HEWLETT PACKARD

The HP 35470A OEM Product Manual

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Contents

Diagnostics Section

Special Features Section

Special features are those extra facilities which set DDS-format drives apart from other tape drives.

DDS Format Section

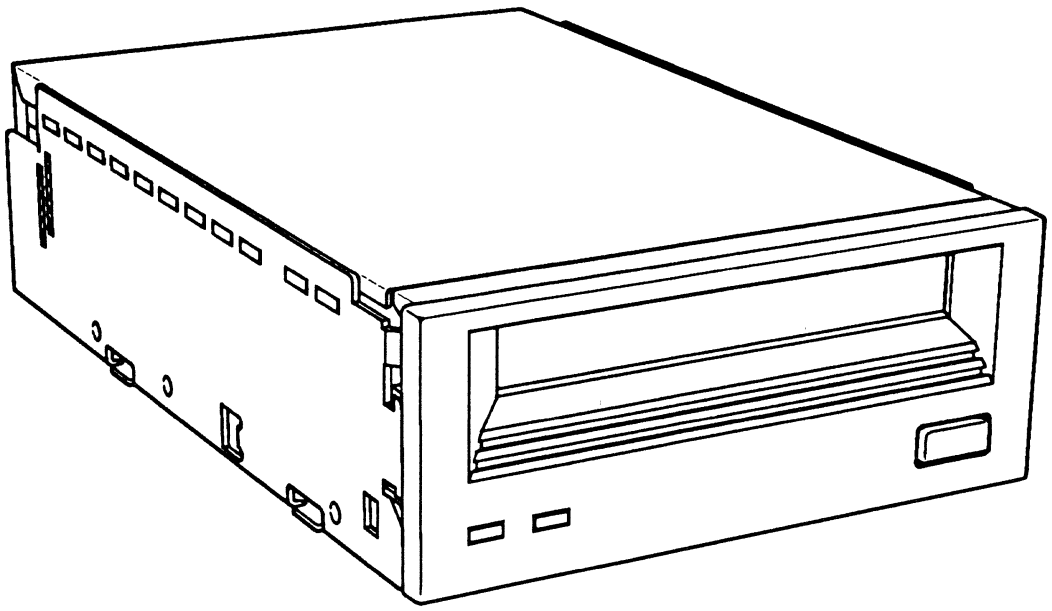
Glossary

A more detailed list of contents is available at the start of each section.

Introduction

Introduction Contents

The HP 35470A DDS-Format Tape Drive



The HP 35470A DDS-Format Tape Drive

The HP 35470A is a DDS-format tape drive with a SCSI interface, designed for the OEM market. It is a low-cost, high-capacity, medium transfer-rate drive for storing data offline on tape. The drive fits a 3½-inch form factor.

As a streaming tape drive, the HP 35470A implements all the mandatory and most of the optional SCSI commands for Sequential Access Devices.

Product Features

The HP 35470A has the following features:

- A standard 3½-inch form factor
- A typical capacity of 2 gigabytes on 90 meter tape
- A typical streaming transfer rate of 183 kilobytes/second
- A large 1 megabyte data buffer to maintain host transfer rate
- Automatic error detection and correction
- Read-after-write error detection and correction
- Three levels of Error Correction Code (ECC)
- Synchronous or asynchronous communication modes
- Single-ended SCSI connection
- Electrically upgradeable firmware
- Compatibility with the SCSI-2 Sequential Access command set
- Support for disconnect and reselect
- Low cost

The DDS-Format and Compatibility

The HP 35470A is an implementation of the DDS (Digital Data Storage) format, a standard developed by Hewlett-Packard for data storage drives which use and build on

DAT technology. The DDS format incorporates the error correction techniques used in DAT drives with additional techniques specifically designed to provide the integrity of data necessary for computer use. These extra methods of error detection and correction are as follows:

- C3 ECC, a third level of Error Correction Code, providing correction across frames within groups.
- Read-After-Write, where data is verified immediately after it is written and re-written if there is any error.
- N-Group Writing, where every group is repeated a set number of times.
- Data Randomizer, for recoding the data in order to provide a consistent signal level. This enables read-after-write to be effective.
- Track checksums, for detecting and locating helical errors, and so improving the performance of C3 ECC.

Each tape can be formatted as a single data space, or as two partitions which can be written to independently.

The DDS format is used by numerous other tape drive manufacturers. Please consult your HP Sales Representative for the latest information about companies planning to build compatible drives.

For full details of the DDS format, refer to the ECMA 139 Standard.

The Purpose of this Manual

Together with the "DDS Digital Data Storage Format Specification" and the SCSI documents mentioned below, this manual provides all the information about the HP 35470A which OEM manufacturers need in order to use the drive in their products.

Related Documents

The following documents provide additional relevant information:

- 3,81 mm Wide Magnetic Tape Cartridge for Information Interchange—Helical Scan Recording—DDS Format, Standard ECMA-139
  DDS Manufacturers Group
- Designing a Data Storage Format for Digital Audio Tape (DAT)
  DDS Manufacturers Group
- Success With DDS Media
  Available from the address below
- Small Computer System Interface (SCSI-1), ANSI X3.131-1986
  The ANSI authorized standard for SCSI implementation, available through ANSI
- Enhanced Small Computer Systems Interface (SCSI-2)
  X3T9.2/86-109 Rev. 10c, available through CBEMA, Washington DC

The first three of these documents are available from your HP Sales Representative, or from:

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Specifications

Specifications Contents

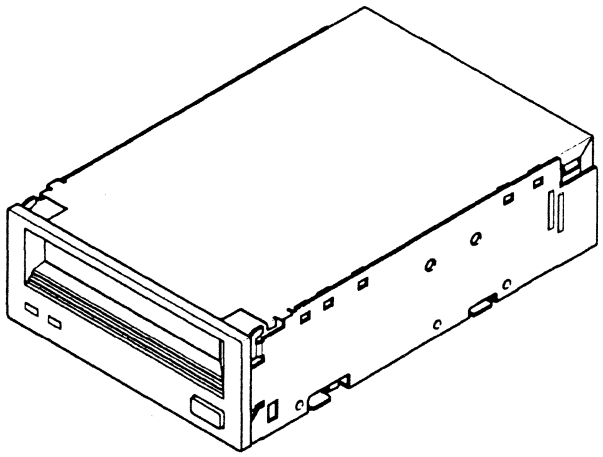
Physical Specification S1

This section gives physical details of the HP35470A. For details of cabling requirements for installation, see chapter O2 "Installation".

Dimensions

Figure S-1 shows the general appearance of the drive. "Installation Requirements" in chapter S2 gives details of cooling requirements.

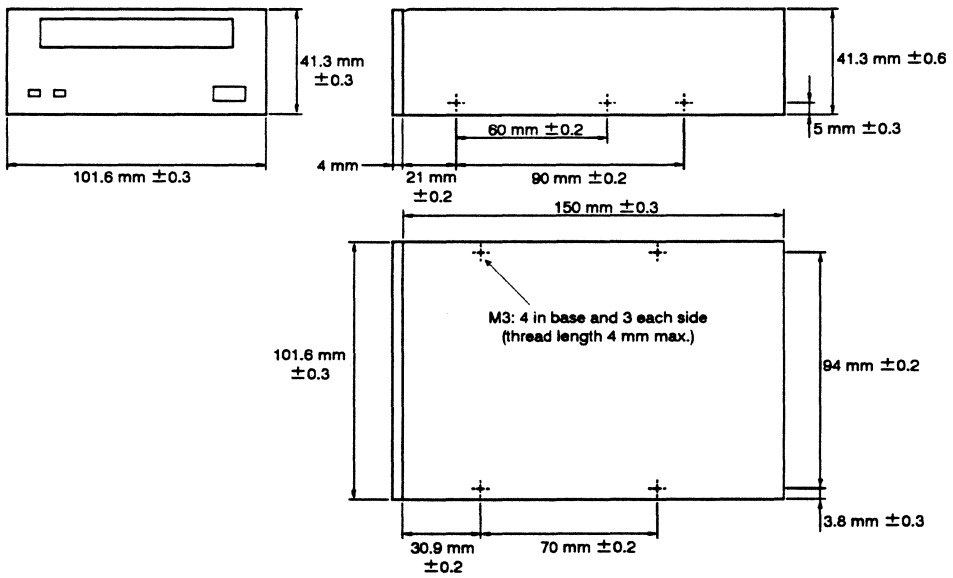
Figure S-1



The HP 35470A
DDS-Format Tape Drive

Figure S-2 gives details of the dimensions, tolerances and fixing centers for the drive.

Figure S-2



Drive Measurements

Weight

One kilogram, without a cartridge.

Clearance for Service

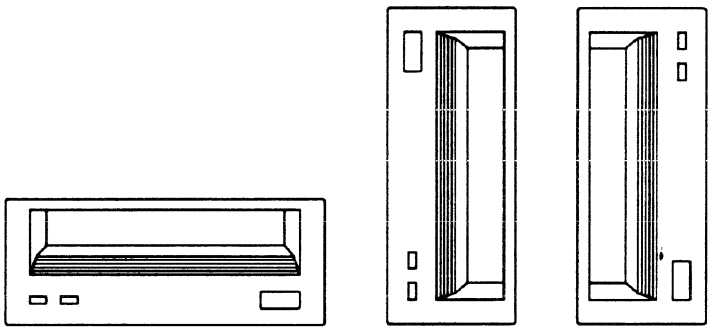
In the event of a fault, the entire drive is replaced. Consequently, it is recommended that you allow for easy access to the mounting screws (see figure S-2).

Orientation

The HP 35470A can operate in three orientations, as shown in figure S-3. No adjustments are needed to internal settings for the different orientations.

Figure S-3

Operating orientations



Safety

The HP 35470A conforms to the following safety standards:

- UL 1950—"Information Processing and Business Equipment" (Fifth Edition).
- CSA C22.2 Number 950, M1986—"Information Processing and Business Equipment".
- IEC 950—"Safety of Information Technology Equipment including Electrical Business Equipment" (First Edition).

Conditions of Acceptability

The HP 35470A is for use only in equipment where the suitability of the combination has been determined by an appropriate certification organization (for example, Underwriters Laboratories Inc. or the Canadian Standards Association in North America, and the British Standards Institution or Verband Deutscher Elektrotechniker eV in Europe).

Other considerations include the following:

1. The drive must be installed in an enclosure to limit an operator's access to live parts, to provide system stability, and to give the drive the necessary grounding integrity.
2. The necessary voltage supplies must be provided. These supplies are Extra Low Voltage (SEC) for UL and CSA, or Safety Extra Low Voltage for BSI, VDE, and so on, of +5V and +12V dc.

Note The drive is only fused to protect it from excessive currents.

Environmental Specification S2

These specifications are for the HP 35470A, not for any particular DDS-format tape. If a tape is used which has more stringent requirements than these specifications, the tape's requirements should be observed.

Parameter		Specification	
Ambient Temperature	*Operating*	5°C to 40°C (ΔT<10°C/h)	
	Operating (mechanism)	0°C to 55°C (ΔT<10°C/h)	
	Non-Operating	–40°C to 70°C (ΔT<20°C/h)	
Humidity	*Operating*	20 to 80% RH, non-condensing Maximum wet bulb temperature = 26°C	
	Operating (no tape)	15 to 95% RH (ΔRH<30%/h)	
	Non-Operating	5 to 95% RH (ΔRH<30%/h)	
Vibration	*Operating (1 Axis)*	*Swept Sine:*	0.3 g peak, 5–500 Hz @ 1 octave/min
		Random:	5–350 Hz @ 0.0002 g^2/Hz 350–500 Hz @ -6 dB/octave 500 Hz @ 0.0001 g^2/Hz (approx. 0.3 g rms)
	Non-Operating (3 Axes)	*Swept Sine:*	0.75 g peak, 5–500 Hz @ 1 octave/min
		Random:	5–100 Hz @ 0.020 g^2/Hz 100–137 Hz @ –6 dB/octave 137–350 Hz @ 0.0107 g^2/Hz 350–500 Hz @ –6 dB/octave 500 Hz @ 0.0052 g^2/Hz (approx. 2.41 g rms)
Shock	*Operating (1 Axis) no performance change*	5 g peak for 3 ms — ½ sine 2 g peak for 11 ms — ½ sine	
	Operating (2 Axes) no data loss	8 g peak for 11 ms — ½ sine 20 g peak for 3 ms — ½ sine	
	Non-Operating (3 Axes) no damage	90 g peak for 3 ms — ½ sine 30 g peak for 26 ms — trapezoidal	
Altitude	*Operating*	0 km to 4.6 km (0 to 15,000 ft)	
	Non-Operating	0 km to 15.2 km (0 to 50,000 ft)	
Transportation Type 1: One drive packaged individually Type 3: Approximately 36 drives boxed and palletized	Vibration *Type 1 package (3 Axes)* *Type 3 package (normal shipping axis only)*	Swept Sine: Random:	0.5 g peak @ 5–200–5 Hz @ 1 octave/min 5 min dwell at peak resonance 5–100 Hz @ 0.015 g^2/Hz 100–200 Hz @ –6 dB/octave 200 Hz @ 0.0038 g^2/Hz (approx. 1.47 g rms) (30 min/axis)
	Impact *Type 1 package* *Type 3 package*	10 vertical impacts (6 faces and 4 bottom package corners from 910 mm height) 5 impacts (1 vertical flat base from 23 cm and 4 rotational edges from 10 cm)	

Parameter		Specification
Magnetic Field Susceptibility	*Operating (no performance change)*	>4 gauss @ 47.5–198 Hz (inside Helmholtz coil) and >Flux densities of 140 picotesla @ 30 Hz decreasing logarithmically to 20 pT @ 30 kHz
ESD	*Operating (no performance change)*	0–15 kV in 2.5 kV steps on the front panel only (ECC and re-read allowed)
	Operating (no permanent damage)	15–25 kV in 5 kV steps on the front panel only (power can be cycled, etc.)
Radiated Susceptibility	*Operating (no performance change)*	5 V/m over the frequency range 14 kHz–1 GHz (per IEC 801-3 Class 2)
Non-Operating Magnetic Field Emissions	*Residual magnetic field emitted when packaged for transportation*	<0.525 microtesla @ 3 ft from any exterior surface of package (IATA transportation restrictions)
Operating Magnetic Field Emissions		<0.5 millitesla ac and/or dc on all exterior surfaces when operating in "worst-case" mode
Conducted Emissions		<FTZ/FCC Level B when tested standalone
Radiated Emissions		<FTZ/FCC Level B when tested standalone
Acoustic Noise Emissions		<4.5 bel soundpower when tested standalone
Thermal Profile		Component surface temperatures not to exceed supplier's design limits under worst-case operating conditions. Tape cassette not to exceed 5°C above ambient temperature under worst case operating conditions with no forced air cooling.
Regulatory Approvals		CSA Certified to C22.2 No. 950 UL Recognized to UL 1950, 1st edition Complies with IEC 950 TUV compliance to IEC950 (GS Mark) Meets General Approval NS/G/1234/J/100003 Requirements
Suspended Particles	*Operating and Non-Operating*	Suspended particle environment, particles <200 microgram/meter^3

Power Requirements

+5V, ± 5%. Ripple <100 mV.

