LIMITS Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	1	0	1
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

ANSI

The READ BLOCK LIMITS command requests that the block length limits be returned for the Logical Unit. The READ BLOCK LIMITS data shown below will be sent during the DATA IN phase of the command.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	1	0	1
01	Maximum Block Length (MSB)							
02	Maximum Block Length							
03	Maximum Block Length (LSB)							
04	Minimum Block Length (MSB)							
05	Minimum Block Length (LSB)							

If the maximum block length equals the minimum block length, fixed-length blocks are specified. Otherwise, variable blocks are specified. For variable-length blocks, if the maximum block length equals 0, no upper limit is specified.

1/4" Cartridge

Same as ANSI. The only block size supported is 512 bytes.

1/2" Reel-To-Reel

Same as ANSI. Minimum block size is 1. Maximum is 10000H (64K) when configured in Microstreamer mode; 8000H (32K) in either cache or GCR mode.

1/2" Cartridge

Same as ANSI.

READ Command (Ref. 9.3)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory
Operation Code: 08H

READ Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	1	0	0	0
01	0	0	0	0	0	0	0	Fixed
02	Transfer Length (MSB)							
03	Transfer Length							
04	Transfer Length (LSB)							
05	0	0	0	0	0	0	Flag	Link

ANSI

The READ command transfers one or more block(s) to the initiator beginning with the next block on the Logical Unit (LU). 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 0, 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 will be sent to the initiator and the incorrect length indicator (ILI) bit and valid bit in extended sense will be set to 1. The information bytes in extended sense will be set to the difference (residue) between the requested transfer length and the actual block length. Targets that do not support negative residues will set the ILI bit to 1 and the residue to 0 when the actual block length is larger than the transfer length. In any case, only transfer length bytes will be transferred to the initiator and the medium will be positioned after the block (EOT side).

If the fixed bit is 1, the transfer length specifies the number of blocks to be transferred to the initiator. This form of the READ command is valid only if the LU is currently operating in fixed block mode. A LU is in fixed block mode when either of the following conditions is true:

(1) The LU reports the same value for minimum block length and maximum block length in response to the READ BLOCK LIMITS command. In this case, the current block length is the value returned.

(2) The LU has been instructed to use fixed-length blocks with the MODE SELECT command. In this case, the current block length is the one defined in the MODE SELECT command.

Otherwise, the LU is in variable block mode. The target may implement fixed block mode, variable block mode, or both modes. If the fixed bit does not match the current mode, or the mode indicated by the fixed bit is not implemented, the target will reject the command by returning a CHECK CONDITION status and by setting the sense key to ILLEGAL REQUEST.

A successful READ command with the fixed bit equal to 1 will transfer one current block length times the transfer length bytes of data to the initiator. Upon termination of the READ command, the medium will be positioned after the last block transferred (EOT side).

If the fixed bit is 1, 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 extended sense will be set to 1. The information bytes will be 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 medium will be positioned after the incorrect length block (EOT side).

If a LU reads a filemark during a READ command, it will send a CHECK CONDITION status to the initiator and will set the filemark bit in extended sense. Upon termination, the medium will be positioned after the filemark (EOT side). If the fixed bit is 1, the target will set the valid bit to 1 and the information bytes will be set to the difference (residue) between the requested transfer length and the actual number of blocks read, not including the filemark.

If a LU encounters the physical EOT during a READ command, the target returns a CHECK CONDITION status to the initiator and sets the EOT bit to 1 in extended sense. The sense key will be set to MEDIUM ERROR. If the fixed bit is 1, the target will set the valid bit to 1 and the information bytes to the difference (residue) between the requested transfer length and the actual number of blocks successfully read. The medium position following this condition is not defined.

When the transfer length is 0, no data will be transferred and the current position on the LU will not be changed. This condition will not be considered as an error.

1/4" Cartridge

The fixed bit must be set to 1 and the variable block mode is not supported. When the physical EOT occurs, the sense key is set to NO SENSE and the EOT bit is set to 1.

When a logical EOT occurs, the CHECK CONDITION extended sense byte is set to BLANK CHECK and the non-extended error code is set to READ EOM. The transfer length is the same as specified in ANSI.

The following unrecoverable errors can be reported in the CHECK CONDITION:

Sense Key	Sense Code	Read Error
BLANK CHECK (08)	READ EOM (34)	The unit detected a logical EOT condition.
ILLEGAL REQUEST (05)	READ EOM (34)	A READ command was issued after a WRITE command but no intervening rewind operation occurred.
ILLEGAL REQUEST (05)	INVALID COMMAND	After a VERIFY command in the immediate mode was issued, a READ command was issued before the verify operation was completed.
NO SENSE (00)	FILE MARK (1C)	The unit detected a file mark. The FM bit in the Extended Sense Byte is set to 1.
NO SENSE (00)	READ EOM (34)	The unit detected a physical EOT.

1/2" Reel-To-Reel

If the tape drive is in variable block mode, a READ command with the fixed bit (Byte 01, Bit 00) set is rejected with an ILLEGAL REQUEST sense key. If the drive is in fixed block mode, a READ command with the fixed bit off is rejected with an ILLEGAL REQUEST sense key. The byte count must not be greater than 64K. If the count is too large, the command is rejected with an ILLEGAL REQUEST sense key.

A Cache Tape tape drive will not support block sizes larger than 32K (8000H) when configured in the cache mode. CacheTape and GCR CacheTape drives are limited to 32K blocks in the non-buffered mode, but can support up to 64K blocks in the buffered mode.

If a buffer parity error occurs, the Sense Key is set to HARDWARE ERROR and a secondary error code of 43 is sent.

1/2" Cartridge

Same as ANSI.

WRITE Command (Ref. 9.4)

Peripheral Device Type : Sequential Access
Operation Code Type : Mandatory
Operation Code : OAH

WRITE command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	1	0	1	0
01	0	0	0	0	0	0	0	Fixed
02	Transfer Length (MSB)							
03	Transfer Length							
04	Transfer Length (LSB)							
05	0	0	0	0	0	0	Flag	Link

ANSI

The WRITE command transfers one or more block(s) from the initiator to the current position on the LU. 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 0, a single block will be transferred from the initiator and will be written to the LU beginning at the current medium position. The transfer length specifies the length (in bytes) of the block to be written. The requested block length will be within the minimum and maximum block length range returned by the READ BLOCK LIMITS command. If this condition is not met, a CHECK CONDITION status will be returned, the sense key will be set to ILLEGAL REQUEST, and no data will be written. Upon successful termination, the medium will be positioned after the block written by this command (EOT side).

If the fixed bit is 1, the transfer length field specifies the number of block(s) to be transferred to the LU beginning at the current medium position. This form of the WRITE command is valid only if the LU is currently operating in fixed block mode. Upon termination, the medium will be positioned after the block(s) written by this command (EOT side).

The target may implement fixed block mode, variable block mode, or both modes. If the fixed bit does not match the current mode, or the mode indicated by the fixed bit is not implemented, the target will reject the command by returning a CHECK CONDITION status and setting the sense key to ILLEGAL REQUEST.

If the early warning EOT condition is encountered while writing, an attempt may be made to finish writing buffered data. The command will terminate with a CHECK CONDITION status and the EOT bit in extended sense will be set to 1. If any data remains in the target's buffer, then the sense key will be set to VOLUME OVERFLOW. If the fixed bit is 1 and the LU is not buffered (buffered mode of the MODE SENSE command is 0), then the valid bit in extended sense will be set to 1 and the information bytes will be set to the difference (residue) between the requested transfer length and the actual number of blocks written to the medium. If the fixed bit is 1 and the LU is buffered (buffered mode of the MODE SENSE command is 1), then the valid bit will be set to 1 and the information bytes will be set to the total number of blocks not written (the number of blocks not transferred from the initiator, plus the number of blocks remaining in the target's buffer). In this case it is possible for the value in the information bytes to exceed the transfer length.

When the transfer length is 0, no data will be transferred and the current position on the LU will not be changed. This condition will not be considered as an error.

1/4" Cartridge

The fixed bit must be set to 1; the variable-block mode is not supported. If the fixed bit is set to 0, the CHECK CONDITION signal is sent and the error code is set to INVALID COMMAND.

The early warning EOT condition is handled as specified in ANSI. If an attempt is made to finish writing data, no additional early warning is given. An attempt to write past the physical EOT results in a CHECK CONDITION status code and a sense code of INSUFFICIENT CAPACITY.

If an unrecoverable error occurs during a WRITE operation, a CHECK CONDITION occurs and the information bytes containing the number of blocks are not written.

A filemark should be written as the last block on the tape.

1/2" Reel-To-Reel

In variable-block mode, the byte count cannot exceed 64K (10000H) in the buffered mode.

1/2" Cartridge

Data blocks can be fixed or variable as specified in the MODE SELECT command, but data is always written in 2-Kbyte sectors. The last sector is zero padded if it is necessary to write a complete block.

TRACK SELECT Command (Ref. 9.5)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 0BH

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	1	0	1	1
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Track Value							
05	0	0	0	0	0	0	Flag	Link

ANSI

The TRACK SELECT command requests that the track specified in the track value field be selected.

1/4" Cartridge

Not supported.

1/2" Reel-To-Reel

Not Supported.

1/2" Cartridge

Same as ANSI. Allowable track values are 01H to "N".

READ REVERSE Command (Ref. 9.6)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 0FH

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	1	1	1	1
01	0	0	0	0	0	0	0	Fixed
02	Transfer Length (MSB)							
03	Transfer Length							
04	Transfer Length (LSB)							
05	0	0	0	0	0	0	Flag	Link

ANSI

The READ REVERSE command functions exactly the same as the READ command, except the tape runs in the reverse direction. Thus, the blocks and bytes in the blocks are transferred in the reverse order and the medium position upon termination is before the last block read (BOT of medium side). This command will terminate with a CHECK CONDITION status and the EOT bit in extended sense will be set to 1 if BOT or load point is encountered. The sense key will be set to NO SENSE. If the fixed bit is 1, then the valid bit is set to 1 and the information bytes will contain the difference (residue) of the requested transfer length and the actual number of blocks transferred.

Filemark handling is the same as in the READ command except the medium position upon command termination will be before the filemark.

If the transfer length is 0, no data will be transferred and the current position on the LU will not be changed. This condition will not be considered an error.

The target may implement fixed block mode, variable block mode or both modes. If the fixed bit does not match the current mode, or the mode indicated by the fixed bit is not implemented, the target will reject the command by returning a CHECK CONDITION status and setting the sense key to ILLEGAL REQUEST.

1/4" Cartridge

Not supported.

1/2" Reel-To-Reel

Same as ANSI.

1/2" Cartridge

Same as ANSI.

SPACE Command (Ref. 9.8)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 11H

SPACE Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	0	0	1
01	0	0	0	0	0	0	Code	
02	Count (MSB)							
03	Count							
04	Count (LSB)							
05	0	0	0	0	0	0	Flag	Link

ANSI

The SPACE command provides a variety of positioning functions that are determined by the code and count. Both forward (toward EOT) and reverse (toward BOT) positioning are provided, although some SCSI devices may only support a subset of this command. Such SCSI devices will return a CHECK CONDITION status and set the sense key to ILLEGAL REQUEST in response to any attempt to invoke a function that is not supported.