+12V, ± 10% (± 5% if programming EEPROM). Ripple <150 mV.

	+5V supply (mA)	+12V supply (mA)	Power (W)
Typical operation	<500	<250	3.9
Worst case peaks	1000	750	10

The HP 35470A has internal fuses to protect it from a power supply delivering an excessive current to the drive. It is recommended that you route the two ground connections separately and directly through low impedance lines to the power supply unit, and connect them to a common grounding point there.

6 Specifications

Reliability and Maintainability S3

This chapter contains information regarding product reliability and service requirements.

Reliability

Definition of Failure

A failure is defined as any permanent malfunction of the drive that prevents you from retrieving data from a tape. This includes failure to power up, failure to unload or eject a cassette, and failure to write and read data to and from the tape, and it assumes that both the drive and tape are being used within specification.

Faults are not considered failures when they are related to operator error, mishandling and abuse, system-related faults (cabling problems, unsupported systems, operating software, and so on), no trouble found, and transportation damage.

Mean Time Between Failures

The mean time between failures (MTBF) for the HP 35470A is 50,000 power-on hours, assuming a duty cycle of 12%, where $duty\ cycle = \frac{tape\ pulling\ time}{power\ on\ time} \times 100$.

12% is assumed as a typical usage level.

Note Hewlett-Packard Company does not warrant that this predicted MTBF is representative of any particular unit installed for customer use. Failure rates are derived from a large database of test samples. The actual failure rate will vary from unit to unit.

Service

Regular Maintenance

No regular maintenance is required apart from cleaning the heads after each 25 hours of use, or when the Caution Signal shows (see "Caution Signal" in chapter O1). The HP 35470A has a built-in head cleaner, which supplements this manual cleaning. Head cleaning is described in chapter O1.

Field Replaceable Units

The drive is itself a single field replaceable unit. In the event of a problem with any of the sub-assemblies in the drive, the whole drive should be replaced, and the faulty drive returned to the factory.

Packaging for Return to the Factory

The drive should be returned in its original packaging.

8 Specifications

Performance Specification S4

The Data Capacity, Data Transfer Rate and Error Rate specifications given in this chapter are based on the following assumptions:

- The media must conform to the DDS Media Specification.
- The drive and media must remain within and always have remained within their respective operating and non-operating environmental specifications.
- The C3 ECC frame is generated on writing and used as necessary on reading.
- Read-after-write rewrites are used as necessary on writing.

Data Capacity

The capacity of a 90 m cassette is 2 gigabytes. The capacity depends on the size of the records sent from the host; a capacity of 2 gigabytes assumes a record size of 512 bytes or greater.

The minimum tape length supported is 3 m.

Data Transfer Rate

Sustained Data Transfer Rate To and From Tape

The sustained transfer rate to and from tape is 11 megabytes per minute (183 KB/sec).

Burst Data Transfer Rate To and From the SCSI Bus

The HP 35470A will sink and source data bursts to and from the SCSI bus at a maximum burst rate of 1.580 megabytes per second, using SCSI asynchronous transfers. Using synchronous transfers, the maximum burst rate is 5 megabytes per second.

Load Time

The load procedure takes a maximum of 25 seconds from the time the cassette is inserted into the HP 35470A to the time the drive is ready to start acting upon the next command from the host. Part of this time is used to access the System Log at the start of the tape.

Error Rate

The uncorrectable bit error rate is expected to be better than 1 in 10^{15}. For further details, refer to "Designing a Data Storage Format for Digital Audio Tape (DAT)", produced for the DDS Manufacturers Group, and available from Hewlett-Packard (see Introduction).

Retries Limits on Rewrites

For Read-After-Write error correction, each frame can be rewritten up to a maximum of 127 times (giving 128 writes of the frame). In addition, the total number of frame rewrites within one group is 128.

Power-Fail Handling

If there is a power-fail, the HP 35470A performs the following actions, and reverts to its default configuration when power is restored:

1. The drive executes the Power-Up sequence of self-tests.
2. If a tape is present, it is threaded with the usual load sequence.
3. The drive fails the next host command and returns a CHECK CONDITION status. The host should then send a REQUEST SENSE command. The HP 35470A responds with the UNIT ATTENTION sense key, and sets the Additional Sense bytes to indicate that the drive has been power-cycled.

Operation and Installation

Operation and Installation

01 Operation

02 Installation

Operation 01

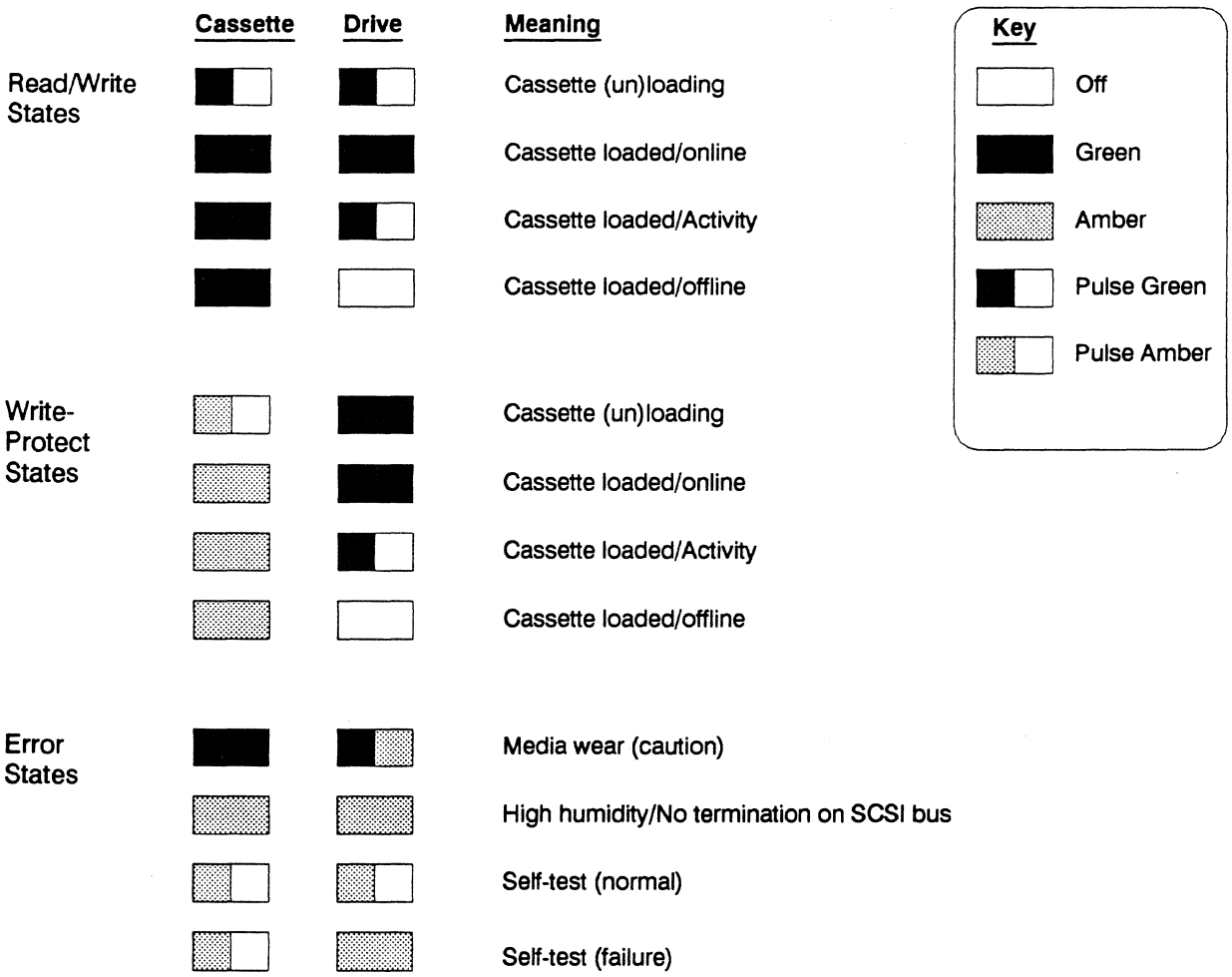
The front panel of the HP 35470A is used for the following:

- Inserting and removing cassettes
- Displaying drive and cassette status

Status Display

The front panel has two bi-color lights (LEDs). Green is used to indicate normal operation, and amber is used to imply warning conditions. Pulsing shows activity between the drive and the SCSI bus. If the Cassette Light (left) shows steady amber, this indicates that the cassette is write-protected. If the Drive Light (right) shows steady amber, this indicates a fault condition.

The following table lists all the possibilities:



Caution Signal

If an excessive number of read-after-write (RAW) or third level error correction (C3 ECC) errors are detected during normal operation of the HP 35470A, a Caution Signal is displayed. The Cassette Light shows steady green and the Drive Light pulses alternate green and amber.

This condition could be caused by dirty heads, so the heads should be cleaned and the operation tried again. If the Caution Signal reappears, assume the cassette is nearing the end of its useful life; copy the data on the cassette onto a new one and discard the old cassette. The Caution Signal is cleared by unloading the cassette.

High Humidity

If the drive detects condensation, a warning is displayed by both lights showing steady amber. Any commands which are currently being executed are aborted, and any commands which access the tape are rejected with a CHECK CONDITION. In addition, the tape is unthreaded to prevent tape and head damage. To minimize the chance of condensation, adhere to the environmental requirements in the specifications and the following cassette guidelines:

- Only use cassettes at temperatures between 5°C (40°F) and 40°C (113°F). You can, however, store them at temperatures down to – 40°C (– 40°F).
- If you expose cassettes to temperatures outside the operating limits, stabilize them before you use them. To do this, leave the cassettes in the operating temperature for a minimum of two hours.

To avoid temperature problems, observe these guidelines:

- Position the drive in a position where the temperature is relatively stable, for example, away from open windows, fan heaters, and doors.
- Avoid leaving cassettes in severe temperature conditions, for example in a car standing in bright sunlight.
- Avoid transferring data (reading from and writing to cassettes) when the temperature is changing by more than 10°C per hour.

Note Steady amber on both front panel lights can also mean that no terminating resistor has been fitted. If the drive is the last device on the SCSI bus, a terminator must be fitted to allow correct operation.

Diagnostic Display

The purpose of the diagnostic firmware is to test the HP 35470A electronics for functionality. During power-up, the drive executes a self-test diagnostic sequence. This is shown by both front panel lights flashing amber at a rate of 2 cycles per second. If the self-test fails, the Drive Light changes to show steady amber.

It is also possible for the host to initiate diagnostic tests of drive functionality. These are displayed on the front panel of the drive as SCSI and drive mechanism activity. The results of these tests will be reported to the host through SCSI.

Operator Action

Loading and Unloading Definitions

With regard to tapes, the drive may be in one of the following states:

- *Not Present* means there is no cassette in the drive.
- *Present but not Loaded* means a cassette is present in the drive but the tape has not been threaded around the head drum.
- *Loaded* means a cassette is present in the drive and it has been logically loaded. Being logically loaded means that operations involving format evaluation (for example, reading the system log, read or write diagnostics) have been performed and the drive is now prepared to accept commands which access the medium.
- *Loading* means the drive is loading the tape. This is a transition state between "Present but not Loaded" to "Loaded".
- *Unloading* means the drive is unloading the tape. This is a transition state between "Loaded" and "Present but not Loaded".
- *Ejecting* means the drive is in the process of ejecting the cassette. This is a change of state from "Present but not Loaded" to "Not Present".

Inserting Cassettes

Insert a cassette into the slot on the front panel. As the cassette is inserted, the drive takes it, performs a load sequence and goes online.

The load sequence is as follows:

1. The drive mechanism threads the tape and rewinds to BOM (Beginning of Media). The tape is then moved to BOP (Beginning of Partition) for Partition 0, and the Reference area is checked to find the tape format (DDS, audio, and so on).
2. If the tape is blank, the drive leaves the tape at BOP for Partition 0 and awaits the next command.
3. If the error rate is high the Caution Signal is set on the front panel lights.
4. The System area is then accessed and the Tape log read into the drive.
5. Finally the drive rewinds to BOP and goes online.

Note If the HP 35470A is power-cycled while a cassette is loaded, the drive performs a load sequence and goes online.

After the load sequence, the drive sends a CHECK STATUS on receipt of the next SCSI command from the host. The UNIT ATTENTION key is set in the returned REQUEST SENSE data to indicate that the tape may have been changed.

Removing Cassettes

A cassette can be removed from the HP 35470A either in response to a SCSI LOAD/UNLOAD command with the Load bit set to 0, or by pressing the Unload button.

For either of these methods, if the host has not previously sent a PREVENT MEDIA REMOVAL command, the drive performs an Unload sequence. In this, the tape is rewound to BOP for Partition 0 and, if the tape is write-enabled, the copy of the Tape log held in RAM is written back to tape. The tape is then rewound to BOM, unthreaded from the mechanism, and ejected.

Note If the host has previously sent a PREVENT MEDIA REMOVAL command, operation of the Unload button is disabled; pressing the button has no effect, and does not initiate an Unload sequence. The Unload button returns to normal operation following receipt of an ENABLE MEDIA REMOVAL command or a SCSI reset.

Also in this case, a LOAD/UNLOAD command with the Load bit set to zero will put the drive into the "present but not loaded" state, that is, it will take the drive offline and unthread the tape, but will not eject the cassette from the drive.

Write-Protecting a Cassette

Cassettes can be write-protected by sliding the tab on the rear of the cassette so that the hole is open. In this state, data can be read from the tape but not written to it.

Caution The Tape log, which contains a history of usage of the tape, will not be updated when the cassette is write-protected. It follows that the Tape log becomes inaccurate if a cassette is used when write-protected.

Head Cleaning

Users should clean the tape heads after every 25 hours of use. Cleaning the heads is also a sensible first step if the Caution Signal display (see earlier in this chapter) appears on the front panel lights. To supplement this manual cleaning, the heads are also cleaned automatically during normal operation by a built-in roller.

In order to clean the heads, use a Cleaning Cassette, HP 92283K. Insert the cleaning cassette in the drive, when the drive will automatically load it and clean the heads. At the end, the cassette is ejected. Note the date on the label on the cleaning cassette, so that there is a record of how many times it has been used. After 25 uses, discard the cassette.

Power-Cycling

If the cassette has not been ejected from the drive before power-cycling the unit, the tape will be "present but not loaded", and threaded when the drive is next powered up. A PREVENT MEDIA REMOVAL command sent before the power-cycle will be reset at power-up, so that the cassette will now be ejected when an UNLOAD command is received.

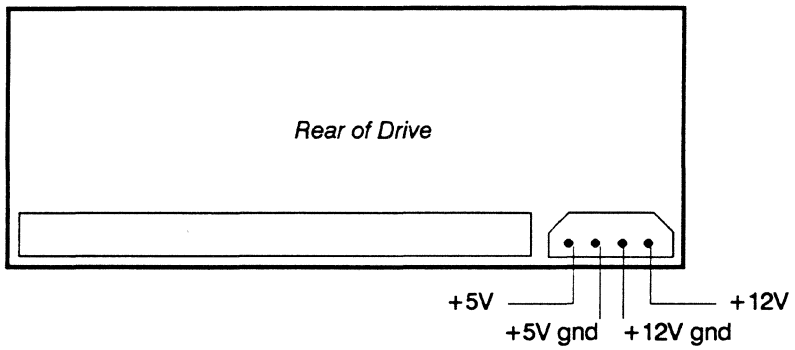
If a bus reset occurs, or a Bus Device Reset is received, any buffered data will be written to tape before the drive goes into its reset sequence. This ensures data integrity.

Installation 02

Power Connection

The power connections are shown in figure O-1.

Figure O-1



Power Connections

SCSI Connection

Single-ended

A single-ended SCSI configuration is supported. The hardware and termination specifications of this interface type can be found in Section 4, Physical Characteristics, of the SCSI X3T9/89-042 Standard.

Only unshielded connectors can be used. Socketed internal termination is provided.

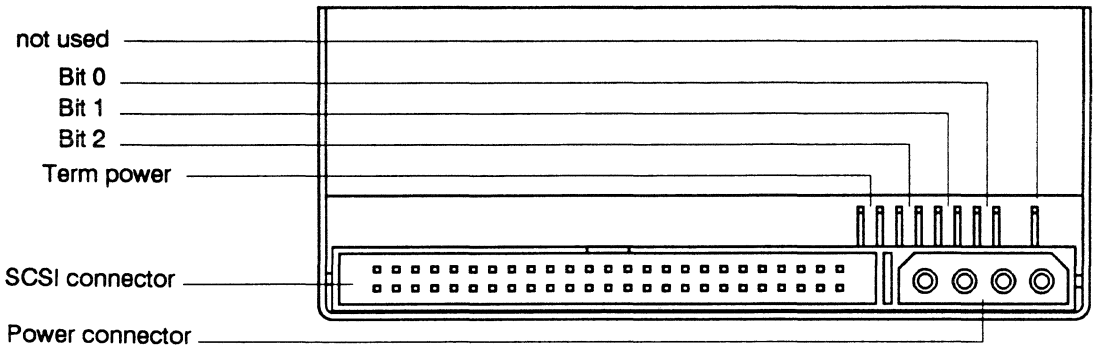
The following are possible cable and terminator sources:

Cable:	28AWG	Ribbon, Spectra Strip	132-2899-887 style 2697
Connector:	3M	Connector	3425–7650
	3M	Strain Relief	3448–3050

Setting the SCSI ID

The SCSI ID is set using jumpers on the set of pins beside the SCSI connector at the rear of the drive, as shown in figure O-2.

Figure O-2



SCSI Jumper Pins

There are three significant bits in the ID, giving an ID range of 0 to 7 inclusive, as shown in the following table:

SCSI ID	Bit 2	Bit 1	Bit 0
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

1 = shorted
0 = open

The HP 35470A reads the SCSI ID at power-up and during self-test, in order to determine the selected target ID of the tape drive on the interface bus.

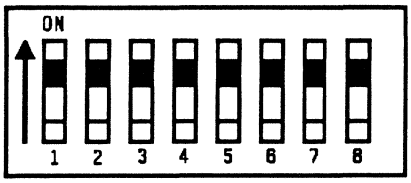
Termination Power

The HP 35470A will provide termination power for the SCSI termination resistors if a jumper is set across the 2 pins marked "Term power" in figure O-2.

Option Switches

The HP 35470A has a set of option switches on the underside of the unit, as shown in figure O-3.

Figure O-3



Option Switches

Switches 1 and 2 are used to configure the data compression operation mode for DC tape drives. Since the HP 35470A does not support data compression, these switches are disabled.

Switches 3 to 8 are used to specify drive connectivity and functionality according to host or customer requirements. The default setting is all switches *on*. Contact your HP distributor or dealer for further details.

Interface

Interface Contents

I1 Interface Implementation

I2 Messages

I3 Commands

Interface Implementation I1

The HP 35470A DDS-format drive uses SCSI-II as the interface to connect to the host system.

Note Throughout this section, the term SCSI implies SCSI-II.

This section covers the implementation of SCSI in the drive.

- Chapter I1, this chapter, gives an overview of SCSI in the HP 35470A, a list of supported and unsupported commands, and a description of SCSI operation with typical sequences.
- Chapter I2 provides details of all the SCSI messages and Status conditions that may be generated. This covers section 6 of the ANSI standard.
- Chapter I3 gives details of all the SCSI commands that are supported.

This section, together with the SCSI documents listed in the Introduction, provides the information required to integrate the HP 35470A with SCSI-compatible computer systems.

See also the chapter on "Special Features".

The HP 35470A SCSI Interface

The Small Computer System Interface (SCSI) is an industry standard interface, approved by the American National Standards Institute (ANSI). It is recommended that you read the ANSI standard document in conjunction with this manual. The ANSI specification defines the interface in general while this document describes the HP 35470A implementation.

The HP 35470A SCSI implementation provides a unit with a standard set of features and functions. These include the following:

- Synchronous data transfers up to 5 Mbytes/second.
- Asynchronous data transfers up to 1.5 Mbytes/second.
- Single-ended glitchless drivers.
- Single-ended SCSI connection.
- 8-bit wide data transfers with parity.
- Ability to retry SCSI command, message, status and data phases.
- Multi-initiator support (queueing of requests, maintenance of separate sense information).
- Optional termination resistors.
- Optional termination power.
- Inplementation of all mandatory and most optional commands of the Sequential Access command set.

Supported Messages

The following messages are supported by the HP 35470A:

- ABORT
- BUS DEVICE RESET
- COMMAND COMPLETE
- DISCONNECT
- EXTENDED MESSAGE—SYNCHRONOUS DATA TRANSFER REQUEST
- IDENTIFY
- INITIATOR DETECTED ERROR
- LINKED COMMAND COMPLETE
- LINKED COMMAND COMPLETE (with flag)
- MESSAGE PARITY ERROR
- MESSAGE REJECT
- NO-OP (NO OPERATION)
- RESTORE POINTERS
- SAVE DATA POINTER

For implementation details on these messages, see chapter I2, "Messages".

Supported and Unsupported Commands

The following commands are supported by the HP 35470A. They include all Mandatory and Extended commands and most Optional commands.

- ERASE
- INQUIRY
- LOAD/UNLOAD
- LOCATE
- LOG SELECT
- LOG SENSE
- MODE SELECT
- MODE SENSE
- PREVENT/ALLOW MEDIA REMOVAL
- READ
- READ BLOCK LIMITS
- READ BUFFER
- READ POSITION
- RECEIVE DIAGNOSTIC RESULTS
- RELEASE UNIT
- REQUEST SENSE
- RESERVE UNIT
- REWIND
- SEND DIAGNOSTIC
- SPACE
- TEST UNIT READY
- VERIFY
- WRITE
- WRITE BUFFER
- WRITE FILEMARKS

For implementation details on these commands, see chapter I3, "Commands".

The following Optional commands are not supported by the HP 35470A.

- CHANGE DEFINITION
- COMPARE
- COPY
- COPY AND VERIFY
- READ REVERSE
- RECOVER BUFFERED DATA

Signal Descriptions

The HP 35470A SCSI interface consists of eighteen signals—nine control lines and nine data lines. A description of these signals is given in the following table.

Signal	Name	Driven by	Description
-BSY	Busy	—	OR-tied signal used to indicate that the SCSI bus is in use.
-SEL	Select	Initiator Target	Used to select a Target during the Selection phase. Used to select an Initiator during the Reselection phase.
-C/D	Control/Data	Target	Indicates whether Control or Data information is on the data bus. True (low) indicates Control, and false (high) indicates Data.
-I/O	Input/Output	Target	Controls the direction of data movement on the bus with respect to the Initiator. This signal is also used to distinguish between Selection and Reselection phases. True (low) indicates input to the Initiator, and false (high) indicates output from the Initiator.
-MSG	Message	Target	Indicates a Message phase on the bus. True (low) indicates a Message phase, and false (high) indicates Command, Data or Status phases.
-REQ	Request	Target	Indicates a request for a REQ/ACK data transfer handshake.
-ACK	Acknowledge	Initiator	Indicates an acknowledgement for a REQ/ACK data transfer handshake.
-ATN	Attention	Initiator	Indicates that the Initiator has a message to send to the Target.
-RST	Reset	—	OR-tied signal which is used to indicate a Reset condition.
DB(7-0)	Data Bus	—	8 data-bit signals, which with the parity-bit signal form the data bus. DB7 is the Most Significant Bit, and has the highest priority during the Arbitration phase.
DB(P)	Data Bus	—	Data parity bit which is set to *odd*, but is a jumper selectable option. Parity is not valid during the Arbitration phase.

SCSI Bus Operation

Typical SCSI Operation

This example describes the typical SCSI bus sequence between the host and the target.

1. The host arbitrates for the SCSI bus by asserting BSY and the data line corresponding to its bus ID. If any other devices wish to compete for the bus, they also assert BSY and the appropriate data line. Each arbitrating device then inspects the data bus and the device with the highest ID wins it. All the other devices must release BSY and their data lines.
2. The host attempts to select the target by asserting SEL and releasing BSY. The host maintains its ID and asserts the target's ID on the data bus. Each target then checks the data lines. If the target's ID matches that on the data bus, it accepts selection by asserting BSY. Once the host has detected BSY being asserted, it asserts ATN to indicate that it will want the target to go to the MESSAGE OUT phase. The host releases SEL.
3. The target now has control of the SCSI bus and it is the target which switches between phases. The target responds to the ATTENTION condition and initiates the MESSAGE OUT phase. The host sends an IDENTIFY message which tells the target which logical unit the host wishes to talk to. The fact that the target responds to the ATN indicates to the host that the target can accommodate more than just a COMMAND COMPLETE message.
4. The target initiates the COMMAND phase and transfers the Command Descriptor Block from the host. In the COMMAND phase, the target decodes the command and either executes the command (TEST UNIT READY) or sets itself up for a data transfer to the host (for example, READ, WRITE, INQUIRY). The target then either switches to the STATUS phase if the command is complete, or the DATA phase if it is ready to transfer data.
5. The data transfer length is set by the host in the Command Descriptor Block. The target remains in the DATA phase until all the data is transferred.
6. The target then initiates a STATUS phase and transfers one byte to the host to indicate whether it has completed the command successfully. If the target has detected an error, the next command that the host is expected to send is REQUEST SENSE. This allows the target to return further status information to the host.
7. The target completes the SCSI sequence by going to the MESSAGE IN phase and transferring a COMMAND COMPLETE message to the host. The target then releases BSY, allowing the bus to go to the BUS FREE state.

Disconnect

In order to improve bus usage and performance, the HP 35470A is capable of disconnecting from the host in order to free the bus to allow other requests to be sent to other targets. To do so, however, the host needs to support Disconnect/Reselect. If Disconnect is implemented, the procedure is as follows:

1. The host arbitrates for the SCSI bus and if it wins it, selects the target device. Before releasing SEL and completing the selection phase, the host asserts the ATN line. The host then releases SEL and BSY. The target now has control of the SCSI bus. By asserting ATN, the host has indicated that the target should go to a MESSAGE OUT phase.
2. After the SELECTION phase is completed, the target responds to the host's ATTENTION condition by initiating a MESSAGE OUT phase. It receives a message from the host which tells it whether the host can support Disconnect/Reselect and the desired logical unit number on the target.
3. The I/O activity from this point is controlled entirely by the target. The target initiates the COMMAND phase and reads in the Command Descriptor Block from the host. After decoding the command, the target determines whether it should disconnect from the bus. The target disconnects from the bus for any non-trivial commands.
4. The disconnect process is when the target initiates a MESSAGE IN phase and sends the host a SAVE DATA POINTERS (during a DATA phase only)and a DISCONNECT message. Following the MESSAGE IN phase, the target releases BSY, freeing the bus which then enters the BUS FREE state. The host can now select another target, or allow another target to win the bus and reselect the host.
5. Although the host and the target are physically disconnected, they are still logically connected. Both know that they have a command to finish and will return to that job later. This principle allows many I/O commands to be executed simultaneously using a single peripheral bus. Once the target has completed a task and is ready to communicate with the host, it must re-establish the physical path. The reselection process involves the target arbitrating for the bus and reselecting the host. After the physical reconnection is made, the target sends an IDENTIFY message to the host to indicate which target logical unit it is. Following completion of this phase, the target initiates the next appropriate phase for the command, usually a DATA phase.
6. During a large data transfer, the target may disconnect at intervals depending on its use of the bus. The drive optimizes its use of the bus so as to maximize the transfer rate when it is connected to the host, and to minimize the time for which it holds the bus without handshakes. If the target disconnects, during a data transfer, the target initiates a MESSAGE IN phase and send the host a SAVE DATA POINTERS message and a DISCONNECT message. The host responds to the SAVE DATA POINTERS message by saving the current data pointer. After transmission of the DISCONNECT message the target releases BSY, freeing the bus.
7. Once the target is again ready to reselect the host, it goes through the same process as before—arbitrating for the bus, reselecting the host and sending an IDENTIFY message. However, the host's response is slightly different in this case since the disconnect was during a data transfer. Host acceptance of the IDENTIFY message also implies a RESTORE DATA POINTERS message to the host. The data transfer can now be resumed.
8. After completion of the data transfer, the target initiates a STATUS phase and sends a single status byte to the host. The final action of the target is to initiate a MESSAGE IN phase and send a COMMAND COMPLETE message to the host.

Note The HP 35470A will disconnect on completion of a data transfer if the final transfer occurs on a disconnect boundary, before initiating the STATUS phase. This is intended to optimize bus usage.

The HP 35470A also disconnects to queue commands from other initiators. See "Command Queueing" below.

The HP 35470A does not disconnect on receipt of the following commands:

- INQUIRY
- REQUEST SENSE
- TEST UNIT READY

The drive will disconnect on other commands if it is configured to do so.

Control Byte— Flag and Link Bits

The control byte of the Command Descriptor Block contains the Flag and Link bits. Use of these bits is entirely host-dependent. Setting the Link bit provides an automatic link to the next command. Instead of returning the usual COMMAND COMPLETE message and going to BUS FREE, the drive goes straight to the COMMAND phase and handshakes in the next Command Descriptor Block from the host. If at any time an error is detected, the drive generates a CHECK CONDITION which breaks the sequence of Linked commands. The host is then expected to issue a REQUEST SENSE command to find the cause of the error.

The following table shows the different permutations of Flag and Link settings.

Flag	Link	Status	Message or Sense Data
0	0	—	—
0	1	INTERMEDIATE GOOD	LINKED COMMAND COMPLETE
1	0	CHECK CONDITION	ILLEGAL COMMAND DESCRIPTOR sense key
1	1	INTERMEDIATE GOOD	LINKED COMMAND COMPLETE with Flag

The host may use the Flag bit to trigger an internal interrupt or take some specific action following completion of the Flagged command within a Linked sequence. The use of the Link and Flag bits means that the drive holds the bus continuously. The host should not enable disconnect while using Linked commands because it would have to arbitrate and reselect the target between commands and so lose the performance gain Linked commands can give.