The code is defined as follows:

DB(1)	DB(0)	Description
0	0	Blocks
0	1	Filemarks
1	0	Sequential Filemarks
1	1	Physical End-of-Data

When spacing over blocks or filemarks, the count field specifies the number of blocks or filemarks to be spaced over. A positive value of N in the count field will cause forward medium movement over N blocks or filemarks ending on the EOT side of the last block or filemark. A 0 value in the count field will cause no medium movement. A negative value of -N (2's complement rotation) in the count field will cause reverse medium movement over N blocks or filemarks ending on the BOT side of the last block or filemark.

If a filemark is encountered while spacing over blocks, tape movement is stopped. The tape will be positioned at the EOT side of the filemark if movement was in the forward direction and on the BOT side of the filemark if movement was in the reverse direction. A CHECK CONDITION status will be sent to the initiator and the filemark and valid bits in extended sense will be set to 1. The information bytes will be set to the differences (residue) in the requested count and the actual number of blocks spaced over, not including the filemark.

If the physical EOT is encountered while spacing forward over blocks or filemarks, the target will return a CHECK CONDITION status to the initiator and will set the EOT bit in extended sense to 1. The sense key will be set to MEDIUM ERROR. The target will set the valid bit to 1 and the information bytes to the difference (residue) between the requested count and the actual number of blocks or filemarks spaced over.

If BOT or load-point is encountered while spacing over blocks or filemarks in the reverse direction, the target will return a CHECK CONDITION status to the initiator and set the EOT bit in extended sense to 1. The sense key will be set to NO SENSE. The target will set the valid bit to 1 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 will cause forward medium movement to the first occurrence of N or more consecutive filemarks stopping over the Nth filemark.

(2) A 0 value will cause no medium movement.

(3) A negative value -N (2's complement notation) will cause reverse medium movement to the first occurrence of N or more consecutive filemarks stopping on the BOT side of the Nth filemark.

When spacing to physical EOD, the count field is ignored. Forward movement of the medium occurs until the LU encounters physical EOD as defined by the sequential-access device. Some sequential-access devices define physical EOD as an erased area on the medium, However, other definitions are not precluded. Targets that implement this function leave the medium positioned so a subsequent WRITE command will append data to the last recorded information on the medium.

1/4" Cartridge

The command operates as specified in ANSI, but the unit does not support reverse spacing. The count field must be a positive number.

1/2" Reel-To-Reel

Same as ANSI, but this unit does not support spacing to the EOD.

1/2" Cartridge

Same as ANSI.

WRITE FILEMARKS Command (Ref. 9.7)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory
Operation Code: 10H

WRITE FILEMARKS Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	0	0	0
01	0	0	0	0	0	0	0	0
02	Number of Filemarks (MSB)							
03	Number of Filemarks							
04	Number of Filemarks (LSB)							
05	Vendor Unique		0	0	0	0	Flag	Link

ANSI

The WRITE FILEMARKS command causes the specified number of filemarks to be written beginning at the current medium position on the LU. A 0 in this field indicates that no filemarks are to be written.

This command is also used to force any buffered data to be written by not returning a GOOD status until all buffered data blocks and filemarks are correctly written on the medium.

If the early warning EOT condition is encountered while writing, an attempt may be made to finish writing any buffered data. The command will terminate with a CHECK CONDITION status and the EOT bit in extended sense will be set to 1. If any filemarks remain to be written, then the sense key will be set to VOLUME OVERFLOW. If the LU is not buffered (buffered mode of the MODE SENSE command is 0), then the valid bit in extended sense will be set to 1 and the information bytes will be set to the number of unwritten filemarks. If the LU is buffered, then the valid bit will be set to 1 and the information bytes will be set to the total number of blocks not written (the number of unwritten filemarks plus the number of blocks remaining in the target's buffer). In this case it is possible for the value in the information bytes to exceed the transfer length.

1/4" Cartridge

Same as ANSI except that Bit 06 in Byte 05, the vendor unique field is used. Bit 06, the Immediate (Imed) bit, is valid only if the unit has been set to cache buffering mode by the BUFM field in the MODE SELECT command. If Imed is set to 1, and BUFM is set to 01, the WRITE FILEMARKS command terminates immediately. If BUFM is set to 0, the WRITE FILEMARKS command terminates only after all buffered data and filemarks have been written to tape. The Imed bit is also used for write synchronization operations. When the number of filemarks field equals 0 and the Imed field is set to 0, the contents of the cache are written to tape before the WRITE FILEMARKS command terminates.

1/2" Reel-To-Reel

Same as ANSI. Filemarks are used to force data in the SCSI buffer to the tape drive or to cache memory in the case of a CacheTape or GCR CacheTape

1/2" Cartridge

Same as ANSI.

VERIFY Command (Ref. 9.9)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 13H

VERIFY Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	0	1	1
01	0	0	0	0	0	0	BytCmp	Fixed
02	Verification Length (MSB)							
03	Verification Length							
04	Verification Length (LSB)							
05	Vendor Unique		0	0	0	0	Flag	Link

ANSI

The VERIFY command verifies one or more blocks beginning with the next block on the Logical Unit. The fixed bit specifies both the meaning of the verification length field and whether fixed-length or variable-length blocks are to be verified.

A byte compare (BytCmp) bit of 0 indicates that the verification will be simply a medium verification (CRC, ECC, etc.) with no data transferred between the initiator and the target. A byte compare bit of 1 indicates that the target will perform a byte-by-byte comparison of the data on the medium, and transfer data from the initiator to the target as in a WRITE command.

A fixed bit of 0 requests that the next block of the LU be verified. The verification length specifies the number of bytes to be verified. A fixed bit of 1 requests verification length blocks be verified beginning with the next logical block on the LU. This form of the VERIFY command is only valid if the LU is currently in fixed block mode, as defined in the READ command. If the data does not compare (byte compare bit equals 1), the command will terminate with a CHECK CONDITION status and the sense key will be set to MISCOMPARE. If the fixed bit is 1, the valid bit will be set to 1 and the information bytes will be set to the difference (residue) between the verification length and the actual number of blocks successfully verified. The medium will be positioned after the block containing the miscompare (EOT side).

The target may implement fixed block mode, variable block mode, or both modes. If the fixed bit does not match the current mode, or the mode indicated by the fixed bit is not implemented, the target will reject the command by returning a CHECK CONDITION status and by setting the sense key to ILLEGAL REQUEST.

The VERIFY command will terminate when the verification length has been satisfied, when a filemark is encountered, or when physical EOT is encountered. The status and sense data for each of these conditions are handled as in the READ command. Upon completion of the VERIFY command, the medium will be positioned after the last block from which data was verified or after the filemark.

1/4" Cartridge

Only the fixed-block mode is supported and the fixed bit must be set to 1.

Bit 06 in the vendor unique field of byte 05 is the immediate bit (Imed). If the unit is operating in the buffered mode when this bit is set to 1, the unit operates in the streaming mode by immediately returning command completion status information. When the Imed bit is set to 0, the unit returns status information after completing execution of the command.

1/2" Reel-To-Reel

The byte compare mode (BytCmp = 1) is not supported.

1/2" Cartridge

Same as ANSI, except that the byte compare mode (BytCmp = 1) is not supported.

RECOVER BUFFERED DATA Command (Ref. 9.10)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 14H

RECOVER BUFFERED DATA Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	1	0	0
01	0	0	0	0	0	0	0	Fixed
02	Transfer Length (MSB)							
03	Transfer Length							
04	Transfer Length (LSB)							
05	0	0	0	0	0	0	Flag	Link

ANSI

The RECOVER BUFFERED DATA command reads data that has been transferred to an SCSI device buffer but has not been written on the medium. It is normally only used to recover from error or exception conditions that make it impossible to write the buffered data on the medium.

This command functions similarly to the READ command except the data is transferred from the SCSI device buffer instead of the medium. The order in which blocks are transferred is the same as if they were being transferred to the medium. One or more RECOVER BUFFERED DATA commands may be used to read the unwritten buffered data.

The target may implement fixed block mode, variable block mode, or both modes. If the fixed bit does not match the current mode, or the mode indicated by the fixed bit is not implemented, the target will reject the command by returning a CHECK CONDITION status and setting the sense key to ILLEGAL REQUEST.

If an attempt is made to recover more logical blocks of data than are contained in the SCSI device buffer, the command will be terminated with a CHECK CONDITION status. The EOT bit in extended sense will be set to 1. If the fixed bit is 1, the valid bit will be set to 1 and the information bytes will be set to the difference (residue) between the requested transfer length and the actual number of blocks transferred.

The transfer length specifies the number of contiguous logical blocks of data to be transferred. A transfer length of 0 indicates that no data will be transferred. This condition will not be considered an error.

1/4" Cartridge

The fixed bit must be set to 1; the variable block mode is not supported.

1/2" Reel-To-Reel

To recover data in a CacheTape drive, the SCSI interface board must be configured to be in the cache mode. This limits the maximum block size to 32K. If configured in the Microstreamer mode, the maximum block size is 64K, but data cannot be recovered from the cache memory in the drive.

1/2" Cartridge

Same as ANSI. The maximum block size is TBD.

MODE SELECT Command (Ref. 9.11)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 15H

MODE SELECT Command

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	1	0	1
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	Parameter List Length				
05	0	0	0	0	0	0	Flag	Link

ANSI

The MODE SELECT command provides a means for the initiator to specify medium, LU, or peripheral device parameters to the target.

The parameter list length specifies the length in bytes of the MODE SELECT parameter list that will be transferred during the DATA OUT phase. A 0 parameter list length indicates that no data will be transferred but will not be considered as an error.

The MODE SELECT parameter list shown below contains a 4-byte header, followed by 0 or more 8-byte block descriptors, followed by the vendor unique parameters, if any.

MODE SELECT Parameter List

Byte	Bit 07	06	05	04	03	02	01	00
06	0	0	0	0	0	0	0	0
07	0	0	0	0	0	0	0	0
08	0	Buffered Mode			Speed			
09	Block Descriptor Length							

Block Descriptors

Byte	Bit 07	06	05	04	03	02	01	00
00	Density Code							
01	Number of Blocks (MSB)							
02	Number of Blocks							
03	Number of Blocks (LSB)							
04	0	0	0	0	0	0	0	0
05	Block Length (MSB)							
06	Block Length							
07	Block Length (LSB)							

A buffered mode of 0 indicates that the target will not report a GOOD status on WRITE commands until the data blocks are actually written on the medium. A buffered mode of 1 indicates that the target may report a GOOD status on WRITE commands as soon as the data block has been transferred to the SCSI device buffer. One or more blocks may be buffered prior to writing the blocks to the medium. Buffered modes of 2H through 7H are reserved.

Code values for the speed field will be assigned as follows:

OH Default (Use the peripheral device's default speed.)
1H Use the peripheral device's lowest speed.
2H-FH Use increasing peripheral device speeds.