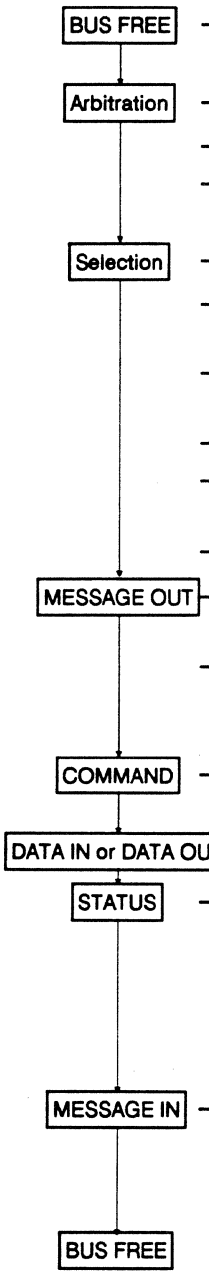
Command Queueing

If the HP 35470A is executing a command, it will disconnect and queue commands sent from other hosts, providing its current host will permit disconnection and reselection. Once a command is queued, the HP 35470A will reselect and continue executing the command at the head of the queue. Commands are queued in the order they arrive, and executed in the same order.

The HP 35470A will *not* queue a second command from a host for which it already has an active operation. The drive will return CHECK CONDITION status with the sense key set to ABORTED COMMAND, and additional sense code of 4E00h (overlapped commands attempted).

Typical SCSI Sequences

1 Without Disconnect



—BSY and SEL are false continuously for a minimum of 1.8 μs (bus settle delay).

—One SCSI device is allowed to gain control of the bus.

—The device asserts BSY and its SCSI ID on the data bus.

—It loses arbitration if there is a higher ID on the data bus, in which case the initiator releases the BSY and ID line.

—If the device wins the bus, it asserts SEL.

—SEL allows the SCSI device which won arbitration to become the initiator by releasing I/O.

—The data bus is set to Initiator and Target ID. The initiator releases BSY.

—The target sets BSY if it has accepted selection.

—The initiator detects the acceptance (that BSY is set) and releases the data bus and SEL.

—The initiator asserts ATN.

—The target indicates that it can accommodate messages by responding to ATN conditions with a MESSAGE OUT phase.

—The first message sent by the initiator after Selection is IDENTIFY. This allows the logical unit to be selected and the initiator to indicate if it supports Disconnect/Reselect.

—The target normally switches to the COMMAND phase and handshakes in the 6, 10 or 12 bytes of the Command Descriptor Block.

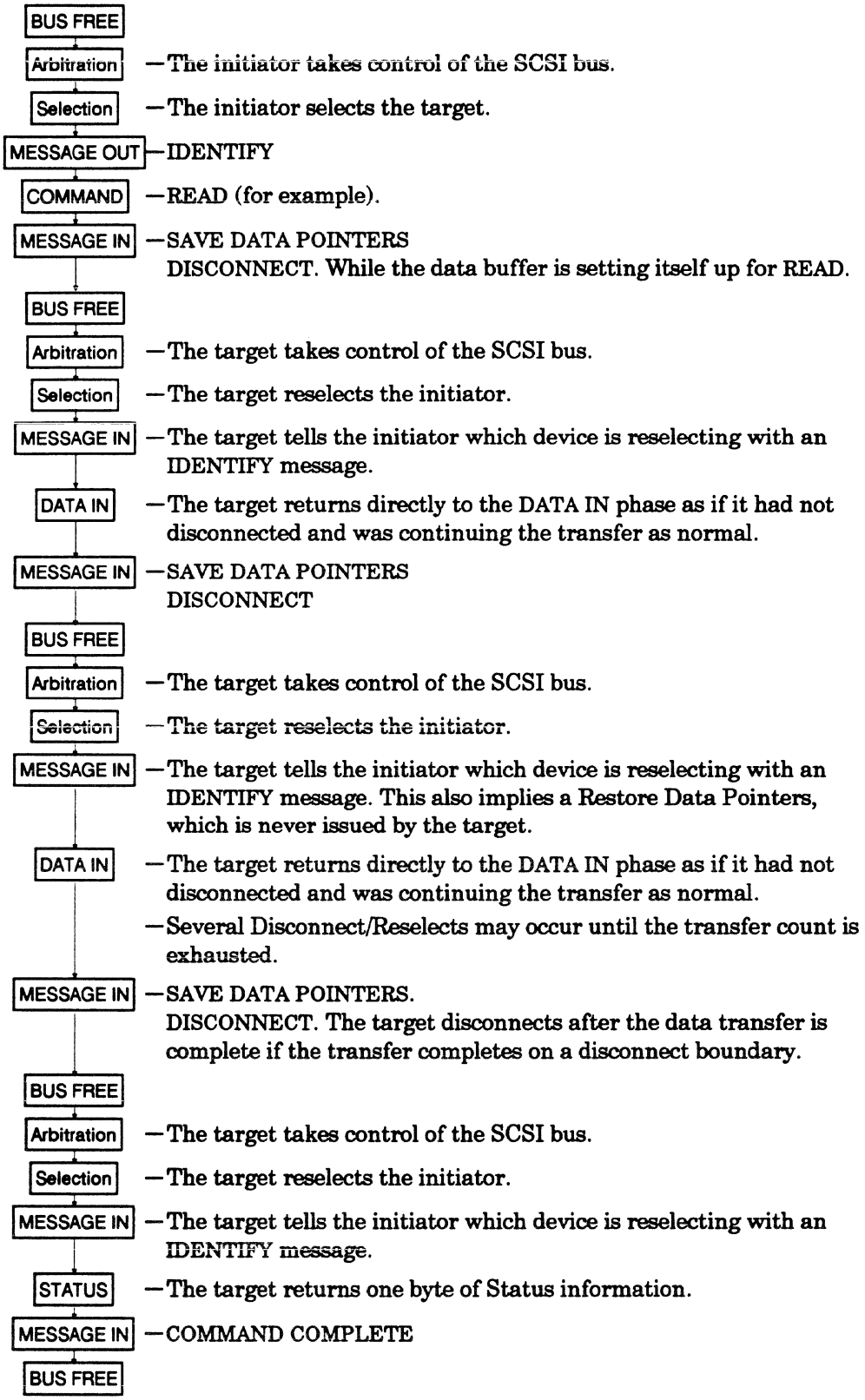
—The target returns one byte of Status information as follows:

00h = GOOD
02h = CHECK CONDITION
08h = BUSY
10h = INTERMEDIATE GOOD
18h = RESERVATION CONFLICT

—The target sends one byte signifying the following:

00h = COMMAND COMPLETE
0Ah = LINKED COMMAND COMPLETE
0Bh = LINKED COMMAND COMPLETE with flag

2 With Disconnect:



Messages I2

This chapter includes all the HP 35470A SCSI messages, both supported and unsupported. Parts of this chapter come from Section 5, Logical Characteristics, of the SCSI X3T9/89/042 standard.

Summary

The message system provides an initiator and a target on the SCSI bus with a means of managing communication. The available messages are as follows:

Code (hex)	Description	Supported
00	COMMAND COMPLETE	Yes
01	EXTENDED MESSAGE	Partially
02	SAVE DATA POINTER	Yes
03	RESTORE POINTERS	Yes
04	DISCONNECT	Yes
05	INITIATOR DETECTED ERROR	Yes
06	ABORT	Yes
07	MESSAGE REJECT	Yes
08	NO-OP	Yes
09	MESSAGE PARITY ERROR	Yes
0A	LINKED COMMAND COMPLETE	Yes
0B	LINKED COMMAND COMPLETE (with flag)	Yes
0C	BUS DEVICE RESET	Yes
0D→7F	RESERVED CODES	No
80→FF	IDENTIFY	Partially

Message Details

COMMAND COMPLETE (00h)

A target sends COMMAND COMPLETE to an initiator to indicate that the execution of a command (or a series of linked commands) is complete and that valid status has been sent to the initiator. After it has sent the message successfully, the target goes to the Bus Free phase by releasing BSY.

If the drive receives COMMAND COMPLETE as a target, it handles it as an illegal message. The drive returns MESSAGE REJECT and enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

EXTENDED MESSAGE (01h)

EXTENDED MESSAGE is usually sent as the first byte of a multiple-byte message by either initiator or target.

It has the following format:

Byte 0	Extended Message Identifier—01h
Byte 1	Extended Message Length
Byte 2	Extended Message Code
Byte 3	Extended Message additional parameters

The Extended Message Length specifies the length of the Extended Message plus the number of additional parameters that are to follow. The length does not include bytes 0 and 1.

The only Extended Message Code supported by the HP 35470A is 01h, Synchronous Data Transfer Request (SDTR). Any other message code is handled as an illegal message; the drive returns MESSAGE REJECT and enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

An SDTR message has the following format:

Byte 0	01h
Byte 1	03h
Byte 2	Synchronous Data Transfer Request code—01h
Byte 3	Transfer Period x 4 nanoseconds
Byte 4	REQ/ACK offset

The HP 35470A supports both *synchronous* and *asynchronous* data transfer.

The HP 35470A will initiate an SDTR before or after a command has been read, when the current data transfer mode is undefined. The default is to negotiate before the Command phase. However, the drive will initiate negotiation *after* the Command phase in the following circumstances:

- The firmware has been configured not to negotiate before the Command phase.
- A host-initiated negotiation, which occurred before the Command phase of a previous operation, failed.

If the host supports synchronous data transfer, it will respond with an SDTR. If the host does not respond to the SDTR, or sends a MESSAGE REJECT, the HP 35470A will configure all future data transfers with this host to *asynchronous* mode. If the HP 35470A receives a delayed SDTR response from the host (548 nanoseconds), the drive will send a MESSAGE REJECT and assume that data transfers are to be in *asynchronous* mode.

If the host sends an SDTR, when the HP 35470A has not sent an SDTR, then the HP 35470A will respond with a message-in SDTR and subsequent data transfers will take place in *synchronous* mode.

The SDTR message from the host must be the first message after a selection phase, otherwise it is handled as an illegal message. In this case, the drive returns MESSAGE REJECT and enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

SAVE DATA POINTER (02h)

A target sends SAVE DATA POINTER to the initiator to save a copy of the present active Data pointer for the logical unit which is currently attached.

The HP 35470A accepts this message when it is the initiator. As a target, the drive sends this message before a disconnect during a data transfer. It does not send a SAVE DATA POINTER message if it intends to move directly to Status phase.

When received as a target, it is handled as an illegal message; the drive returns MESSAGE REJECT and enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

RESTORE POINTERS (03h)

A target sends RESTORE POINTERS to direct the initiator to restore the pointers for the currently attached logical unit which were saved most recently to the active state. Pointers to the command, data, and status locations for the logical unit are restored to the active pointers. Command and Status pointers are restored to the beginning of the present Command and Status areas. The Data pointer is restored to the value at the beginning of the data area in the absence of a SAVE DATA POINTER message, or to the value at the point at which the last SAVE DATA POINTER message occurred for that logical unit.

As a target, the HP 35470A does not normally send a RESTORE POINTERS message. Rather, it relies on the Restore Pointers implicit in a reselection. (RESTORE POINTERS may be sent when retrying a SCSI phase).

When acting as initiator, the HP 35470A accepts a RESTORE POINTERS (or a reselection without a RESTORE POINTERS) if SAVE DATA POINTER was received earlier.

When received as a target, RESTORE POINTERS is handled as an illegal message; the drive returns MESSAGE REJECT and enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

DISCONNECT (04h)

A target sends DISCONNECT to tell an initiator that the present physical path is going to be broken—the target intends to disconnect by releasing BSY. Later, reselection is required in order to complete the current operation.

Note The initiator detects a catastrophic error condition if the Bus Free phase occurs (other than as result of a reset condition) without first receiving a DISCONNECT or COMMAND COMPLETE message. If the target intentionally creates this condition, the target clears the current command. This message does not cause the initiator to save the Data pointer.

The HP 35470A supports this message as an initiator.

As a target, the HP 35470A supports this message and disconnects if the initiator allows it. The Disconnect strategy of the drive is discussed in Chapter I1.

When received as a target, DISCONNECT is handled as an illegal message; the drive returns MESSAGE REJECT and enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

INITIATOR DETECTED ERROR (05h)

An initiator sends INITIATOR DETECTED ERROR to inform a target that an error has occurred which does not prevent the target from trying the operation again—for example, a parity error. At this time, present pointer integrity is not assured. A RESTORE POINTERS message or a disconnect followed by a reselection, will restore the pointers to their previously defined state.

As initiator, the HP 35470A does not send this message. If the drive receives this message for any phase other than Data-in or Status, it enters the Status phase, reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

ABORT (06h)

An initiator sends ABORT to a target to clear the present operation. All pending data and status from the affected logical unit is cleared, and the target goes to the Bus Free phase. This message can be sent to a logical unit that is not currently performing an operation for the initiator.

This message can also be sent to a logical unit which is currently performing an operation for the host. It should be sent using "select to abort", whereby the host selects and sends an IDENTIFY-ABORT sequence.

MESSAGE REJECT (07h)

Either initiator or target sends MESSAGE REJECT to indicate that the last message received was inappropriate or has not been implemented.

In order to indicate that it is about to send this message, the initiator asserts the ATN signal before it releases ACK for the REQ/ACK handshake of the message that is to be rejected. MESSAGE REJECT is issued in response to any messages which the drive considers to be illegal or not supported. The illegal message causes the current command to be aborted, and the drive enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

When the drive is acting as a target and receives the message, if the drive was previously in Message In phase (that is, sending messages to the host), MESSAGE REJECT causes the drive to go straight to the Status phase with a CHECK CONDITION status and a sense key of COMMAND ABORTED. If the drive was not previously in Message In phase, MESSAGE REJECT is handled as an illegal message.

NO-OP (NO OPERATION) (08h)

If a target requests a message, the initiator sends NO-OP if it does not currently have any other valid message to send. The message is accepted when the drive is acting as a target, and may be sent when it is an initiator. If a NO-OP is received during any phase, the drive is likely to repeat that phase.

MESSAGE PARITY ERROR (09h)

An initiator sends MESSAGE PARITY ERROR to a target to indicate that one or more bytes in the last message it received had a parity error.

To indicate that it intends to send the message, the initiator sends the ATN signal before it releases ACK for the REQ/ACK handshake of the message that has the parity error. This provides an interlock so that the target can determine which message has the parity error.

As initiator, the HP 35470A does not send this message. If the drive receives the message while acting as a target, it enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

LINKED COMMAND COMPLETE (0Ah)

A target sends LINKED COMMAND COMPLETE to an initiator to indicate that the execution of a linked command is complete and that status has been sent. The initiator then sets the pointers to the initial state for the next linked command.

The HP 35470A returns this message to the host when a linked command is completed and the Flag bit in the command descriptor block is not set.

When it receives the message as a target, the drive handles it as an illegal message; it returns MESSAGE REJECT and enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

LINKED COMMAND COMPLETE, with Flag (0Bh)

A target sends LINKED COMMAND COMPLETE with Flag to an initiator to indicate that the execution of a linked command with the Flag bit set to one is complete and that status has been sent. The initiator then sets the pointers to the initial state of the next linked command. Typically, this message would be used to cause an interrupt in the initiator between two linked commands.

When the HP 35470A is acting as a target, it handles this as an illegal message; the drive returns MESSAGE REJECT and enters the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

BUS DEVICE RESET (0Ch)

Caution Due to the catastrophic nature of this message, it should be used cautiously in a multi-initiator system.

An initiator sends BUS DEVICE RESET to direct the drive to clear all current commands. When it recognizes this message, the drive aborts the command currently being executed and proceeds to the Bus Free state. The drive then executes a hard reset which leaves it as if it had been power-cycled.

A BUS DEVICE RESET message only resets the drive rather than all the devices on the bus, and so should be used to reset the drive instead of a hard reset.

IDENTIFY (80h–FFh)

Either initiator or target sends these messages to establish the physical connection path between an initiator and target for a particular logical unit. The message byte can have the following bits set:

Bit 7: This bit is always set to one to distinguish these messages from other messages.

Bit 6: This bit can only be set to one by the initiator, and indicates that the initiator has the ability to disconnect and reconnect.

Bits 5: LUNTAR—this bit is always zero to indicate that the LUNTRN field (bits 2–0) is valid.

Bits 4–3: Reserved.

Bits 2–0: LUNTRN—these bits specify a Logical Unit Number in a target, and must always be set to zero because the HP 35470A is a single target, single logical unit device on the SCSI bus. The Logical Unit Number for the drive is fixed and is set to zero. Any other value causes the drive to enter the Status phase reporting CHECK CONDITION with the sense key set to COMMAND ABORTED.

It follows that the HP 35470A will only support the values 80 hex and C0 hex for the IDENTIFY message.

When sent from a target to an initiator during reconnection, an implied RESTORE POINTERS message is performed by the initiator before completing this message, since a RESTORE POINTERS is not usually sent.

Status

A Status byte is sent from the drive to the host during the Status phase at the end of each command as specified in the SCSI specification, unless the command has been cleared by an ABORT message, by a BUS DEVICE RESET message, or by a hard reset.

The Status bytes that the HP 35470A returns are as follows:

00h **GOOD**: This status indicates that the drive has successfully completed the command.

02h **CHECK CONDITION**: Any error, exception, or abnormal condition that causes sense data to be set returns CHECK CONDITION. The REQUEST SENSE command should be sent following this status to determine the nature of the error.

08h **BUSY**: The drive is busy. This status is returned whenever the drive cannot accept a command from an otherwise acceptable initiator. For example, if the HP 35470A is executing a command from an initiator which will not permit disconnect, and receives a command from a different initiator, The HP 35470A will return BUSY status. See "Command Queueing" in the Interface Implementation section.

Note that if an initiator which permits disconnect sends overlapped commands to the drive (in other words if it sends a new command while the previous one is still executing and the drive is disconnected), the first command will be aborted, and a CHECK CONDITION will be returned to the initiator to indicate that the command was aborted. The second command will *not* be executed.

Note The BUSY status returned by the drive must not be confused with DRIVE NOT READY. DRIVE NOT READY is returned as part of the Sense data following a REQUEST SENSE command and indicates that the drive is offline. The drive is regarded as offline if the tape is currently unloaded. Normally the tape will be ejected from the drive, but the drive is still offline if the tape is retained within the drive following a PREVENT MEDIA REMOVAL command issued by the host before the unload.

In the offline state, the host cannot perform any operation which would cause tape motion, in other words, write, read, verify and space commands. These commands will return a CHECK CONDITION status with a DRIVE NOT READY sense key set. The host may execute any diagnostic commands which do not access the tape, and a GOOD status will be returned. These commands are as follows:

- INQUIRY
- LOG SELECT
- LOG SENSE
- MODE SELECT
- MODE SENSE
- READ BLOCK LIMITS
- PREVENT/ALLOW MEDIUM REMOVAL
- READ BUFFER
- RECEIVE DIAGNOSTIC RESULTS
- REQUEST SENSE
- RESERVE/RELEASE UNIT
- SEND DIAGNOSTIC
- WRITE BUFFER

The host may load the tape when the unit is offline so long as the tape has been prevented from being ejected by using the PREVENT MEDIA REMOVAL command.

The TEST UNIT READY command is used to determine the online/offline status of the drive and so will return a CHECK CONDITION status with a DRIVE NOT READY sense key set if no tape is currently loaded or if a tape has just been loaded and the drive is now online.

10h **INTERMEDIATE GOOD**: This status is returned for every command in a series of linked commands except the last command, unless an error, exception or abnormal condition causes a CHECK CONDITION status or RESERVATION CONFLICT status to be set. If INTERMEDIATE GOOD is not returned, the chain of linked commands is broken; no further commands in the series are executed.

18h **RESERVATION CONFLICT**: This status is returned by the drive if the host or another SCSI device attempts to access the drive when it has been reserved with the RESERVE UNIT command.

Commands I3

This chapter describes all HP 35470A SCSI commands. Parts of the chapter are based on sections 7 and 9 of the SCSI X3T9/89/042 draft revision specification.

Summary

There are different groups of SCSI commands, each with a required length. Most of the commands are Group 0 commands which are 6 bytes long. Group 1 and Group 2 commands are 10 bytes long. For each command, the drive waits until the required number of bytes have been transferred, and at the end, sends a status byte to the initiator.

The following table is a summary of the SCSI commands for sequential access devices, showing the operation code and whether the command is supported:

	Opcode (hex)	Type	Command Name
Group 0	00	S	TEST UNIT READY
	01	S	REWIND
	03	S	REQUEST SENSE
	05	S	READ BLOCK LIMITS
	08	S	READ
	0A	S	WRITE
	0F	U	READ REVERSE
	10	S	WRITE FILEMARKS
	11	S	SPACE
	12	S	INQUIRY
	13	S	VERIFY
	14	U	RECOVER BUFFERED DATA
	15	S	MODE SELECT
	16	S	RESERVE UNIT
	17	S	RELEASE UNIT
	18	U	COPY
	19	S	ERASE
	1A	S	MODE SENSE
	1B	S	LOAD/UNLOAD
	1C	S	RECEIVE DIAGNOSTIC RESULTS
	1D	S	SEND DIAGNOSTIC
	1E	S	PREVENT/ALLOW MEDIUM REMOVAL
Group 1	2B	S	LOCATE
	34	S	READ POSITION
	39	U	COMPARE
	3A	U	COPY AND VERIFY
	3B	S	WRITE BUFFER
	3C	S	READ BUFFER
Group 2	40	U	CHANGE DEFINITION
	4C	S	LOG SELECT
	4D	S	LOG SENSE

Key		
	S =	Command is supported. See the command description for details.
	U =	Command is not supported.

Command Details

The command descriptions in this section are listed in alphabetical order of command name. Each command is described briefly. This is followed by a list of pre-execution checks which are described below. The Command Descriptor Block is then given, with details of the various parameter bits and fields.

In all Command Descriptor Blocks, bits 7–5 of byte 1 are the Logical Unit Number (LUN) field, and should be cleared to zero as recommended in the SCSI-2 standard.

In order to be SCSI-2 compatible, the following scheme is used to check the LUN:

SCSI-2 states that the LUN addressed by the host should appear in the IDENTIFY message sent to the target on selection. The HP 35470A checks the LUN field in the Command Descriptor Block for SCSI-1 and SCSI-2. However, SCSI-1 and SCSI-2 devices are allowed to coexist on the same bus, and SCSI-1 hosts will not send an IDENTIFY message. If the HP 35470A does not receive an IDENTIFY message on selection, it will check the LUN field in the Command Descriptor Block and expect it to be zero. If it is not zero, the drive will return a CHECK CONDITION status with an ILLEGAL REQUEST sense key set.

Pre-Execution Checks

Note In compliance with the SCSI specification, the HP 35470A terminates a command with a CHECK CONDITION status and sets the sense key to ILLEGAL REQUEST when a reserved bit, byte, field or code is received which is not zero.

Before executing a command, the HP 35470A makes a number of checks. They fall into three categories:

- Checks on the command sent by the host. These ensure that no reserved or fixed fields have been set to illegal values. They check the syntax of commands, in other words the cross dependency of fields. For example, the Flag bit must not be set if the Link bit is not set.
- Checks to ensure that there is no asynchronous status pending for the host that sent the command. This status would be either a UNIT ATTENTION condition or a DEFERRED ERROR.
- Checks on media access abilities. These are performed for commands requiring access to the tape. A command is rejected if it attempts to access the tape when no tape is present or the tape is unloaded.

The checks are described below in alphabetical order. The usual order of execution is Illegal Field, Fixed Bit, Flag Link, Bad LUN, Reservation, Deferred Error, Unit Attention, Media Access, Media Write, Diagnostic Status, Humidity, Parameter List.

Bad LUN Check

This checks that the logical unit number in the *identify* message sent by the host was zero. This check is made after the logical unit number specified in the command descriptor has been seen to be zero.

If the check fails, the host has sent conflicting logical unit identification information, and has requested use of a non-zero logical unit.

If the host command is not REQUEST SENSE, CHECK CONDITION is reported to the host with a sense key of ILLEGAL REQUEST and additional sense of 2500h (logical unit not supported).

If the host command *is* REQUEST SENSE then the original sense data is replaced with a sense key of ILLEGAL REQUEST and additional sense of 2500h (logical unit not supported), and this sense data is returned to the host immediately. After the command has completed successfully, the sense data is cleared.

Deferred Error Check

A deferred error is generated when a command with immediate report fails after the report has been returned. The check looks to see if a deferred error exists for the host which sent the command, in other words, a deferred error for which CHECK CONDITION

status has not yet been reported. If such an error exists, then the HP 35470A reports CHECK CONDITION. The sense data for the command is set to DEFERRED ERROR (which was generated when some previous command failed).

Note that if a UNIT ATTENTION condition and a DEFERRED ERROR condition both exist for an initiator, the DEFERRED ERROR condition will be reported first. This is because the operation leading to the deferred error must have been older than that leading to the unit attention. The HP 35470A reports the conditions in the order in which they arose.

Diagnostic Status Check

This ensures that the drive is in a fit state to access the media. It does this by checking that there is no DIAGNOSTIC FAIL status within the drive.

If the drive has failed diagnostics, CHECK CONDITION is reported with a sense key of HARDWARE ERROR and additional sense of 40XXh (diagnostic failure of component XX).

Fixed Bit Check

For the READ, VERIFY and WRITE commands, a Fixed bit set to 1 indicates that the length parameter of the command is for fixed block mode. If fixed block mode is selected then the block size in the Mode Select block descriptor must not be zero. Otherwise CHECK CONDITION is reported with a sense key of ILLEGAL REQUEST and additional sense of 2400h (invalid field in CDB).

Flag Link Check

This check ensures that the host has not set the Flag bit in the Command Descriptor Block of the command without setting the Link bit as well. If the test fails then CHECK CONDITION is reported with a sense key of ILLEGAL REQUEST and additional sense of 2400h (invalid field in CDB). The Flag field is identified as the bad field.

Humidity Check

This tests if the humidity is low enough for the HP 35470A to operate. If the humidity is too high, CHECK CONDITION is reported with a sense key of HARDWARE ERROR and additional sense of 8280h (vendor-unique code for humidity).

If a high humidity condition occurs during the execution of a command which accesses the media, the command will be aborted. Sense will be set as before. All commands which access the media will continue to be rejected by this test until the high humidity condition ceases.

Illegal Field Check

This checks that the host has set legal values in each of the fields, as described in the descriptions of each command that follow. If a field has been set to an illegal value, CHECK CONDITION is reported to the host with a sense key of ILLEGAL REQUEST and additional sense of 2400h (invalid field in CDB).

Media Access Check

This checks if the drive is able to perform media access commands. If the media is inaccessible then CHECK CONDITION status is reported with a sense key of NOT READY. The additional sense will be set to one of the following:

- 3A00h (media not present). There is no cassette in the drive.
- 0402h (initializing command required). A cassette is present but is unloaded (or being unloaded). The host must send a LOAD command before the tape can be accessed.

- 0401h (logical unit in process of becoming ready). The HP 35470A is in the process of loading media and should be prepared to accept media access commands in future.

  Note This means the drive is executing a LOAD command with immediate report on. The load could have been initiated by a host or it could be an autoload. The host must effectively poll the HP 35470A by repeating the command until the media is loaded, at which point the command can be executed. If polling is not acceptable, it is advisable to disable autoload. The host must then initiate all load operations, which it should do with IMMEDIATE REPORT disabled so that the HP 35470A reports status only when the load is complete.

- 3E00h (logical unit has not self-configured yet). The HP 35470A is executing its power-on self-test. When this is complete, the additional sense will change to 3A00h, 0402h, or 0401h depending on whether a cassette is present at power-on and whether the drive is configured to autoload tape.

Media Write Check

This checks whether the media is write-protected. If it is, then CHECK CONDITION is reported with a sense key of DATA PROTECT and additional sense of 5A02h (operator selected write-protect).

Parameter List Check

For LOG SELECT, MODE SELECT and COPY, the HP 35470A reads parameter lists. These are described under the command names later in this section. Checks are performed to test the following:

- Fixed field have not been modified. Fixed fields are indicated by a number in round brackets following the field name.
- A field has been set to an invalid value.
- The syntax of the page of parameters has been violated—for example, where a particular value in one field imposes limitations on the valid range for another field.

If a field has been set to an illegal value, CHECK CONDITION is reported to the host with a sense key of ILLEGAL REQUEST and additional sense of 2600h (invalid field in parameter list).

Reservation Check

This checks to see if the HP 35470A has been reserved for use by a host, and if it has, whether the host is the same host that sent the command being executed.

If the HP 35470A has been reserved for some other host then RESERVATION CONFLICT status is reported. See the RESERVE UNIT and RELEASE UNIT commands.

Unit Attention Check

This checks if a UNIT ATTENTION condition exists for the host which sent the command. If it does, the HP 35470A reports CHECK CONDITION status with a sense key of UNIT ATTENTION. The remaining sense data will be set according to the unit attention condition which exists. See Unit Attention Sense in the description of the REQUEST SENSE command which follows.

ERASE 19h

Description:

ERASE causes part or all of the remaining data within a partition to be erased, beginning at the current logical position. Write-behind data is written to tape before the ERASE is executed. Once an erase has started, it will be completed even if the SCSI operation is aborted.

Pre-Execution Checks:

Illegal Field	Flag Link	Bad LUN	Reservation	Deferred Error
Unit Attention	Media Access	Media Write	Diagnostic Status	Humidity

Command Descriptor Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (19h)							
1	Logical Unit Number (0)			Reserved			Immed	Long
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved						Flag	Link

CDB Fields:

Immed

0 The target will not return status until the ERASE has completed.

1 Status will be returned immediately after the pre-execution checks have been completed.

Long The Long bit controls the distance to be erased.

0 The erase length is zero. Any later command which makes the drive change direction writes an EOD before reversing. The zero erase length is supported for compatibility reasons only, and merely interrupts streaming. However, it can be used as a quick way of erasing the partition when security is not important. By performing a zero erase at BOP and then rewinding, EOD is written, and the drive considers data beyond that point as invalid. The data still exists on the tape however, and could be retrieved by other means, so this method of erasing a partition should not be used if the erased data is sensitive.

1 The drive writes EOD followed by ambles to the end of the partition (EOP).

Erase Specific Status:

Event	Status	Key	Additional Sense
The erase fails	CHECK CONDITION	HARDWARE ERROR	5100h (erase failure)

INQUIRY 12h

Description

INQUIRY tells the drive to return information about the drive parameters to the host.