The block descriptor length specifies the length in bytes of all the block descriptors. It is equal to the number of block descriptors times eight and does not include any vendor unique parameters. lock descriptor length of 0 indicates that no block descriptors are included in the parameter list. This condition will not be considered as an error.

Each block descriptor specifies the medium characteristics for all or part of a LU. Each block descriptor contains a density code, a number of blocks, and a block length.

Code values for the density code field will be assigned as follows:

00H	Default (peripheral device's default density)
01H	X3.22-1983 (800 CPI, NRZI)
02H	X3.39-1973 (1600 CPI, PE)
03H	X3.54-1976 (6250 CPI, GCR)
04H	1/4 inch cartridge, QIC-11 format
05H	1/4 inch cartridge, QIC-24 format
06H	X3B5/85-13 (Project Number 0391-D) (3200 CPI, PE)
07H-7FH	Reserved
80H-FFH	Vendor unique

The number of blocks in a field specifies the number of logical blocks on the medium that meet the density code and block length in the block descriptor. If the number of blocks of 0, it indicates that all of the remaining logical blocks of the LU will have the medium characteristics specified by the block descriptor.

The block length specifies the length in bytes of each logical block described by the block descriptor. A block length of 0 indicates that the length will be variable.

1/4" Cartridge

The command is the same as ANSI. The parameter list can have no block descriptors or one block descriptor. The block descriptor is nine bytes in length; only the first and last bytes are used. The number of blocks and block-length fields are not used. Block sizes are variable. The speed field is 0.

MODE SELECT Parameter List For 1/4" Cartridge

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	0
01	0	0	0	0	0	0	0	0
02	0	Buffered Mode			0	0	0	0
03	Block Descriptor Length							

Block Descriptors

Byte	Bit 07	06	05	04	03	02	01	00
00	Density Code							
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	0	0
06	0	0	0	0	0	0	0	0
07	0	0	0	0	0	0	0	0
08	0	0	0	0	0	DEA	AUI	SEC

The density code can have four values, the first three are the same as specified for ANSI:

00H	Default: 1/4 inch cartridge, QIC-24 format, 9 tracks
04H	1/4 inch cartridge, QIC-11 format, 4 tracks
05H	1/4 inch cartridge, QIC-24 format, 9 tracks
84H	1/4 inch cartridge, QIC-11 format, 9 tracks

The Disable Erase Ahead (DEA) bit enables or disables the erase-ahead option. When DEA is 0, the drive erases 55 inches of tape after writing its last block. This enables the user to remove the tape at any time. When DEA is 1, the DEA occurs only if the last block is a filemark, or when a REWIND or UNLOAD command is issued.

The Auto-Load Inhibit (AUI) bit specifies whether the tape drive is to perform a logical automatic cartridge load. If AUI is set to 0, the auto-load feature is enabled and no LOAD command is required when a cartridge is installed. If AUI is set to 1, the auto-load feature is not enabled and a LOAD command must be sent to the drive before any other command can be performed on the drive.

The soft error count (SEC) bit specifies whether recoverable errors are to be reported to the user. When a recoverable error is detected by the unit, it maintains a count in the sense key and sense code information. If SEC is set to 0, the unit issues a CHECK CONDITION after a command that causes a recoverable error. If SEC is set to 1, the CHECK CONDITION is not sent. The sense key and sense code can be retrieved even if the CHECK CONDITION is not sent.

1/2" Reel-To-Reel

The command is the same as ANSI. The default conditions are:

- o Buffered mode
- o High speed
- o Fixed length block sizes of 512 bytes

The block descriptor list can be either 0 (no descriptor) or 8 (one descriptor).

1/2" Cartridge

Only one speed and one density are provided. The parameter list can be 0, 4, 12, 13, 14, 15 or 16 bytes in length. The maximum list is shown below:

MODE SELECT Parameter List For 1/2" Cartridge

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	0
01	0	0	0	0	0	0	0	0
02	0	Buffered Mode			0	0	0	0
03	Block Descriptor Length							

Block Descriptors

Byte	Bit 07	06	05	04	03	02	01	00
00	Density Code							
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	Block Length (MSB)							
06	Block Length							
07	Block Length (LSB)							

	ADDITIONAL PARAMETERS (VENDOR UNIQUE)							
00	0	0	0	0	0	0	0	0
01	0	0	0	0	0	ECC	TDE	ERP
02	Read Retry Count							
03	Write Skip Count							

The number of blocks must be 0. The block length is as specified in ANSI, but a value of FFFFFFFF can be used to specify an unlimited block length.

The disable ECC bit specifies whether error correction is to be performed on READ operations. A value of 0 enables ECC, a value of 1 disables ECC. This bit does not disable the generation of error correction information on WRITE operations, nor does it disable error detection.

The Disable Terminate on Data Error (DTDE) bit disables the termination of commands on hard data errors.

The Disable Error Recovery Procedures (DERP) bit disables error recovery on READ operations and disables write skips on WRITE operations.

The read retry count specifies the number of READ retries to be permitted before a hard read error is declared. A value of 0 disables read retry operations. Values can be up to 255, and the default value is five.

The WRITE skip count specifies the maximum number of WRITE skips (sectors rewritten to correct write errors) to be permitted before a hard WRITE error is declared. A value of 0 disables write skip operations. Values can be up to 255, and the default value is five.

NOTE: Additional parameters may be added to this format.

RESERVE UNIT and RELEASE UNIT Commands (Ref. 9.12)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 16H and 17H, respectively

Byte	Bit 07	06	05	04	03	02	01	00
00	Operation Code 16H or 17H							
01	0	0	0	3rdPty	Third Party Device ID			0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

ANSI

The RESERVE UNIT and RELEASE UNIT commands use the CDB shown above.

RESERVE UNIT Command. The RESERVE UNIT command (Operation Code 16H) reserves the specified LU for the exclusive use of the requesting initiator.

The reservation remains in effect until a RELEASE UNIT command is received from the same initiator, a BUS DEVICE RESET message is received from any initiator, or a "hard" RESET condition occurs. The occurrence of the last two conditions is indicated by a sense key of UNIT ATTENTION on the next command following the condition. It is not an error to issue this command to a LU that is currently reserved to the requesting initiator.

If the LU is previously reserved for another initiator, then the target will respond by either:

(1) returning a RESERVATION CONFLICT status

(2) queuing the reservation request, disconnecting until all previously queued reservations have been released and the LU is available, then reconnecting to perform the reservation.

If, after honoring the reservation, any other initiator subsequently attempts to perform any command on the reserved LU other than a RESERVE UNIT command, which may be queued, the command will be rejected with a RESERVATION CONFLICT status.

The third-party reservation option for the RESERVE UNIT command allows an initiator to reserve a LU for another SCSI device. This option is intended for use in multiple-initiator systems that use the COPY command. Any target that implements the third-party reservation option will also implement the third-party release option.

If the third-party (3rdPty) bit is 0, then the third-party reservation option is not requested. If the 3rdPty bit is 1 and the third-party reservation option is implemented, then the RESERVE UNIT command will reserve the specified LU for the SCSI device specified in the third-party device ID field. The target will preserve the reservation until it is released by the same initiator (or by a BUS DEVICE RESET message from any initiator or a "hard" RESET condition). The target will ignore any attempt made by another initiator to release the reservation.

If the 3rdPty bit is 1 and the third-party reservation option is not implemented, then the target will reject the RESERVE UNIT command with a CHECK CONDITION status and a sense key of ILLEGAL REQUEST.

RELEASE UNIT Command. The RELEASE UNIT command (Operation Code 17H) will release the LU if it is currently reserved by the requesting initiator.

It is not an error to attempt to release a LU that is not currently reserved by the requesting initiator. However, it will not be released if it is reserved by another initiator.

The 3rdPty release option for the RELEASE UNIT command allows an initiator to release a LU that was previously reserved using the 3rdPty reservation option. This option will be implemented if the reservation option is implemented. This option is intended for use in multiple-initiator systems that use the COPY command.

If the 3rdPty bit is 0, the release option is not requested. If the bit is 1 and the target implements the third-party release option, then the target will release the specified LU but only if the reservation was made using the 3rdPty reservation option by the same initiator for the same SCSI device as specified in the 3rdPty device ID field.

If the 3rdPty bit is 1 and the target does not implement the release option, then the target will terminate the command with a CHECK CONDITION status and the sense key will be set to ILLEGAL REQUEST.

1/4" Cartridge

Same as ANSI. If a RESERVE UNIT command is received while the unit is reserved for another initiator, the RESERVATION CONFLICT status is returned. Reservation queuing is not permitted. 3rdPty reservations are supported.

1/2" Reel-To-Reel

Same as ANSI. As with the 1/4" drive, reservation queuing is not supported; 3rdPty reservations are supported.

1/2" Cartridge

Same as ANSI. The reservation queuing and 3rdPty reservation features are supported.

ERASE COMMAND (Ref. 9.13)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 19H

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	0	0	1
01	0	0	0	0	0	0	0	Long
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

ANSI

The ERASE command causes part or all of the remaining medium to be erased beginning from the current medium position. As used here, "erased" means either the medium is erased or a pattern is written on the medium that appears as gap to the target.

The distance to be erased is controlled by the Long bit. A Long bit of 1 indicates that all remaining medium on the LU will be erased. A Long bit of 0 indicates that a peripheral device specified portion of the medium will be erased. Normally, short erases are used to create an extended gap for software controlled error recovery or for support of "update in place" functions. The medium position following an ERASE command with a Long bit of 1 is not defined by this standard.

NOTE: Some targets may reject ERASE with the long bit set to 1 if the medium is not positioned at the BOT.

1/4" Cartridge

Same as ANSI except that the drive only erases the entire tape. The Long bit must be set.

1/2" Reel-To-Reel

If the Long bit is set to 0, about four inches of tape is erased. If the Long bit is 1, the tape is erased from the present position to the end.

If the buffer contains data from a previous READ operation, the buffer is cleared and the erasure is performed. If the buffer contains data from a previous WRITE operation, the data is written to tape before the remainder of the tape is erased.

If the EOT (early warning) is encountered on the write, the remaining data in the buffer is written to tape, an EOT status is reported, and a residue of 1 is reported to indicate that the erase was not performed.

1/2" Cartridge

The ERASE command operates in two modes: AC erase and security erase.

The AC erase (Long bit set to 1) causes the entire tape cartridge to be erased. The tape must be at the BOT, or the command is rejected.

The security erase (Long bit set to 0) writes unreadable patterns to the tape from the present position to the write-end-of-track (WEOT) on the last track. The security erase operation must begin at the end of a logical (user) data block. If write data is in the buffer when this command is issued, the data is written to tape before the erase.

MODE SENSE Command (Ref. 9.14)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 1AH

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	0	1	0
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Allocation Length							
05	0	0	0	0	0	0	Flag	Link

ANSI

The MODE SENSE command provides a means for a target to report its medium, Logical Unit (LU), or peripheral device parameters to the initiator. It is a complementary command to the MODE SELECT command for support of a medium that may contain different densities, such as half-inch tapes.