Pre-Execution Checks:

Illegal Field Flag Link

Command Descriptor Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (12h)							
1	Logical Unit Number (0)			Reserved				EVPD
2	Page Code							
3	Reserved							
4	Allocation Length							
5	Reserved						Flag	Link

CDB Fields:

EVPD *Enable Vital Product Data*

0 Normal inquiry data is returned.

1 A page of vital product data is returned.

Page Code If the EVPD bit is zero the Page Code field must be zero.
If the EVPD bit is set, The HP 35470A returns the page of inquiry data specified by the Page Code field:

00h Supported Pages Page
01h ASCII Information Page 1
02h ASCII Information Page 2
03h ASCII Information Page 3
C0h Vendor-Unique Firmware Page
C1h Vendor-Unique Servo Revision Page

Allocation Length

0 An Allocation Length of zero means that no Inquiry data is to be transferred.

>0 This specifies the maximum number of bytes that the HP 35470A will return. The drive will terminate the Data In phase when Allocation Length bytes have been transferred, or when all available Inquiry data has been transferred to the host, whichever is less.

Returned Data

INQUIRY returns its standard data if the EVPD bit is zero, or returns a page of data as specified by the Page Code field.

The following table shows the standard inquiry data format:

Standard Inquiry Data Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (0) (3) if LUN in Identify message nonzero			Peripheral Device Type (1) (1Fh) if LUN in Identify message nonzero				
1	RMB (1)	Device-Type Modifier (0)						
2	ISO Version (0)		ECMA Version (0)			ANSI-Approved Version (2)		
3	Reserved				Response Data Format (2)			
4	Additional Length (26h)							
5	Reserved							
6	Reserved							
7	RelAdr (0)	WB32 (0)	WB16 (0)	Sync (1)	Linked (1)	Reserved	CmdQ (0)	SftRe (0)
8	(MSB)	Vendor Identification ("HP ")						
15								(LSB)
16	(MSB)	Product Identification (" ")						
31								(LSB)
32	(MSB)	Product Revision Level (" ")						
35								(LSB)
36	(MSB)	Manufacturing Date Code (HP Vendor-Unique) (" YY WW")						
39		1960 + YY = absolute year, WW = week 1-52						(LSB)
40	Reserved							
41	Reserved							
42	HPCS Version (2)							

Inquiry Data Fields

Peripheral Qualifier *and* Peripheral Device Type		The LUN will usually be zero, and the drive will return a Peripheral Device Type of 01h (sequential-access device) and the Peripheral Qualifier field set to 000b (the sequential access device is currently connected). However, if the host sends a LUN greater than zero, the drive will return the Peripheral Qualifier field set to 011b (the target is not capable of supporting a physical device on this logical unit) and the Peripheral Device Type set to 1Fh (unknown device type).
RMB	1	The Removable Medium bit is one, indicating that the tape can be removed.
Device-Type Modifier	0	This is a seven-bit user defined code, set to zero.
ISO Version	0	This field is zero, indicating that the drive does not necessarily comply with the ISO version of SCSI.
ECMA Version	0	This field is zero, indicating that the drive does not necessarily comply with the ECMA version of SCSI.
ANSI Approved Version	2	This field is set to 2, indicating that the drive complies with the ANSI version of SCSI-2.
Response Data Format	2	This field has the value 2, indicating that the Inquiry Data format complies with the ANSI version of SCSI-2.
Additional Length	26h	The additional length field specifies the length in bytes of the parameters, in this case, 38 (26h) bytes.
RelAdr	0	Relative Addressing is not supported.
WB32	0	32-bit wide data transfers are not supported. Only 8-bit transfers are supported.
WB16	0	16-bit wide data transfers are not supported.
Sync	1	Synchronous data transfer is supported
Linked	1	The drive supports linked commands, so this bit is set to one.

CmdQ	0	Command Queuing is not supported. This means that the drive will not queue multiple commands from a single host. It will, however, queue single commands from several hosts.
SftRe	0	The drive responds to the reset condition with a hard reset, so the Soft Reset bit is never set.
Vendor Identification	This field contains eight bytes of ASCII data identifying the vendor of the product as 'HP'. This and the next two fields are left-aligned with the unused bytes at the end of the fields filled with space characters (20h).	
Product Identification	This field contains sixteen bytes of ASCII data identifying the product as ' '.	
Product Revision Level	This field contains four bytes of ASCII data, which define the SCSI Interface Revision Level.	
Manufacturing Date Code	This field contains four bytes of Vendor-Unique data.	
HPCS version	This is a single byte Vendor-Unique field identifying which version of HPCS the drive supports.	

Inquiry Data Pages

The following diagram shows the Supported Pages Page:

Supported Vital Product Data Pages

	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (0)			Peripheral Device Type (1)				
1	Page Code (00h)							
2	Reserved							
Byte 3	Page Length (06h)							
4	Supported Pages Code (00h)							
5	ASCII Information Page 1 (01h)							
6	ASCII Information Page 2 (02h)							
7	ASCII Information Page 3 (03h)							
8	Vendor-Unique Firmware Revision Page (C0h)							
9	Vendor-Unique Servo Revision Page (C1h)							

The ASCII Information Pages

The three ASCII Information Pages are as follows:

ASCII Information Page 1

	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (0)			Peripheral Device Type (1)				
1	Page Code (01h)							
Byte 2	Reserved							
3	Page Length (19h)							
4	ASCII Length (18h)							
5	MSB	"FRU 1 fail. Brain Dead."						
28								LSB

ASCII Information Page 2

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (0)			Peripheral Device Type (1)				
1	Page Code (02h)							
2	Reserved							
3	Page Length (19h)							
4	ASCII Length (18h)							
5	MSB "FRU 2 fail. Brain Dead."							
28								LSB

ASCII Information Page 3

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (0)			Peripheral Device Type (1)				
1	Page Code (03h)							
2	Reserved							
3	Page Length (19h)							
4	ASCII Length (18h)							
5	MSB "FRU 3 fail. Brain Dead."							
28								LSB

Vendor-Unique Information Pages

The Vendor-Unique Information Pages are as follows:

Vendor-Unique Firmware Revisions

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (0)			Peripheral Device Type (1)				
1	Page Code (C0h)							
2	Reserved							
3	Page Length (89h)							
4	ASCII Length (88h)							
5	MSB "Firmware Rev = xxxxxxxxxxxxxxx"							
:	"Build Date = xxxxxxxxxxxxxxxxx"							
140	"xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx70							LSB

Vendor-Unique Servo Revisions

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (0)			Peripheral Device Type (1)				
1	Page Code (C1h)							
2	Reserved							
3	Page Length (15h)							
4	ASCII Length (14h)							
5	MSB "Servo Rev = RRR.VVV"							
:	(RRR = Revision, VVV = Version)							
24								LSB

LOAD/UNLOAD 1Bh

Description:

LOAD/UNLOAD tells the target to load or unload a tape.

Pre-Execution Checks:

Illegal Field	Flag Link	Bad LUN	Reservation
Deferred Error	Unit Attention	Diagnostic Status	Humidity

Command Descriptor Block

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Bh)							
1	Logical Unit Number (0)			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved							Load
5	Reserved						Flag	Link

CDB Fields:

Immed	0	If this bit is zero, status is returned after the operation has completed.
	1	When this bit is set, status is returned as soon as the load or unload operation is started.
Load	0	If the bit is zero, the drive performs an *unload* operation; it writes any buffered data to the tape, rewinds the tape to BOM and ejects it.
	1	When this bit is set, the drive performs a *load* operation; it loads the tape and positions it at the beginning of Partition 0.

Load/Unload Specific Status:

Event	Status	Key	Additional Sense
Cannot read media	CHECK CONDITION	MEDIA ERROR	3000h (Cannot read media, incompatible format)
Format corrupted	CHECK CONDITION	MEDIA ERROR	3100h (Media format corrupted)
No tape present	CHECK CONDITION	NOT READY	3A00h (medium not present)
Tape being loaded	CHECK CONDITION	NOT READY	0401h (LUN in process of becoming ready)
Tape being unloaded	CHECK CONDITION	NOT READY	0400h (LUN not ready, cause unreportable)
After successful load	GOOD	UNIT ATTENTION posted at all other initiators*	2800h (not ready to transition)
When UNIT ATTENTION cleared	UNSOLICITED POSITIONAL SENSE	NO SENSE	0004h (BOP detected), EOM bit set
Load or Eject fails	CHECK CONDITION	H/W or MEDIA ERROR UNIT ATTENTION posted at all other initiators	5300h (media load/eject failed)— for all initiators which are not involved in the load

* An exception to this is when the tape is already loaded and positioned within partition 0. In this case, no unit attention sense is generated.

Loading a Tape:

- If the tape is already loaded in partition 0, the tape is positioned at BOP (as if a REWIND command had been issued).
- After a successful load, the tape is logically positioned at the beginning of partition 0. Media access commands are then permissible.
- If a tape is in the process of being loaded, the drive waits for the load operation to complete. Status is generated as follows:
  - If the load command was issued by the current host, and completed successfully, GOOD status is returned to the host. No further action is taken.
  - If the load command was issued by a different host and completed successfully, CHECK CONDITION status is returned to the current host, with a sense key of UNIT ATTENTION and additional sense of 2800h (not ready to transition).
  - If the load command was issued by the current host and failed, CHECK CONDITION is reported, since a deferred error condition will exist for the current host.
  - If the load was issued by a different host and failed, the load will be re-attempted for the current host.

Note The drive cannot detect the presence of media during power-on self-tests. If a load command is received during this period, CHECK CONDITION status is returned to the host with a sense key of NOT READY and Additional Sense of 3E00h (LUN has not self-configured yet).

Unformatted Tape

If an unformatted tape is inserted, the drives loads the tape and behaves as though it has a single partition.

Unloading a Tape

- Unload can also be initiated by pressing the Unload button, unless PREVENT MEDIA REMOVAL is in effect.
- All media access commands are rejected after an Unload command.
- If an unload command is received while unloading is already in progress, the command will be queued until unloading completes. If the unloading operation is successful, GOOD status is reported. If not, another unload operation is initiated for the host that issued the command.
- If an unload command is received while there is no cassette present, or a cassette is present-but-not-loaded and medium removal is prevented, GOOD status is reported.

The unload procedure is as follows:

1. Any buffered data is written to tape.
2. The system area of the current partition is updated.
3. The tape is rewound to BOM.
4. If media removal is not prevented, the cassette is ejected. If media removal *is* prevented, the tape is retained in the drive and a LOAD command can load the tape again.
5. The drive waits for the operator to load another tape.

LOCATE 2Bh

Description:

The LOCATE command moves the current logical position to a new position specified by the following:

1. A new partition
2. The offset from the start of the new partition in terms either of blocks (ignoring marks), or the count of all blocks and marks. The BT (Block address Type) bit selects which. Block 1 is located at the start of the partition.

Any unwritten data is written to tape before the command is executed.

Pre-Execution Checks:

Illegal Field	Flag Link	Bad LUN	Reservation	Deferred Error
Unit Attention	Media Access	Diagnostic Status	Humidity	

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (2Bh)							
1	Logical Unit Number (0)			Reserved		BT	CP	Immed
2	Reserved							
3	(MSB)							
4				Block Address				
5								
6								(LSB)
7	Reserved							
8	Partition							
9	Reserved						Flag	Link

CDB Fields:

BT *Block address Type*

- 0 The Block Address field is the total number of blocks, filemarks and setmarks from the beginning of the partition.
- 1 The value in the Block Address field is the number of blocks from the beginning of the partition to the new position.

CP *Change Partition*

- 0 No change of partition is made.
- 1 The drive will change partitions to the partition specified in the Partition field. The tape must be two-partition for a value of 1 to be valid.

Immed

- 0 The HP 35470A will not report status until the locate operation has completed.
- 1 The drive flushes any unwritten data and, if necessary, switches partitions before reporting to the host. The drive then moves to the required position within the partition after reporting status.

Block Address The Block Address specifies either the number of blocks or the total number of blocks plus marks from the beginning of the partition to the new position. The BT bit determines which measure is used. The Block Address must be greater than 0, otherwise a CHECK CONDITION is reported.

Partition If the CP bit is set, the Partition field specifies which partition to change to. 0 and 1 are the only valid values. If the CP bit is not set, the value of the field is ignored.

Locate Specific Status:

Event	Status	Key	Additional Sense
EOD encountered	CHECK CONDITION	BLANK CHECK	0005h (EOD encountered). EOM bit set.
EOP encountered	CHECK CONDITION	VOLUME OVERFLOW	0002h (EOP encountered). EOM bit set.
Incompatible data format	CHECK CONDITION	MEDIUM ERROR	3002h (can't read media)
Failed to read data—media error or non-fatal drive error	CHECK CONDITION	MEDIUM ERROR	3B00h (sequential positioning error)

LOG SELECT 4Ch

Description:

LOG SELECT allows the host to clear logs in the drive. The logs are maintained by the drive, and contain statistical information about the drive and the media. Since access to individual parameters within log pages is not supported, the host is restricted to resetting complete log pages only. For information about log page format, parameters and supported pages, see the LOG SENSE command description.

Pre-Execution Checks:

Illegal Field Flag Link Bad LUN Reservation Deferred Error Unit Attention Diagnostic Status

Command Descriptor Block:

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (4Ch)							
1	Logical Unit Number (0)			Reserved			PCR	Reserved
2	PC		Reserved					
3	Reserved							
6								
7	(MSB)		Parameter List Length					
8								(LSB)
9	Reserved						Flag	Link

CDB Fields:

PCR — *Parameter Code Reset*

- 1 *All* log pages will be cleared which can be cleared
- 0 The function performed is defined by the PC field. The Parameter List Length must be greater than zero.

PC — The *Page Control* field defines the type of parameter values to be selected:

- 00b Current Threshold Values—NO-OP is performed
- 01b Current Cumulative Values—logs are cleared as specified by the parameter data
- 10b Default Threshold Values—NO-OP is performed
- 11b Default Cumulative Values—all internal logs are cleared

Parameter List Length

- 0 No data is to be transferred. If the PCR bit is 1, all log pages which can be cleared are cleared.
- >0 Specifies the length in bytes of the LOG SELECT parameter list to be transferred from the initiator to the target during the DATA OUT phase. The value of this field must be a multiple of 4. The PC field must be 01b.