The allocation length specifies the number of bytes that the initiator has allocated for returned MODE SENSE data. An allocation length of 0 indicates that no MODE SENSE data will be transferred. This condition will not be considered as an error. Any other value indicates the maximum number of bytes that will be transferred. The target will terminate the DATA IN phase when allocation length bytes have been transferred or when all available MODE SENSE data have been transferred to the initiator, whichever is less.

The MODE SENSE data contains a 4-byte header, followed by 0 or more 8-byte block descriptors, followed by any vendor unique parameters.

MODE Sense Data Format

Byte	Bit 07	06	05	04	03	02	01	00
00	Sense Data Length							
01	Medium Type							
02	WP	Buffered Mode				Speed		
03	Block Descriptor Length							

Block Descriptor

Byte	Bit 07	06	05	04	03	02	01	00
00	Density Code							
01	Number of Blocks (MSB)							
02	Number of Blocks							
03	Number of Blocks (LSB)							
04	0	0	0	0	0	0	0	0
05	Block Length (MSB)							
06	Block Length							
07	Block Length (LSB)							
	Vendor Unique Parameters							
00-n	Vendor Unique Parameter Bytes							

The sense data length specifies the length in bytes of the following mode sense data that is available to be transferred during the DATA IN phase. The sense data length does not include itself.

Code values for the medium type field will be assigned as follows:

00H	Default (Only one medium type supported)
01H-7FH	Reserved
8H-FFH	Vendor unique

A Write Protected (WP) bit of 0 indicates that the medium is write enabled. A WP bit of 1 indicates that the medium is write protected.

A buffered mode of 0 indicates that the target does not report a GOOD status on WRITE commands until the data blocks are actually written on the medium. A buffered mode of 1 indicates that the target may report a GOOD status on WRITE commands as soon as the data block has been transferred to the SCSI device buffer. One or more blocks may be buffered prior to writing the blocks to the medium. Buffered modes of 2H through 7H are reserved.

Code values for the speed field are assigned as follows:

OH	Default (only one speed supported)
1H	Lowest peripheral device speed
2H-FH	Increasing peripheral device speed

The block descriptor length specifies the length in bytes of all the block descriptors. It is equal to the number of block descriptors times eight and does not include any vendor unique parameters. A block descriptor length of 0 indicates that block descriptors are not included in the parameter list. This condition will not be considered as an error.

Each block descriptor specifies the medium characteristics for all, or part of, a LU. Each block descriptor contains a density code, a number of blocks, and a block length.

Code values for the density code field will be assigned as follows:

OOH	Default (only one density supported)
O1H	X3.22-1983 (800 CPI, NRZI)
O2H	X3.39-1973 (1600 CPI, PE)
O3H	X3.54-1976 (6250 CPI, GCR)
O4H	1/4 inch cartridge, QIC-11 format
O5H	1/4 inch cartridge, QIC-24 format
O6H	X3B5/85-13 (Project Number 0391-D) (3200 CPI, PE)
O7H-7FH	Reserved
80H-FFH	Vendor unique

The number of blocks field specifies the number of logical blocks on the medium that meet the density code and block length in the block descriptor. A 0 number of blocks indicates that all of the remaining logical blocks of the LU have the medium characteristics specified by the block descriptor.

The block length specifies the length in bytes of each LU described by the block descriptor. A block length of 0 indicates that the length is variable.

1/4" Cartridge

Block size must be 512 bytes. A thirteenth byte is provided in the sense data for vendor unique information:

Byte	Bit 07	06	05	04	03	02	01	00
12	0	0	0	0	0	DEA	AUI	SEC

The Disable Erase Ahead (DEA) bit indicates whether the erase-ahead option is enabled. If DEA is 0, the drive erases 55 inches of tape after writing its last block. This enables the user to remove the tape at any time. IF DEA is 1, the Erase-

Ahead only occurs if the last block is a filemark or a REWIND or UNLOAD command has been issued.

The Auto-Load Inhibit (AUI) bit specifies whether the auto-load feature is enabled. If AUI is set to 0, the auto-load feature is enabled and a LOAD command is not required when a cartridge is installed. If AUI is set to 1, the auto-load feature is not enabled and a LOAD command must be sent to the drive before any other command can be performed on the drive.

The Soft Error Count (SEC) bit specifies whether recoverable errors are to be reported to the user. When a recoverable error is detected by the unit, it maintains a count in the sense key and sense code information. If SEC is set to 0, the unit issues a CHECK CONDITION to the user after a command causes a recoverable error. If SEC is set to 1, the CHECK CONDITION is not sent. However, the sense key and sense code can be retrieved.

1/2" Reel-To-Reel

Same as ANSI. In the sense data, the buffered mode field has these values:

0 - Unbuffered mode, write enabled
1 - Buffered, write enabled
8 - Unbuffered mode, write protected
9 - Buffered, write protected

In the block descriptor list, the density code can have the following values, depending on the attached tape drive:

02 - 1600 CPI
03 - 6250 CPI
06 - 3200 CPI

For Microstreamer and CacheTape, the default value is 02. For GCR CacheTape, the default value is 03.

1/2" Cartridge

Same as ANSI. The parameter list has the same configuration as specified for the 1/2" cartridge MODE SELECT, including the special ECC, TDE and ERP parameters.

LOAD/UNLOAD Command (Ref. 9.15)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 1BH

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	0	1	1
01	0	0	0	0	0	0	0	Imed
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	Re-Ten	Load
05	0	0	0	0	0	0	Flag	Link

ANSI

The LOAD/UNLOAD command requests the target enable or disable the LU for further operations. This command may also be used to request the retension function for peripheral devices that support this function.

A load bit of 1 indicates that the medium on the LU will be loaded and positioned to the BOT or load-point as determined by the peripheral device. A load bit of 0 indicates that the medium on the LU will be positioned for removal from the peripheral device.

Status will be returned after the medium is positioned unless the immediate (Imed) bit is 1. If the Imed bit is 1, status may be returned as soon as the command has been accepted.

A retension (Re-Ten) bit of 1 indicates that the medium on the addressed LU will be correctly tensioned before the LOAD/UNLOAD command is completed. This is an operational function intended for use by those peripheral devices that support the retension function.

1/4" Cartridge

The unit may disconnect from the initiator while executing this command. The Imed bit is not supported. The retension function is supported; LED 4 is illuminated.

1/2" Reel-To-Reel

If either the load or retension bit is set, the command is treated as a standard REWIND command.

1/2" Cartridge

Same as ANSI.

PREVENT/ALLOW MEDIUM REMOVAL Command (Ref. 9.16)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional
Operation Code: 1EH

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	1	1	0
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	Prevent
05	0	0	0	0	0	0	Flag	Link

ANSI

The PREVENT/ALLOW MEDIUM REMOVAL command requests that the target enable or disable the removal of the medium in the LU.

A prevent bit of 1 inhibits mechanisms that normally allow removal of the medium. A prevent bit of 0 allows removal of the medium.

This prevention of medium removal condition terminates upon receipt of a PREVENT/ALLOW MEDIUM REMOVAL command with the prevent bit set to 0, by the receipt of a BUS DEVICE RESET message from any initiator, or by a "hard" RESET condition.

1/4" Cartridge

The tape drive cannot mechanically prevent removal of the tape. When the PREVENT command is issued, LED 4, the not-safe-to-remove-cartridge indicator, is illuminated. The LED is extinguished when the ALLOW command is sent.

1/2" Reel-To-Reel

This command is not supported.

1/2" Cartridge

Same as ANSI.

APPENDIX A

CIPHER 1/4-INCH CARTRIDGE STREAMING TAPE DRIVE

SPECIFICATIONS

POWER REQUIREMENTS

Performance Specifications

The surge current, caused by bringing the cartridge up to speed, lasts for 350 ms.

+5 VDC plus or minus 5% @ 1.3 Amp maximum
+12 VDC plus or minus 5% @ 1.8 Amp nominal, 2.6 Amp surge max
or +24 VDC plus or minus 10% @ 0.9 Amp nominal, 1.3 Amp surge max

Power Dissipation

(5V X 1.3 Amp) + (12V X 1.8) = 28.1 Watts operational
(5V X 1.3 Amp) + (12V X 2.6) = 37.7 Watts surge

Drive Selection

Four drives can be daisy chained to a single controller as long as each has a different unit number. The maximum total cable length is ten feet and only the last drive should have the U5 and U6 termination resistor packs. The drive select jumpers on the basic I/O adapter are shown below.

Drive	Jumper
0	W0
1	W1
2	W2
3	W3

If a jumper is not installed, that drive is always unselected.

For more information, read Bulletin No. 03-311-0485-2K.

APPENDIX B

CIPHER 1/2-INCH REEL-TO-REEL TAPE DRIVE

SPECIFICATIONS

Temperature and Humidity

The interface will meet the following temperature and humidity requirements:

	Temp Range	Temp Chg	Rel Hum Range	Rel Hum Chg
Working Range	5C to 45C	1C per min.	10% to 90% (No condensation)	10% per hr.
Extreme Pwr-On Range	0C to 40C	10C per hr.	10% to 95% (No condensation)	------
Storage Range	-10C to 50C	15C per hr.	10% to 90%	------
Transit Range	-40C to 70C	20C per hr.	5% to 95%	------

Because the interface dissipates approximately 30 watts, adequate cooling must be provided to maintain the working range temperatures.

Technical Constraints

Error Recovery

Parity is provided on all data Read/Write buses (except in the SCSI chip), on the data buffer memory, and on the tape drive to allow detection and recovery of single-bit data errors. In addition, if a Read-After-Write error is detected while writing to the tape drive, the interface can back the tape up and rewrite the record that was in error.

Performance

Because of the need to keep the tape drive streaming, the interface contains a 64K byte data buffer memory to facilitate data transfers between the tape and the other SCSI controllers/host adapters.

If a data transfer request is greater than 16K, the interface breaks this request into several SCSI bus transfer requests with a transfer size of approximately 16K bytes in each connection with the SCSI bus. This transfer size was chosen to provide enough data in the buffer memory to keep a Microstreamer streaming and to free up the SCSI bus as much as possible.

Compatible Tape Drives

This interface will control the following Cipher streaming tape drives:

- Microstreamer
- 890/891 CacheTape
- 990 GCR CacheTape

SCSI Bus

Transfer rate	1.5 Megabytes per sec (max)
Organization	8-bit parallel with parity
Transceivers	Single-ended
Cable length	6m (max) daisy chain

APPENDIX C

CIPHER 1/2-INCH CARTRIDGE TAPE DRIVE

SPECIFICATIONS

The specifications for the 1/2-inch cartridge tape drive were not available at the time this publication was printed.

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Bulletin No.01-314-1285-2.5K

source: TEAC2/DCAS0000

revision: November 19, 1986 09:10:03
November 20, 1986 17:50:29

WANG PRODUCT SPECIFICATION

Streaming Cassette - D/CAS INTERFACE

WLI P/N 725-_____

191-_____

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(continued)

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1.0 Scope:

The purpose of this document is to describe the specifications of a specific product. Although this device is implemented via the generic interface known as QIC-02, this specification, will treat each item on a device basis. Additional information is included with respect to applications, although out of context for a product specification it is intended for clarity, in application and design.

For reference, the Cassette devices evolved through a standard known as D/CAS, (Data Cassette Interchange), which is a sister to the QIC-02 interface.

All commands, features, protocol, and timing, specified herein are MANDITORY. Any reference to optional, preferred, or not recommended are for applications of the product, with respect future interface compatibility and performance.

2.0 Applicable Documents

Shipping Specification	10-521	Revision A.
Electrostatic Discharge (ESD)	10-630	Revision -.
Shock and Vibration Test Procedure	191-2505	Revision A.

3.0 Standards Compliance

This product as received by Wang Laboratories Inc. must conform to the general, physical, electrical, and safety requirements, of the following organizations:

UL	Underwriters Laboratories
CSA	Canadian Standards Association

Further when this device is installed in a Wang computer or word processing system, shall not, in itself, due to faulty design or assembly, prevent Wang from gaining EMI, RFI compliance of said system, as specified under FCC docket 20780/FCC 80-148 Part 15.
Further this product must perform, to this specification, in all Wang Systems without exception.

4.0 Physical Description

This device is categorized in general as a "Half High 5 1/4 inch" form factor. It shall conform to the specific dimensions specified herein.

4.1 Dimensions (also refer to figure B.7)

Height	413 +/- 0.5 mm	
Width	146 +/- 0.5 mm	
Depth	203 +/- 1.0 mm	(Excluding External Interface connector projection.)

4.2 Mounting

The drive may be affixed using the mounting holes on the sides and bottom, reference figure B1.

4.3 Orientation

The Drive may be mounted in either of two (2) orientations, with the front bezel at right angle to a horizontal plain:

a Ejection button on the right hand side
b Ejection button on the top

The drive may be mounted as specified above with a declination angle of 15 degrees maximum, such that the front panel is at an equal or higher elevation than the rear of the unit.

4.4 Color

The front bezel and all of it's exposed parts, with the cassette removed shall be BLACK (Munsell N1) The front panel indicator shall be RED (when iluminated).

4.5 Weight 1.2 kg Approximately

5.0 Power

The drive shall be independant of power sequencing, in any order, without damage to data recorded on the medium.

Nominal (Volts)	Regulation	Ripple [1]	Current [2]
+ 5.0	+/- 5%	100 mV	1.1 Amp Max.
+12.0	+/- 5%	200 mV	1.6 Amp Max.

notes: 1. Ripple includes spike noise.
2. Maximum current is source impedance dependent (reference figure B-3)

6.0 Environmental

The operating environmental conditions specified herein are with Natural Air Convection Cooling.

6.1 Ambient temperature

Operating	+ 5 - +45	deg. C
Nonoperating	-25 - +60	deg. C

6.2 Temperature gradient

Operating	15 deg. C pre hour	(Non Condensing)
Nonoperating	30 deg. C pre hour	(Non Condensing)

6.3 Relative Humidity

Operating	20% - 80 %	(Non Condensing Max. Wet Bulb 26 deg. C)
Nonoperating	10% - 90 %	(Non Condensing)

6.4 Vibration Tested per Wang Specification (reference section 2.0)

Operating	0.2 G	5 - 50 Hz.
Nonoperating	2.0 G	5 - 50 Hz.

6.5 Shock Tested per Wang Specification (reference section 2.0)

Operating	5.0 G	10 mS.
Nonoperating	40.0 G	10 mS.

7.0 Reliability

7.1	MTBF	8000 Hours Minimum	(Operating with TAPE MOTION)
7.2	MTTR	30 Minutes Maximum	(Field replacable unit)
7.3	Component Design Life	5 years	(except for head wear)
7.4	**Head wear**	**— Hours minimum**	**TO BE SPECIFIED**
7.5	Preventative Maintenance	Head Cleaning	(monthly) or 200 (BOT to EOT to BOT) motions

7.6 Error Rate
- a. Soft 10^{-8} bits Read
- b. Hard 10^{-10} bits Read

8.0 Operational Characteristics

8.1	Tape Speed	90 ips nominal
8.2	Long term Speed Variation	4% max.
8.3	Instantaneous Speed Variation	4% max.
8.4	Average Data Transfer Rate	86.3 k Bytes per second (Reference only)
8.5	Block Length	512 Bytes (fixed)
8.6	Buffers	3 at (512 Bytes each)
8.7	Retry Count RECORDING	16 Maximum
8.8	Retry Count READING	16 Maximum
8.9	Repositioning Time	1 Second Approximate (media defect dependant)
8.10	Rewind Time	70 Second Approximate (Media length dependant)

9.0 Recording Geometry

9.1	Method	GCR 4/5 conversion (0-2 RLL Code) reference table A.2
9.2	Recording Form	Single track serpentine serial
9.2	Area & Sequence	Reference figure B.3
9.2	Track Locations	Reference figure B.3
9.3	**Number of Tracks**	**9 total Reference Wang Fornat command 13.XXX**
9.4	Track Pitch	0.406 mm (nominal)

9.5 Track Width
- a. Write 0.279 +/- 0.013 mm
- b. Read 0.203 +/- 0.013 mm

10.0 Recording Format

The Recording format describes the longitutional parcing of all the information recorded on the medium, it includes a detailed description of all fields within each of the types of blocks used.

Default mode:

Records in a single partition D/CAS standard format employing the three types of recorded blocks: DATA BLOCKS, FILEMARK BLOCKS, AND CONTROL BLOCKS.

Wang Mode:

Records in a two partition format employing the two types of recorded blocks: USER DATA BLOCKS, FILEMARK BLOCKS. The CONTROL BLOCKS have been omitted to allow the functional application of "Locate Block N" command. as these blocks are recorded without the knowledge of the user, and would displace the numbering sequence, in an unpredictable manner.

10.1 Reference Burst (reference figure B.3)

A 10,000. frpi pattern, recorded at the beginning of TRACK 0, and extends from a point within 381 mm of the BOT Clear Leader to a point within 12 mm prior to, or 101 mm after the BOT HOLE.

10.2 Block Format

The Block Format specifies the structure for all recorded blocks. all fields specified in bytes are converted into 10 bit GCR Patterns, according to TABLE A-2.

Preamble	Block Sync. (1 Byte)	D A T A F I E L D (512 Bytes)	Block Address (4 Bytes)	C R C (2 Bytes)	Postamble

The individual fields are described in the succeeding sections.

10.3 Preamble Postamble

A pattern recorded at a fixed frequency (10,000. frpi) over fixed or variable lengths for the purpose maintaining read circuit synchronization between blocks. The lengths are normally kept to a minimum during streaming, and are extended to account for head spacing and velocity changes associated with re-positioning, caused by underruns, and track (direction) changes.

The lengths of and conditions under, which the various Preamble & Postambles are implemented, is tabulated as follows:

Preamble Type	field length in flux reversals			
	Minimum	Nominal	Maximum	Condition when invoked
Normal	120	140	300	All blocks (written normally)
Elongated	3,500	5,000	7,000	First Block after repositioning
Long	15,000	25,000	30,000	First Block on each track

Postamble Type	field length in flux reversals			
	Minimum	Nominal	Maximum	Condition when invoked
Normal	5	10	20	All blocks (written normally)
Elongated	3,500	5,000	7,000	REWRITTEN Block (media defect) or Buffer Underrun or End of Track

10.0 Recording Format (continued)

10.4 Block Sync. Byte

A Unique 10 Bit pattern, (GCR Byte) following a preamble and preceeding a Data Field. It's purpose is to allow the data separator to synchronize at the beginning of a Data Block. It has the following GCR bit pattern, is never transmitted over the BUSS and no equivalent in 8 bit BUSS pattern.

| 1 1 1 1 1 0 0 1 1 1 |

10.5 Data Field

This field will always contain 512 Bytes of data converted to and from a GCR patterns per table A-2 As mentioned earlier the This field may contain three types of data: "User Data", "File Mark Data" and "Control Information".

10.6 Block Address

This field contains; a unique address for each block on the medium, the track number where that block resides, and the "Control Nibble". The format is described as follows:

Byte 0		Byte 1		Byte 2	Byte 3	
Track number		CONTROL NIBBLE		B L O C K .	N U M B E R	
msb .	lsb	msb		.	.	lsb

Track number Indicates the track in which the relevant block is written.

Control Nibble

Identifies the Block Type:

The type of data contained in any given block is determined by the data itself, in conjunction with a "Control Nibble", located within the "Block Address Field".
This qualification is summarized as follows:

Block Type	Data Field content (512 Byte)	Control Nibble contents	
		HEX	GCR Pattern
Control	any data pattern	1	1 1 1 0 1
File Mark	GCR Bytes 0 0 1 0 1 0 0 1 0 1	0	1 1 0 0 1
User Data	U S E R D A T A	0	1 1 0 0 1

Block Number

A sequence of of consecutive numbers starting from 1, which number each block on medium, including DATA BLOCKS, FILEMARK BLOCKS, AND CONTROL BLOCKS.

10.7 CRC

The Cyclic Redundancy Check (CRC), is a check sum of two bytes, or 20 GCR bits. The checking process covers the Data Bytes (512) and the Block Address bytes (4).

The generation polynominal is $X^{16} + X^{12} + X^{5} + 1$ (initial value: all bits 1).

Group Code Recording CONVERSION TABLE

Host Buss data					RECORDED DATA (on tape)					
B3 B7	B2 B6	B1 B5	B0 B4	Hex Value	G4	G3	G2	G1	G0	Hex Value
				0	1	1			1	19
			1	1	1	1		1	1	1B
		1		2	1			1		12
		1	1	3	1			1	1	13
	1			4	1	1	1		1	1D
	1		1	5	1		1		1	15
	1	1		6	1		1	1		16
	1	1	1	7	1		1	1	1	17
1				8	1	1		1		1A
1			1	9		1			1	09
1		1		A		1		1		0A
1		1	1	B		1		1	1	0B
1	1			C	1	1	1	1		1E
1	1		1	D		1	1		1	0D
1	1	1		E		1	1	1		0E
1	1	1	1	F		1	1	1	1	0F

TABLE A-2

All data is converted on a nibble bound according to table A-2. Please note that all zeros within the binary portion of the table have been omitted for readability.

This recording scheme is one of the common Group Code Recording (GCR) techniques use in the industry and is refered to as the 5 bit to 4 bit conversion, or 0 - 2 Run Length Limited (RLL) code.

The 5 - 4 conversion relates to the range in number of bits recorded on the medium versus those transfered over the BUSS, for a given "nibble".

The 0 - 2 RLL description relates to the number of consecutive zeros recorded on medium, within any string of bytes or nibbles.

Recording in this method using 5 bits per nibble allows half the absolute binary combinations to be disgarded. The combinations chosen for recording are those which yield the minimum bit shift, and thus increase the reliability.

A deviation to the above is the unique synchronization "Data Block Marker" [11111 00111], which preceeds all recorded data fields, and the "Filemark Data Pattern" [00101 00101], which fills the data field in a filemark block.