Since the host can only reset complete log pages, it must send the log page header of the page to be cleared with the Page Length field set to 0 during the DATA OUT phase. The following pages can be cleared in this manner:

Page Code	Page Description
02h	Write Error Counters Page
03h	Read Error Counters Page
31h	Channel Trace Log Page
32h	Buffer Trace Log Page
33h	Device Trace Log Page
34h	Write Frames Error Counters Page
35h	Read Frames Error Counters Page
36h	Bad Group Log Page
37h	Drive Counters Page
38h	Mechanism Counters Page

Because of this method of clearing the log pages, the Parameter List Length field must be a multiple of 4, the length of the Log Page header. Otherwise the command will be terminated with a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

LOG SENSE 4Dh

Description:

LOG SENSE allows the host to read logs from the HP 35470A. A single log is returned with each invocation of LOG SENSE.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (4Dh)							
1	Logical Unit Number (0)			Reserved				
2	PC			Page Code				
3	Reserved							
6								
7	(MSB)			Allocation Length				
8								(LSB)
9	Reserved						Flag	Link

CDB Fields:

PC The *Page Control* field defines the type of parameter values to be selected:

- 00b Current Threshold Values—cannot be changed. These are the maximum values that each parameter can attain. Note that for some parameters the term threshold value has no meaning—see the descriptions of individual pages and parameters which follow for more details.
- 01b Current Cumulative Values—the values computed since the last reset of the drive (either by power-cycling, BUS DEVICE RESET or SCSI RESET). Note that for some parameters these values cannot be reset by any method—see the descriptions of individual pages and parameters which follow for more details.
- 10b Default Threshold Values—same as the Current Threshold Values
- 11b Default Cumulative Values—the values to which each parameter gets initialized when reset, as described above. See the descriptions of individual pages and parameters which follow for more details.

The PC field has no effect on the data returned when the selected log contains event or trace codes rather than counts.

Page Code The *Page Code* field identifies which log page is being requested by the host, as follows:

- 00h List of Supported Pages Page
- 02h Write Error Counters Page
- 03h Read Error Counters Page
- 30h Tape Log Page
- 31h Channel Trace Log Page
- 32h Buffer Trace Log Page
- 33h Device Trace Log Page
- 34h Write Frames Error Counters Page
- 35h Read Frames Error Counters Page
- 36h Bad Group Log Page
- 37h Drive Counters Page
- 38h Mechanism Counters Page

Allocation Length The Allocation Length field specifies the maximum number of bytes of data which should be returned to the host. The drive will return the entire log or Allocation Length bytes, whichever is the lesser.

Log Parameter Pages

Log Page Descriptor

Each page begins with a 4-byte page header followed by one or more variable-length parameter structures. LOG SENSE returns only the single log page specified in the Page Code field of the command descriptor block. With LOG SELECT however, several log page headers can be sent to clear several pages simultaneously.

Supported Log Pages Page

The Supported Log Pages page has the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (00h)							
1	Reserved							
2	(MSB)	Page Parameter Length (Ch)						
3								(LSB)
4	Supported Pages page code (00h)							
5	Write Error Counters page code (02h)							
6	Read Error Counters page code (03h)							
7	Tape Log page code (30h)							
8	Channel Trace Log page code (31h)							
9	Buffer Trace Log page code (32h)							
10	Device Trace Log page code (33h)							
11	Write Frames Error Counters page code (34h)							
12	Read Frames Error Counters page code (35h)							
13	Bad Group Log page code (36h)							
14	Drive Counters page code (37h)							
15	Mechanism Counters page code (38h)							

The PC field of the LOG SENSE command has no effect on the values returned in this page. The Supported Log Pages Page is not a valid page to send during LOG SELECT.

Write and Read Error Counter Pages

The Write and Read Error Counters Pages have the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (02h Write Error Counters or 03h Read Error Counters)							
1	Reserved							
2	(MSB)	Page Length (1Ch)						
3								(LSB)
	—Error Counter Descriptors—							
0	(MSB)	Parameter Code						
1								(LSB)
2	DU (0)	DS (1)	TSD (0)	ET (0)	TMC (0)		Reserved	LP (0)
3	Parameter Length (*m*)							
4	(MSB)	Parameter Value						
3+*m*								(LSB)

Write and Read Error Counters Page Fields:

Note The Current or Default Cumulative, or Current or Default Threshold values are returned according to the PC field of LOG SENSE.

The DU (Disable Update), DS (Disable Save), TSD (Target Save Disable), ET (Enable Threshold Comparison), TMC (Threshold Met Criteria) and LP (List Parameter) fields are collectively referred to as the *control byte*.

Parameter Code The Parameter Code field identifies which parameter of data is being transferred. The following parameter codes are supported for each Error Counters page:

Parm. Code	Description	Length (bytes)	Default Cumulative	Default Threshold
0003h	Total Errors Corrected (Soft Errors)	2	0	FFFFh
0004h	Total Times Correction Algorithm Processed	4	0	FFFFh
0005h	Total Blocks Processed	4	0	FF FF FF FFh
0006h	Total Errors Uncorrected (Hard Errors)	2	0	FFFFh

DS 1 This tells the host that saveable parameters are disabled (i.e. not supported).

LP 0 Must be zero; the parameter is a data counter rather than a list parameter.

DU, TSD, ET, TMC 0 Must be zero. For a full description of these fields refer to the SCSI-2 standard.

Tape Log Page

The Tape Log page is used to return information to the host in a format which conforms to the LOG SENSE command page format. The Tape Log cannot be cleared. If no tape is loaded, the information returned is undefined. If a blank tape is loaded, the information returned will indicate a load count of 1 and all other fields will be zero. The PC field of LOG SENSE is ignored for this page.

The page has the following format:

		Bit							
		7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte	**0**	Page Code (30h)							
	1	Reserved							
	2	(MSB)			Page Length (88h)				
	3								(LSB)
		—Tape Log Descriptors—							
	0	(MSB)			Parameter Code				
	1								(LSB)
Byte	**2**	DU (0)	DS (1)	TSD (0)	ET (0)	TMC (0)		Reserved	LP (0)
	3	Parameter Length (*m*)							
	4	(MSB)			Parameter Value				
	3+*m*								(LSB)

Tape Log Page Fields:

Parameter Codes Supported Parameter Codes in this page and their meanings are as follows:

Code	Description	Length *(bytes)*
0001h	Current Number of Groups Written	3
0002h	Current RAW Retries	2
0003h	Current Number of Groups Read	3
0004h	Current C3 ECC Retries	2
0005h	Previous Number of Groups Written	3
0006h	Previous RAW Retries	2
0007h	Previous Number of Groups Read	3
0008h	Previous C3 ECC Retries	2
0009h	Total Number of Groups Written	4
000Ah	Total RAW Retries	3
000Bh	Total Number of Groups Read	4
000Ch	Total C3 ECC Retries	3
000Dh	Load Count	2

'Current' refers to the current load of the tape. 'Previous' refers to the last tape load. 'Total' refers to the life of the tape since it was first initialized, including the current load.

The log is held in RAM in the Drive Controller. When a tape is loaded, the contents of the System Area are copied into this log to become the 'previous' and 'total' information. The log is updated as the tape is used and the 'current' and 'total' values are copied back to the System Area when the tape is unloaded.

Tape Partitions

The information returned by the Tape Log is specific to the current partition.

Partition 0 The counts indicate read, write and ECC activity in this partition. For a single partition tape, this means the whole tape.
The *load count* is a special case. For a single partition tape, this indicates the total number of loads (including the current load) since the tape was last formatted. For a 2-partition tape, the Partition 0 load count is set to zero.

Partition 1 The counts indicate the total read, write and ECC for *both* partitions.The load count indicates the total number of loads for both partitions (including the current load) since the tape was last formatted, with the count for Partition 0 set to zero.

Use of the Tape Log Page

An estimate of reading and writing performance can be made by the ratio of 'RAW retries' to 'groups written', and 'C3 ECC retries' to 'groups read'. An indication of tape degradation can be gained by comparing these ratios for 'current', 'previous', and 'total' entries.

Any attempt to change this page using LOG SELECT will result in a CHECK CONDITION with the ILLEGAL REQUEST sense key value returned. The current Cumulative values will be returned regardless of the Page Control field in the LOG SENSE command descriptor block.

Channel Trace Log Page

The Channel Trace log consists of *n* parameters, each representing an event which has occurred concerning the channel code. The first entry is the oldest event, and the last the most recent.

n parameters are always available even if the drive has just been powered up and the log is not filled. The oldest events are overwritten as new channel events occur, so that logging never stops.

The PC field of the LOG SENSE command has no effect on the data returned in this log.

The log page has the following format:

		Bit							
		7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte	**0**	Page Code (31h)							
	1	Reserved							
	2	(MSB)	Page Length (XXh)						
	3								(LSB)
		—Channel Event Traces—							
	0	(MSB)	Parameter Code (*n*)						
	1								(LSB)
Byte	**2**	DU (0)	DS (1)	TSD (0)	ET (0)	TMC (00)		Reserved	LP (0)
	3	Parameter Length (02h)							
	4	(MSB)	Trace Code						
	5								(LSB)

Buffer Trace Log Page

The Buffer Trace log consists of *n* parameters, each representing an event which has occurred concerning the buffer code. The first entry is the oldest event, and the last the most recent.

n parameters are always available even if the drive has just been powered up and the log is not filled. The oldest events are overwritten as new buffer events occur, so that logging never stops.

The PC field of the LOG SENSE command has no effect on the data returned in this log.

The log page has the following format:

		Bit							
		7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte	**0**	Page Code (32h)							
	1	Reserved							
	2	(MSB)	Page Length (XXh)						
	3								(LSB)
		—Buffer Event Traces—							
	0	(MSB)	Parameter Code (*n*)						
	1								(LSB)
Byte	**2**	DU (0)	DS (1)	TSD (0)	ET (0)	TMC (00)		Reserved	LP (0)
	3	Parameter Length (08h)							
	4	(MSB)	Trace Point I.D.						
	5								(LSB)
	6	(MSB)	Time Stamp						
	7								(LSB)
	8	(MSB)	Argument 1						
	9								(LSB)
	10	(MSB)	Argument 2						
	11								(LSB)

Buffer Trace Log Page Fields:

Trace Point I.D.	This is a unique code identifying the event which occurred
Time Stamp	The value of the lower 16 bits of the system clock at the time the event occurred
Argument 1	A parameter associated with the event
Argument 2	A parameter associated with the event

Device Trace Log Page

The Device Trace log consists of *n* parameters, each representing an event which has occurred concerning the device code. The first entry is the oldest event, and the last the most recent.

n parameters are always available even if the drive has just been powered up and the log is not filled. The oldest events are overwritten as new device events occur, so that logging never stops.

The PC field of the LOG SENSE command has no effect on the data returned in this log.

The log page has the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (33h)							
1	Reserved							
2	(MSB)	Page Length (XXh)						
3								(LSB)
	—*Device Event Traces*—							
0	(MSB)	Parameter Code (*n*)						
1								(LSB)
2	DU (0)	DS (1)	TSD (0)	ET (0)	TMC (00)		Reserved	LP (0)
3	Parameter Length (08h)							
4	(MSB)	Trace Point I.D.						
5								(LSB)
6	(MSB)	Time Stamp						
7								(LSB)
8	(MSB)	Argument 1						
9								(LSB)
10	(MSB)	Argument 2						
11								(LSB)

Device Trace Log Page Fields:

Trace Point I.D.	This is a unique code identifying the event which occurred
Time Stamp	The value of the lower 16 bits of the system clock at the time the event occurred
Argument 1	A parameter associated with the event
Argument 2	A parameter associated with the event

Write and Read Frame Error Counter Pages

The Write and Read Frame Error Counter Pages have the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (34h Write Frame Error or 35h Read Frame Error Counters)							
1	Reserved							
2	(MSB)	Page Length (38h/48h)						
3								(LSB)
	—*Error Counter Descriptors*—							
0	(MSB)	Parameter Code						
1								(LSB)
2	DU (0)	DS (1)	TSD (0)	ET (0)	TMC (0)		Reserved	LP (0)
3	Parameter Length (*m*)							
4	(MSB)	Parameter Value						
3+*m*								(LSB)

Write and Read Error Counters Page Fields:

Note The Current or Default Cumulative, or Current or Default Threshold values are returned according to the PC field of LOG SENSE.

The DU (Disable Update), DS (Disable Save), TSD (Target Save Disable), ET (Enable Threshold Comparison), TMC (Threshold Met Criteria) and LP (List Parameter) fields are collectively referred to as the *control byte*.

Parameter Code The Parameter Code field identifies which parameter of data is being transferred. The following parameter codes are supported for each Error Counters page:

Parm. Code	Description	Length (bytes)	Default Cumulative	Default Threshold
0001h	Frames Read or Written	4	0	FF FF FF FFh
0002h	Main Data C1 Block Errors Pos. Track	4	0	FF FF FF FFh
0003h	Main Data C1 Block Errors Neg. Track	4	0	FF FF FF FFh
0004h	Sub Area 0 C1 Block Errors Pos. Track	4	0	FF FF FF FFh
0005h	Sub Area 1 C1 Block Errors Pos. Track	4	0	FF FF FF FFh
0006h	Sub Area 0 C1 Block Errors Neg. Track	4	0	FF FF FF FFh
0007h	Sub Area 1 C1 Block Errors Neg. Track	4	0	FF FF FF FFh
0008h	Total Retry Count (read only)	4	0	FF FF FF FFh
0009h	Read C2 Uncorrectable Block	4	0	FF FF FF FFh

DS	1	This tells the host that saveable parameters are disabled (i.e. not supported)
LP	0	Must be zero; the parameter is a data counter rather than a list parameter.
DU, TSD, ET, TMC	0	Must be zero. For a full description of these fields refer to the SCSI-2 standard.

Bad Group Log Page

The Bad Group log consists of *n* parameters, each representing a group error event which has occurred concerning the device code. The first entry is the oldest event, and the last the most recent.

n parameters are always available even if the drive has just been powered up and the log is not filled. The oldest events are overwritten as new channel events occur, so that logging never stops.

The PC field of the LOG SENSE command has no effect on the data returned in this log.

The log page has the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (36h)							
1	Reserved							
2	(MSB)	Page Length (XXh)						
3								(LSB)
	—Bad Group Event Traces—							
0	(MSB)	Parameter Code (*n*)						
1								(LSB)
2	DU (0)	DS (1)	TSD (0)	ET (0)	TMC (00)		Reserved	LP (0)
3	Parameter Length (03h)							
4	Error Code							
5	(MSB)	Group Count						
6								(LSB)

Error Codes

The Error codes that can occur are as follows:

Code	Description
0x20	Group read after write retry limit exceeded
0x21	Write hard error
0x22	Retrying a group (writing)
0x23	Group read retry limit exceeded
0x24	Retrying a group (reading)
0x25	C2 Uncorrectable Tracks
0x26	Read drive error
0x27	Group needed C3 correction
0x28	Group needed Read After Write

Drive Counters Log Page

The Drive Counters Log Page has the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (37h)							
1	Reserved							
2	(MSB)	Page Length (18h)						
3								(LSB)
	—*Drive Counter Descriptors*—							
0	(MSB)	Parameter Code						
1								(LSB)
2	DU (0)	DS (1)	TSD (0)	ET (0)	TMC (0)		Reserved	LP (0)
3	Parameter Length (*n*)							
4	(MSB)	Parameter Value						
5								
6								
7								(LSB)

Drive Counters Page Fields:

Note The Current or Default Cumulative, or Current or Default Threshold values are returned according to the PC field of LOG SENSE.

The DU (Disable Update), DS (Disable Save), TSD (Target Save Disable), ET (Enable Threshold Comparison), TMC (Threshold Met Criteria) and LP (List Parameter) fields are collectively referred to as the *control byte*.