In the application used, they do not violate the above zero's rule, as the data block marker is always 10 bits and bounded by 1's. and the filemark pattern is always 10 bits, preceeded by a "Data Block Marker".

Input / Output Control Signals

All signals are true "ACTIVE LOW"

RESET (RST) Type: Unidirectional Direction: Host to Target

Resets the drive to an INITIALIZED condition equal to a power on reset.

a. Resets: ACKNOWLEDGE, READY and DIRECTION.
b. Sets: EXCEPTION
c. Terminates: all commands.

ONLINE (ONL) Type: Unidirectional Direction: Host to Target

Used by the Host to hold a DRIVE ONLINE, and must remain active during all WRITE or READ operations.

REQUEST (REQ) Type: Unidirectional Direction: Host to Target

Controls the transfer of Commands to the target, or Status from the target, in a handshake control with the READY (RDY) line.

Qualification: Ready (RDY) must be true for command transfer.
EXCEPTION (EXC) true Read Status must be transfered.

Exclusion: When EXCEPTION (EXC) is True all commands apart from READ STATUS are rejected.

READY (RDY) Type: Unidirectional Direction: Target to Host

a. Controls the transfer of Commands to the target, or Status from the target, in a handshake control with REQUEST (REQ) line.

b. Informs the Host that one of the following commands have been completed.
   POSITION to BOT
   ERASE TAPE (The entire tape)
   PREWIND
   SELECT Nth TRACK (This command may not exist)
   WRITE FILEMARK
   WRITE FILEMARK without ERASE
   Implicit REWIND (executed via host droping ONLINE during a WRITE operation).

c. Informs the Host that a 512 Byte DATA BLOCK was transfered to or from the Target Buffers. At this point Data transfer may continue or New command issued.
   WRITE
   WRITE (w/o ERASE)
   READ

   Exclusion: When EXCEPTION (EXC) is True all commands apart from READ STATUS are rejected.

TRANSFER (XFR) Type: Unidirectional Direction: Host to Target

Controls the transfer of WRITE and READ DATA to and from the target, in a handshake control with the ACKNOWLEDGE (ACK) line.

During a WRITE operation it indicates that the host has data setup on the bus.
During a READ operation it indicates that the host has removed data from the bus.

ACKNOWLEDGE (ACK) Type: Unidirectional Direction: Target to HOST

Controls the transfer of WRITE and READ DATA to and from the target, in a handshake control with the TRANSFER (XFR) line.

During a READ operation it indicates that the drive has data is setup on the bus.
During a WRITE operation it indicates that the drive has removed data from the bus.

EXCEPTION (EXC) Type: Unidirectional Direction: Target to HOST

A request from the Drive that a status is pending.
This signal is reset by a READ STATUS command, all other commands will be rejected.

DIRECTION (DIR) Type: Unidirectional Direction: Target to HOST

Informs the Host as to the valid direction of data over the buss, per the states as described:

True: STATUS and READ data can be transfered to the HOST.
False: COMMAND and WRITE data can be transfered to the DRIVE.

DATA BUS Bit 7-0 (HB7 - HB0) Type: Bidirectional

A common bus for READ, WRITE, STATUS, and COMMAND data. HB7 is the Most Significant Bit (MSB), and HB0 is the Least Significant Bit (LSB).

BUS PARITY (HBP) Type: Bidirectional

Parity is ODD.
The drive ALWAYS generates PARITY, for STATUS and READ DATA.
The drive TEST PARITY, for COMMAND and WRITE DATA, only if TP7 and TP8 are shorted together, else it will ignore PARITY.

IN TIMING diagrams note the following abbreviations:

X	logic Level arbitrary.
H & L	high level (false), and low level (true) respectively.
HB	Host data buss including parity bit.

D/CAS Cassette COMMAND LIST

OP CODE HEX	OP CODE mnemonic	CASSETTE (D/CAS)	
01	SD	Select Drive	
11	SDL	Select Drive (LOCK)	Lights the Led on the front of the Drive.
21	BOT	Position to BOT	
22	ERA	Erase (entire tape)	
24	PRW	Prewind (tension)	Tape motion CP-EOT-BOT.
40	WRT	Write	
42	WRTE	Write without ERASE	REQUIRED BRIDGE TO PARTITIONED TAPE.
80	RD	Read	
A3	SEOD	Seek EOD (End of DATA)	ON CURRENT PARTITION
C0	RSTU	Read Status	
AD	LBN	Locate Block (n)	4 byte parameter command for compatibility to SCSI-LOCATE command.
60	WFM	Write FILE MARK	INCOMPAITBLE with SCSI ENHANCED commands.
A0	RFM	Read FILE MARK	do
Bn	RFM(N)	Read (n) File Marks	do
WANG PROPRITARY COPYWRITE COMMANDS			
Xn	SWF	Select Wang Format	Required by WANG for protection of software, and improved performance.
Xn	SIF	Select Industry Format	Unit powers up in DESELECTED MODE.
Vendor Unique Commands			
C8	ESTU	Read Extended Status	
Dn	TEST(n)	TEST n = (0 - F)	TEST may be useful for repair diagnostic functions.

NOTE: any command not listed above will be rejected by the DRIVE.

Cartridge Unique Commands			
E0		READ EXTENDED STATUS	A Cipher UNIQUE

Additional OP codes used by Cartridge (QIC-02), with unspecified results: (where x is any value 0 thru 7)
00 40 49 62 7x 82 89 C2 C4 CA CB 12 14 18 41 43 62 29 2A 2B 2C

OP CODE C0 Read Status Command Mnemonic RSTU

This command requests 6 bytes of status from the drive. Transfered via a REQUEST / READY handshake.

COMMAND FORMAT:

Single byte OP Code C0.

BYTE	content							
	7	6	5	4	3	2	1	0
00	1	1	0	0	0	0	0	0

RETURNED STATUS:

BYTE	content							
	7	6	5	4	3	2	1	0
00	Exception Status (Byte 0)							
01	Exception Status (Byte 1)							
02	DATA ERROR COUNTER (MSB)							
03	DATA ERROR COUNTER (LSB)							
04	UNDERRUN COUNTER (MSB)							
05	UNDERRUN COUNTER (LSB)							

POWER UP DEFAULT:

INTERFACE TIMING: per Appendix A, Figure ____.

Exception Status: Two byte field with bit weighted status information, per table _____.

DATA ERROR COUNTER: RESET by Reading Status via RSTU command.

An unsigned 16 bit value containing the total number error blocks, resulting from any READ or WRITE operation. This count is incremented by 1 for each error as defined:

Write: Any block rewritten up to 15 times, will increment by that number.

Read: Any read retry up to 15 times, will increment by that number.

UNDERRUN COUNTER: RESET by Reading Status via RSTU command.

An unsigned 16 bit value containing the total number of underruns / overruns, resulting from any READ or WRITE operation. This count is incremented by 1 for each condition as defined:

Write: Any time the host fails to keep up with with the Drive and all filled buffers (512 bytes) have been written and verified on medium.

Read: Any time the host fails to keep up with with the Drive and all available buffers (512 bytes) have been filled.

NOTE: It is the host responsibility to track partial blocks, via the READY signal.

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Summary of Exception Status

STATUS BYTE 0

STATUS BYTE 1

ST0	CNI	USL	WRP	EOM	UDA	BNL	FIL	ST1	ILL	NOT	MBD	BOM	BPE	0	POR	DESCRIPTION
1	1		X													NO Cassette
1	1		1													NO Drive
1			1					X				X				Write Protected
1				1												End of Media
1			X		1			1				1				Read or Write Abort
1			X	X	1	1										Read Error, Filler Block Transfered
1			X		1	1		1		1						Read Error No Data
1			X	1	1	1		1		1						Read Error No Data & EOM
1			X	X			1									File Mark detected
X	X	X	X					1	1			X				Illegal Command
X	X	X	X					1	1							Illegal Command (tape not at BOT)
X	X	X	X					1				X			1	Power ON / RESET
1			X				1	1			1					Marginal Block Detected
X	X	X	X					1				X	1			Bus Parity Error

Note: All BLANK BIT fields are zero (0) filled.
The value "X" may be zero or one.

BIT DEFINITIONS

BIT	STATE
ST0	A status bit is set in byte 0
CNI	Cassette not in Place
USL	Unselected Drive
WRP	Write Protected (Cassette).
EOM	End of Media (Physical end of current Partition).
UDA	Unrecoverable Data Error
BNL	Bad Block Not Located
FIL	File Mark Detected

BIT	STATE
ST1	A status bit is set in byte 1
ILL	Illegal Command.
NOT	No data detected
MBD	Marginal Block Detected
BOM	Beginning of Media
BPE	Buss Parity Error
0	THIS BIT IS RESERVED ALWAYS ZERO.
POR	(POWER ON) or (RESET SIGNNAL) occured.

November 17, 1986 13:16:30

OP CODE C8 Read Extended Status Command Mnemonic ESTU

This command requests 6 bytes of status from the drive. Transfered via a REQUEST / READY handshake.

COMMAND FORMAT:

Single byte OP Code C8.

BYTE	content							
	7	6	5	4	3	2	1	0
00	1	1	0	0	1	0	0	0

RETURNED STATUS:

BYTE	content							
	7	6	5	4	3	2	1	0
00	Identity Code							
01	FSB	ROM	RAM	BUF	STL	BOT	DRV	0
02	RESERVED (0)						Selected Drive	
03	Track Number				Current Block address (MSB)			
04	Current Block Address							
05	Current Block Address (LSB)							

POWER UP DEFAULT A number of "self Tests" are executed at the POWER UP, or after a drive RESET SIGNAL (PIN32).

INTERFACE TIMING: per Appendix A, Figure ____.

Identy Code: One byte Reserved field value (0).

Fault Status: Byte 01: All values may be reset by issuing a Drive RESET via the RESET Signal Pin 32.

FSB	One or more bits set in Fault Status Byte.
ROM	Drive detected ROM fault, after POWER-UP or after a RESET.
RAM	Drive detected RAM fault, after POWER-UP or after a RESET.
BUF	Drive detected BUFFER fault, after POWER-UP or after a RESET.
STL	STALL, Tape did not move, after motion command issued to drive.
BOT	Drive failed to detect; EOT, BOT, or Clear Leader.
DRV	DRIVE FAULT, detected by the drive, and may be be inclusive or exclusive with other bits.

RESERVED: Six Bit field fixed value (0).

Selected Drive: Fixed value (1).

Track Number: Bits 7 and 4 correspond to msb and lsb respectvely.

Current Block Address: A 20 Bit field, where (Byte 3, Bit 3) and (Byte 5, Bit 0), correspond to msb and lsb respectvely.

OP CODE Xn Wang Format Command ********** OP CODE TO BE DETERMINED **********

This command allows the host to select the recording format modes. This command will only be accepted (valid) with tape rewound to BOT Track 0, or "NO CASSETTE in the drive".

Industry Mode: Records all information per the O/CAS-12 standard which is as described within this specification, with the following exceptions:

1. Exclusion of "LOCATE BLOCK n" command.
2. All recording is in a single partition 9 track mode.
3. When "ONLINE" signal is dropped (false), the drive will flush the data buffer, "WRITE a FILEMARK", and rewind to Beginning of tape (BOT).

Wang Format Mode: There are modifications to the CONTROL AND DATA BLOCK STRUCTURES, to allow the implementation of "LOCATE BLOCK" command, and partitioned media features. There is also a modification to the "ONLINE PROTOCAL" to enable multi tasking operations.

1. All recording is in a two partition mode, refer to "LOCATE COMMAND" for a description.
3. When "ONLINE" signal is dropped (false), the drive will flush the data buffer and Maintain the current LOGICAL POSITION on tape. This will allow the next READ or WRITE operation will Read the next block or perform a Write append opetation.

COMMAND FORMAT:

Single byte OP code Fn, with the value of n used to select the following modes:

	content							
BYTE	7	6	5	4	3	2	1	0
00	OP CODE				0	0	0	FMT

FORMAT MODES: FMT Value of 0 will select Industry recording mode.
Value of 1 will select WANG FORMAT RECORDING MODE.
The drive will remain in the selected mode until reselected or a power up reset occures.
The drive will perform all subsequent commands in the selected state.

POWER UP DEFAULT MODE: Shall be Industry RECORDING Mode.

STATUS RETURNED:
Successful: Command completition will return with drive Ready.
Un-successful: Any conflicts which occure between the drive and media format will result in an EXCEPTION set and return status:

Conflict State	Results	STATUS Byte 0	BYTES Byte 1
Tape not at BOT	"Illegal Command not at BOT"	xxxx 0000	1100 0000
Read	"Read Abort"	100x 0100	1000 1000
Locate	"Read Abort"	100x 0100	1000 1000
Seek end of Data	"Read Abort"	100x 0100	1000 1000
NO Cassette	"No Cassette"	110x 0000	0000 0000

NOTE: "x" may be 0 or 1 value.

OP CODE **AD** **Locate command** This command is functional in the Wang Mode ONLY.

This command allows the host to position the medium to any specified logical block, which exists within a contiguous string starting from the beginning of any partition. Uppon successful completion the next block to be read will be that LOGICAL block.
The block is located by a series of successive approximations, in such a manner as to minimize the random block access time.

COMMAND FORMAT: Single byte opcode AD followed by a four (4) byte ADDRESS BLOCK, using a REQUEST / READY hand shake. The format of the ADDRESS BLOCK is described as follows:

	c o n t e n t							
BYTE	7	6	5	4	3	2	1	0
00	PARTITION							
01	LOGICAL BLOCK ADDRESS (MSB)							
02								
03	LOGICAL BLOCK ADDRESS (LSB)							

PARTITION: An 8 Bit field specifying the track group (partition) to be selected, prior to searching for the logical block specified, by the LOGICAL BLOCK FIELD.
Partition (0) will select tracks 0 through 7.
Partition (1) will select track 8.

LOGICAL BLOCK ADDRESS: A 24 Bit field specifying the ADDRESS of the LOGICAL BLOCK to be LOCATED.

RANGE of ADDRESSABLE BLOCKS: Media dependent.

Status Returned:

Successful command completition will return with drive READY.
Un-successful command completition will return with EXCEPTION and the appropriate bits set in the status bytes:

Results	STATUS BYTES Byte 0	Byte 1
"Read Abort"	100x 0100	1000 1000

APPLICATION NOTES:

1. PREREQUISITE to the successful use of this command: a means to assure that the logical target block exists within a contiguous string of blocks starting from BOT of the specified partition.
   This may be accomplished by:
   a. Erasing the entire tape prior to the first recording on the media.
   b. All WRITES (from BOT), or WRITE APPENDS (from end of recorded data) are "WRITE without ERASE", OP Code (42h).
   c. NO FILEMARKS are recorded on the media.
   d. The host does NOT ACCESS a block outside the range of a contiguous string within a specified partition.
2. WRITE APPEND
   A write append operation requires the medium to be logically positioned immediately after the last recorded block within a partition.
   This may be accomplished by:
   a. LOCATING a block at or near the end of recorded media, followed by a SEEK END OF DATA (SEOD Hex A3) Command. A return status of (88 00 H) in Status Bytes 0 & 1 will qualify a write append.
   b. Issuing a SEEK END OF DATA (SEOD Hex A3) from any valid position within the partition, with the returned of (88 00 H). This method can take up to 8 minutes to process.

REV. A

TEAC MT-2ST/45DF
STREAMING CASSETTE MAGNETIC TAPE UNIT
SUMMARY OF DIFFERENCES FROM MT-2ST/45D

TEAC CORPORATION

1. PREFACE

MT-2ST/45DF has been developed in order to broaden the application range of cassette streamer by changing the firmware in PCBA IC.
For the use of this equipment, be sure to read the MT-2ST/45D Instruction Manual besides this material.

2. CHANGED CONTENTS

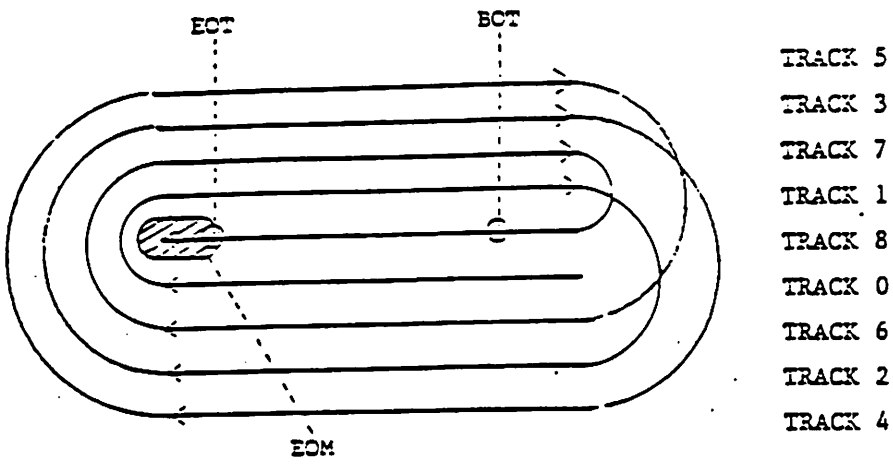
2-1 Track Configuration

The basic track configuration is identical between models 45D and 45DF. (See the MT-2ST/45D specifications.)
However, model 45D is controlled continuously up to the last track (track 8) while model 45DF is controlled separately in two units, tracks 0 through 7 and track 8. Fig. 1 summarizes the difference in track sequence between models 45D and 45DF.
Therefore, EOM is set at detection of the EOT hole in model 45D; it is set at detection of the BOT hole on track 7 or at detection of the EOT hole on track 8.

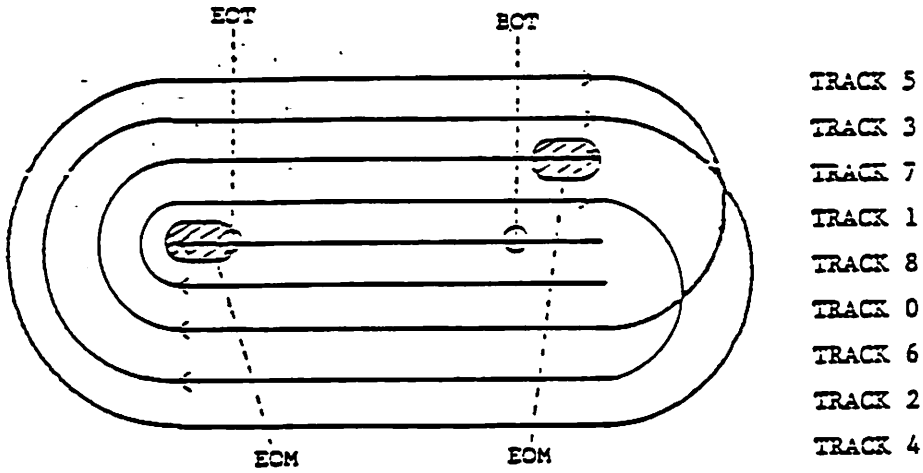
2-2 Additional Commands

Model 45DF supports all the commands of model 45D and has the following commands:

(1)	SELECT Nth TRACK	: STR (N)
(2)	SEEK EOD	: SEOD
(3)	READ N FILEMARKS	: RFM (N)
(4)	WRITE WITHOUT ERASE	: WRTE
(5)	WRITE WITHOUT UNDERRUNS AND ERASE	: WUNE
(6)	WRITE FILEMARK WITHOUT ERASE	: WFME



(A) Model MT-2ST/45D Track Sequence



(B) Model MT-2ST/45DF Track Sequence

(Fig. 1) Track Sequences of Models 45D and 45DF

2-3 Status

(1) EOM set condition

In model 45DF, EOM is set when the head passes through the BOT hole on track 7 or the EOT hole on track 8.

2-4 Others

(1) During execution of the WRT command, the REW or PRW command can be inputted. This command enables the write operation to be terminated without writing the file mark block.

(2) Models 20D, 45D, and 45DF can be distinguished by the IDENTITY CODE in EXTENDED SENSE DATA as shown below:

Model Name \ Bit	IDENTITY CODE								
	7	6	5	4	3	2	1	0	
MT-2ST-20D	0	0	0	0	0	1	0	0/1	*1
MT-2ST/45D	0	0	0	0	0	1	1	0	
MT-2ST/45DF	0	0	0	0	0	0	1	0	

*1 is set to 0 at tape speed 90 ips and 1 at tape speed 30 ips.

3. DETAILS OF ADDITIONAL COMMANDS

(1) SELECT Nth MARK (STR(N))

Command code: 1001xxxx

(a) This command is used to move the head to track xxxx. xxxx shall be the value ranging from 0 to 8. If the value other than the above is set, the command is regarded as illegal.

(b) At completion of head movement, this command sets the RDY signal to TRUE to report so to the host computer.

(c) Immediately after completion of executing this command, any of commands WRT, WUNR, WFM, WRTE, WUNE, and WFME cannot be executed.

(d) If any of commands RD, RFM, RFM (N), and SEOD is inputted immediately after execution of this commands, the read operation starts with the first-detected block after rewinding the tape up to the beginning of the specified track.

(e) If this command is executed to move the head to any of tracks 0 through 7, first check whether data is recorded on the track by inputting the RD of RFM command. If no data is read from the track at execution of the RD command, it is regarded that no data is recorded on the track. At this time, following this command, any of commands WRT, WRTE, WFM, WFME, and WUNE cannot be executed.
If the RFM command is inputted, the first file mark recorded on the track is searched.

(f) If NO DATA is detected during execution of any of commands RD, RFM, RFM (N), and SEOD after the head is moved to track 8 by executing this command, any of commands WRT, WRTE, WTM, WTME, WUNR, and WUNE can be executed. In this case, if data has already been recorded on track 8, the inputted command starts being executed with the position after the recorded data; if not recorded, it starts being executed with the beginning of track 8.

(g) If the head is moved to track 0 by executing this command, MTU returns to the state immediately after mounting the cassette.

(2) SEEK EOD (SEOD)

Command code: 10100011

(a) This command is used to start the read operation with the position where the tape stops then and search for the end of non-recording area (more than 35 inches in length). If the command executed before is STR (N), however, the head returns to the beginning of the track to start the operation.

(b) Execution of this command can be suspended by setting the ONL signal to FALSE. In this case, the tape is rewound to the clear reader section on the BOT side of track 0.

(c) During execution of this command, no data is transferred and each file mark block is skipped.

(d) If the non-recording area is detected, the EXC signal is set TRUE to report so to the host system and terminate this command. (Read Error, No Data)

(3) READ N REMARKS (RFM(N))

Command code: 1011 xxxx

(a) This command is used to start the read operation with the position where the tape stops then and stops it at the position after completion of reading the file marks in the specified number (1 to 15). If the command executed immediately before this command is STR (N), however, the head returns to the beginning of the track to start the operation.

(b) When N=1, this command is fully identical to the RFM command.

(c) If the non-recording area more than 35 inches in length is detected during execution of this command or if the clear reader area on track 7 or 8 is detected, the command suspends being executed and the EXC signal is outputted after the tape stops. (Read Error, No Data or Read Error, No Data & EOM)

(d) When the file marks in the specified number are detected, the EXC signal is set TRUE to report so and terminate this command. (Read a File Mark)

(e) If a read error is detected during file mark search, the re-read processing is performed in the same manner as the RD command.

(f) During execution of this command, no data is transferred.

(4) WRITE WITHOUT ERASE (WRTE)

Command code: 01000010

(a) This command is used to perform the same operation as that of the WRT command except that data is not erased from the entire track during the operation on track 0.

(5) WRITE WITHOUT UNDERRUN AND ERASE (WUNE)

Command code: 01000011

(a) This command is used to perform the same operation as that of the WUNR command except that data is not erased from the entire track during the operation on track 0.

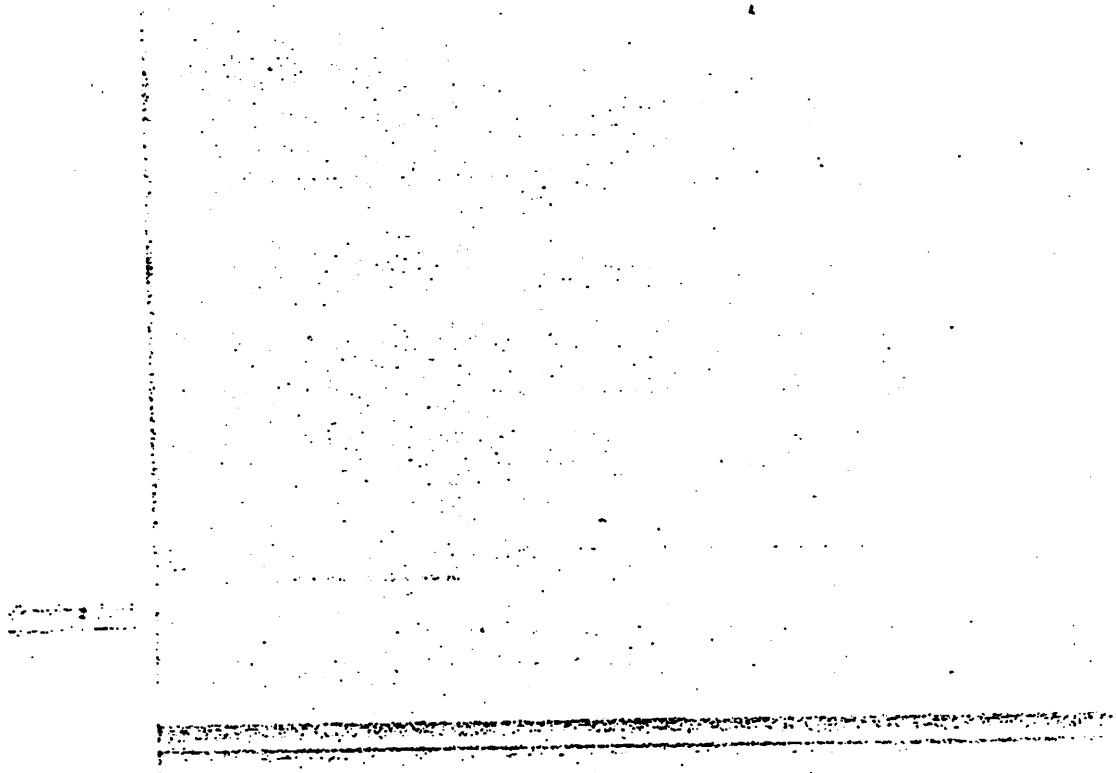
(6) WRITE FILEMARK WITHOUT ERASE (WFME)

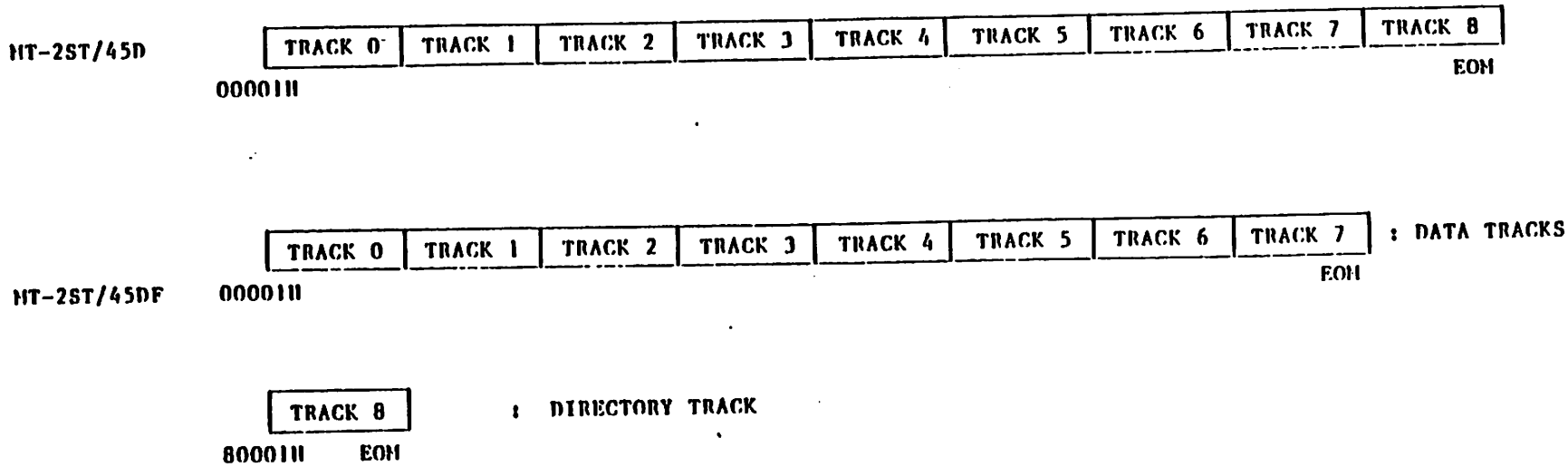
Command code: 01100010

(a) This command is used to perform the same operation as that of the WFM command except that data is not erased from the entire track during the operation on track 0.

s 45D and 45DF.
ed on tracks 0
Therefore, the
ced by effective
ording area is
er as model 45D
e block address
effective block
CKS; track 8 is

the recorded
update the
ast data on the
to validate the
con to both DATA
ending, see the





Note: (1) 000001H and 800001H indicate the first block addresses and they are incremented by blocks.

Fig. 2 Typical Recording Areas of 45D and 45 DF

4-3 File Management of Model 45DF

Since track 8 can be independently controlled, file management data (directory) is recorded on this track. It enables immediate reading of the file names, capacities, and positions recorded on the tape. If the file contents are updated by appending or a new file is added, the directory on track 8 is also updated to always keep the latest recording status of the tape.

(1) Files on Tape

To limit the number of repositions during recording and reading, it is desirable that each file on tape has the recording capacity as large as possible. It is recommended that the files each with the small capacity are put together a file on tape. Be sure to use file marks to delimit the files. If the track position is read by executing the ESTU command before writing each file mark and file and stored as a directory data item, the file can be easily searched by using commands STR (N) and RFM (N). The track data to be read by the ESTU command indicates the track which includes the data block to be next processed. The track positions for both the file mark and the first data block in each file are checked to detect the track if the track is switched.

(2) Writing Data to DIRECTORY TRACK

After completion of writing a number of files to DATA TRACKS, the file management data on these files is written to DIRECTORY TRACK. The head can be moved to DIRECTORY TRACK if the STR (8) command is executed after rewinding tape. Therefore, be sure to rewind tape. After detection of No Data by executing the RD command, data can be written to DIRECTORY TRACK by inputting the WRT command.

To update the data on DIRECTORY TRACK, tape is first rewound and the head is moved to DIRECTORY TRACK by executing the STR (8) command. Then, the end of recorded data is detected by executing the RD or SEOD command to write new directory data by inputting the WRT command.

(3) Writing data to DATA TRACKS

Data can be written to DATA TRACKS basically in the same manner as MT-2ST/45D. When writing data to DIRECTORY TRACK after writing data to DATA TRACKS, be sure to take either of the following methods:

(a) If data starts being written with the beginning of track 0 by executing the WRT command, it needs to be longer enough than the data to be later written to DIRECTORY TRACK.
The reason is that the erase head operates to erase data entirely on track 0 and data is written to track 0 if the WRT command starts being executed with the beginning of track 0. Therefore, if the data to be written to track 0 is shorter than the data to be written to DIRECTORY TRACK, data may be written to the DIRECTORY TRACK on which data is not erased. And the DIRECTORY TRACK contents may be erased with the erase head if data is appended to the data area on the tape.

(b) If tape is used for the first time, the ERA command is first executed to erase all the data on the tape. Then, the WRIE command is executed to write data. Be careful so as not to execute the WRIE command on which data has not been erased.

4-4 HOW TO READ THE BACK TAPE IN WHICH DATA IS RECORDED BY MODEL 20D OR 45D

The cautions to be taken for reading the tape in which data is recorded by model 20D or 45D with model 45DF are described here. If data is recorded by model 20D or recorded in only tracks 0 to 7 on the tape by model 45D, this tape can be read by model 45DF in the same manner. If data is recorded up to track 8, however, EXCEPTION (Read Error, No Data & EOM) is detected at completion of reading data from track 7 and the read operation is terminated when the tape is read by model 45DF. At this time, read data continuously from track 8 according to the following procedure. Other than this procedure, data cannot be read from track 8 because 80001H is set as the first block address on this track.

(1) Detect Read Error, No Data & EOM at track 7.

(2) Execute the STR (8) command to move the head to track 8.

(3) Execute the RD command.

Only when the STR (8) command is executed after track 7 completes being read with Read Error, No Data & EOM, the head is moved to track 8 with the block addressed kept in sequence. On the other hand, do not execute the STR (8) command under the above condition when using track 8 as DIRECTORY TRACK.