Parameter Code The supported Parameter Codes in this page are as follows:

Parm. Code	Description	Length *(bytes)*	Default Cumulative	Default Threshold
0001h	Loads	4	0	FF FF FF FFh
0002h	Write Drive Errors	4	0	FF FF FF FFh
0003h	Read Drive Errors	4	0	FF FF FF FFh

Mechanism Counters Log Page

The Mechanism Counters Log Page has the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (38h)							
1	Reserved							
2	(MSB) Page Length (a0h)							
3								(LSB)
	—Mechanism Counter Descriptors—							
0	(MSB) Parameter Code							
1								(LSB)
2	DU (0)	DS (1)	TSD (0)	ET (0)	TMC (0)		Reserved	LP (0)
3	Parameter Length (4h)							
4	(MSB) Parameter Value							
5								
6								
7								(LSB)

Mechanism Counters Page Fields:

Note The Current or Default Cumulative, or Current or Default Threshold values are returned according to the PC field of LOG SENSE.

The DU (Disable Update), DS (Disable Save), TSD (Target Save Disable), ET (Enable Threshold Comparison), TMC (Threshold Met Criteria) and LP (List Parameter) fields are collectively referred to as the *control byte*.

Parameter Code The supported Parameter Codes is this page are as follows:

Parm. Code	Description
0001h	Faulty 12V
0002h	High Humidity
0003h	Mode Sensor Fault
0004h	Tension Fault
0005h	Bad Diameter
0006h	Capstan Stalled
0007h	Drum Lock Lost
0008h	Drum Stalled
0009h	Drum Dref Lost
000ah	Drum PG Lost
000bh	Supply Reel Stuck Unthreading
000ch	Supply Reel Stuck Capstan Mode
000dh	Capstan Clean Slip
000eh	Take-up Reel Stuck Capstan Mode
000fh	RLS Stuck RL Mode
0010h	RAM Test Fail
0011h	ROM Check Fail
0012h	Supply Reel Brake Fail
0013h	Take-up Reel Brake Fail
0014h	Signal Processor Test

MODE SELECT 15h

Description:

MODE SELECT allows the host to modify parameters in the Mode Parameter pages in order to configure the drive. These parameters cannot be saved, and after a power-up or reset, the default configuration will always be set.

MODE SENSE allows the drive to report which configuration parameters it supports and what its current configuration is.

Implementing MODE SELECT and MODE SENSE requires a certain amount of handshaking between the host and the drive. Before configuring the drive, the host should issue a MODE SENSE. The drive can then return its current configuration and indicate what parameters are configurable. The host interprets this information and may then issue MODE SELECT to set the drive to the host's preferred configuration.

The drive's behavior when it receives a MODE SELECT command is as follows:

1. Any unwritten data in the buffer is flushed to tape.
2. The Mode Select Parameter list is transferred from the host to the drive during the Data-Out phase. The list contains a header followed by zero or more Mode Parameter pages. Pages which are supported are Disconnect-Reconnect (02h), Device Configuration (10h), Medium Partitions (11h) for changing the size or number of partitions, and Command and Timers Page (20h), which is read-only.
3. The HP 35470A sets internal parameters to the values in the pages. It checks values for validity as it goes along, so if the command terminates because of an error, earlier parameter values will already have been set to their new values.

Note In the MODE SELECT and MODE SENSE descriptions much of the information overlaps and the descriptions should be read in conjunction.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Only complete parts of a parameter list may be sent. It is illegal to send a partial mode parameter header, mode block descriptor or mode page.

If the Medium Partitions page is sent, Parameter List, Media Access, Media Write, Diagnostic Status and Humidity checks are also performed. Note that the tape must be at BOP for this page to be sent.

If the Device Configuration page is sent, the Media Access check is performed.

Command Descriptor Block:

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (15h)							
1	Logical Unit Number (0)			PF (1)	Reserved			SP (0)
2	Reserved							
3	Reserved							
4	Parameter List Length							
5	Reserved						Flag	Link

CDB Fields:

PF	*Page Format*	
	0	The Mode Select parameter data is not SCSI-2 compatible. Only the parameter header and block descriptor may be sent. As a result, the HP 35470A will report ILLEGAL REQUEST if the Parameter List Length is greater than 12 bytes.
	1	The data sent by the host after the MODE SELECT header and block descriptors complies with the definition of pages in the SCSI-2 specification.
SP	*Save Pages*	
	0	This bit is not supported and must be zero.
Parameter List Length	0	No data is transferred.
	>0	The length in bytes of the MODE SELECT parameter list to be transferred.

Completion:

After successful completion of MODE SELECT, UNIT ATTENTION is posted to all initiators other than the initiator of the command. Additional sense is 2A01h (mode parameters changed).

Mode Select Specific Status:

Event	Status	Key	Additional Sense
Incorrect parameter list	CHECK CONDITION	ILLEGAL REQUEST	1A00h (parameter list length error)
Mode parameter rounded to match drive sensitivity	CHECK CONDITION	RECOVERED ERROR	3700h (rounded parameter)

Mode Parameter Pages

Mode Page Representation

Certain conventions are used in the following Mode Parameter pages in order to describe the nature of the parameters. Most parameters are given by name, followed by a number in brackets. The brackets have the following meanings:

Square brackets [ ] Square brackets indicate that the parameter may be modified. The number inside the brackets is the default value for the field—in other words, the power-up or reset value.

MODE SELECT may modify this value by sending the page with a new value in the field.

MODE SENSE (current values) will return the current value of the parameter.

MODE SENSE (default values) will return the value in brackets [].

MODE SENSE (changeable values) will return a value of all ones.

Round brackets ( ) Round brackets indicate that the parameter is fixed. The number inside the brackets is the fixed value for the field.

MODE SELECT must set the parameter to this value, otherwise CHECK CONDITION will be reported with a sense key of ILLEGAL REQUEST.

MODE SENSE (current values) will return the fixed value.

MODE SENSE (default values) will return the fixed value.

MODE SENSE (changeable values) will return a value of all zeros.

Curly brackets {} Curly brackets indicate that the field is fixed. The number inside them will always be returned irrespective of whether current, default or changeable values are being returned.

Parameter Rounding

The following parameters in the mode pages may be rounded by the HP 35470A:

- Disconnect Time Limit, to the nearest 100 microseconds
- Bus Inactivity Limit, to the nearest 100 microseconds
- Write Delay Time Limit, to the nearest 100 milliseconds

If this happens, CHECK CONDITION status is returned with a sense key of RECOVERED ERROR and an additional sense code of 3700h (rounded parameter).

Mode Data Format

Mode data consists of a 4-byte header, optionally followed by block descriptor and Mode Parameter pages.

Mode Parameter Header

The Mode Parameter header must be either 0 or 4 bytes, and has the following format:

Byte \ Bit	7	6	5	4	3	2	1	0
0	Mode Data Length							
1	Medium Type (00h)							
2	Reserved	Buffered Mode [001]			Speed (0h)			
3	Block Descriptor Length							

Header Fields:

Mode Data Length

MODE SELECT: Mode Data Length field must be zero.

MODE SENSE: Mode Data Length field is set to the length of the data available. Note that the actual value returned may be truncated to the Allocation Length for the command.

Buffered Mode

0 The drive will not report GOOD status on write commands until all blocks and filemarks have been written successfully.

1 The HP 35470A will report GOOD status on write commands as soon as all the data has been transferred to the data buffer. Data for multiple commands from the different initiators may be buffered before being written to tape.

2 The drive will report GOOD status on write commands as soon as both the following conditions are satisfied:

- All data specified in the write command has been transferred to the data buffer.
- All buffered data from different initiators has been successfully written to tape.

Note that data for multiple commands from the same initiator may be buffered before being written to the medium.

Block Descriptor Length

Only the values 0 and 8 are valid.

0 No block descriptor is being transferred.

8 The Mode Parameter header must be followed by the 8-byte block descriptor described in the next section.

Mode Block Descriptor

The format of the Mode Parameter block descriptor is as follows:

Byte	Bit 7	6	5	4	3	2	1	0
0	Density Code [00h]							
1	(MSB)	Number of Blocks (00 00 00h)						
3								(LSB)
4	Reserved							
5	(MSB)	Block Length [00 00 00h]						
7								(LSB)

Mode Parameter Block Descriptor Fields:

Density Code This must be 00h, 13h or 7Fh. For MODE SENSE 13h is always returned. Any of the values may be sent for MODE SELECT.

- 00h Default: Hewlett-Packard/Sony DDS Format
- 13h Hewlett-Packard/Sony DDS Format
- 7Fh No change from previous density

Block Length This indicates the size of fixed blocks. See the description of the Fixed fields in the READ and WRITE commands. It is also used when deciding whether to report an illegal length block on reads (see the SILI error in the Status section of the READ command).

Disconnect-Reconnect Page

The drive supports the Disconnect-Reconnect Page which has the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code {02h}							
1	Page Length {0Eh}							
2	Buffer Full Ratio (00h)							
3	Buffer Empty Ratio (00h)							
4	(MSB)	Bus Inactivity Limit [5.7 ms]						
5								(LSB)
6	(MSB)	Disconnect Time Limit [0]						
7								(LSB)
8	(MSB)	Connect Time Limit (0)						
9								(LSB)
10	(MSB)	Maximum Burst Size [64 KB]						
11								(LSB)
12	Reserved						DTDC (0)	
13	Reserved							
14	Reserved							
15	Reserved							

Disconnect-Reconnect Page Fields:

Buffer Full Ratio, Buffer Empty Ratio, Connect Time Limit, and DTDC (Data Transfer Disconnect Control) are not supported by the drive and must be cleared to zero.

Bus Inactivity Limit	>0	The maximum time in 100 microsecond increments for which the HP 35470A will assert the BSY signal without a REQ/ACK handshake. Since the HP 35470A's timing capabilities have a resolution of about 1 millisecond, parameter rounding may occur. Since the firmware overhead from the last ACK of a command phase to the first REQ of a data phase is typically 5 ms, setting the bus inactivity limit to <5 ms will cause the firmware to disconnect following the command phase (typically <700 μs from the last ACK of the command phase). This applies to a configurable subset of commands only.
	0	The time limit becomes infinite. In practice, this means the HP 35470A will not disconnect between receipt of a command and the first data phase of that command. Note that a command with multiple data phases (for example, to match maximum burst size) will still have disconnects between phases.
Disconnect Time Limit	The minimum time in 100 microsecond increments that the drive will wait after releasing the SCSI bus before attempting reselection. Since the HP 35470A's timing capabilities have a resolution of about 1 millisecond, parameter rounding may occur	
Maximum Burst Size	>0	The maximum amount of data the drive will transfer during a data phase before disconnecting, expressed in increments of 512 bytes.
	0	There is no limit to the amount of data that will be transferred.

Note If the host does not grant disconnect privilege in its IDENTIFY message these parameters become meaningless. The HP 35470A will stay connected on the bus for the duration of an operation or until the host sends a mid-operation IDENTIFY granting disconnect privilege.

Device Configuration Page

The drive supports the Device Configuration Page, which has the following format:

Byte	*Bit* 7	6	5	4	3	2	1	0
0	Page Code {10h}							
1	Page Length {0Eh}							
2	Reserved	CAP	CAF	RAW	C3ECC[1]	N-Group [000]		
3	Active Partition							
4	Write Buffer Full Ratio (00h)							
5	Read Buffer Empty Ratio (00h)							
6	(MSB) Write Delay Time [0032h]							
7								(LSB)
8	DBR (0)	BIS (0)	RSmk [1]	AVC (0)	SOCF (00)		RBO (0)	REW [0]
9	Gap Size (00h)							
10	EOD Defined (000)			EEG (1)	SEW (0)	Reserved		
11	(MSB) Buffer Size at Early Warning (00 00 00h)							
13								(LSB)
14	Select Data Compression Algorithm (00h)							
15	Reserved							

Device Configuration Page Fields:

The DBR (Data Buffer Recovery), AVC (Automatic Velocity Control), SOCF (Stop On Consecutive Filemarks), RBO (Recover Buffer Order), Gap Size, Buffer Size at Early Warning and Select Data Compression Algorithm fields are not supported by the drive and must be cleared to zero.

CAP	*Change Active Partition* MODE SELECT If the CAP bit is set to 1, the logical partition is to be changed to that specified by the Active Partition field. MODE SENSE The CAP bit must be zero.
CAF	*Change Active Format* MODE SELECT If the CAF bit is set to 1, the active format is to be changed to that given by the RAW, C3 ECC and N-Group fields. MODE SENSE The CAF bit must be zero.
RAW	0 Read-After-Write is enabled. The drive rewrites frames which have not been read back correctly through RAW. 1 Read-After-Write disabled. The results of RAW are ignored. The drive proceeds to write the next frame. To modify this bit using MODE SELECT, the CAF bit must be set.
C3 ECC	1 C3 ECC is enabled. This is the default configuration. 0 C3 ECC is disabled. To modify this bit using MODE SELECT, the CAF bit must be set.
N-Group	The number of times a group will be repeated on tape after the first writing. The default is zero repetitions. This feature may be used to match the performance of the drive and the host. The range is 0 (000b) to 7 (111b). To modify this bit using MODE SELECT, the CAF bit must be set.
Active Partition	MODE SELECT Provided the CAF bit is set to 1, MODE SELECT will change the current partition to the partition indicated by this field. After the change, the tape will be positioned at BOP in the new partition. It follows that if you try to change the partition to the partition that is already active, the effect is simply of rewinding the tape. For a 1-partition tape, the only valid value is 01h. For a 2-partition tape, 00h and 01h are valid, and the default after load, power-up or reset is 00h. To format a tape as two partitions, use the Mode Select Medium Partitions page. MODE SENSE This field indicates the current active partition.
Write Delay Time	0 The drive will never flush buffered data to tape as a result of a timeout. >0 The maximum time, in 100 millisecond increments, that the drive will wait with a partially full buffer before flushing unwritten data to tape. Since the HP 35470A's timing capabilities have a resolution of about 1 millisecond, parameter rounding may occur.
BIS	Block Identifiers Supported. It must be set to 1 to indicate that the drive has recorded information about the logical block ID relative to the partition. The bit is ignored on MODE SELECT.
DBR	This is always 0, showing DBR is not supported. It is ignored on MODE SELECT.
RSmk	*Report Setmarks* 0 Setmarks are not reported, and are ignored. 1 Setmarks are reported. This is the default.
REW	Report Early-Warning End-of-Media. For writes, the drive will report early-warning (EW) at a distance of 500 mm before EOP/M, irrespective of the state of the REW bit. For reads and space operations, early-warning will only be reported if this bit is set. See READ. The default is that the REW bit is cleared to zero.
EOD Defined	0 This field must be zero so that the drive will use its default EOD definition to detect and generate EOD.
EEG	1 *Enable EOD Generation.* This bit must be set to 1 to indicate that the drive will generate an EOD before any change of direction following a write-type operation. The bit is ignored on a MODE SELECT command.
SEW	0 *Synchronize at Early Warning.* The drive does not synchronize at the early warning point. However, the default firmware configuration permits a Mode Select command to set this bit without causing an error or affecting drive operation. This bit will always be 0 in the Mode Sense data.

Medium Partitions Parameter Page

The drive supports the Medium Partitions Parameter Page, with the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code {11h}							
1	Page Length {08h} or (06h)							
2	Maximum Additional Partitions (01h)							
3	Additional Partitions Defined							
4	FDP (0)	SDP (0)	IDP (1)	PSUM (10)		Reserved		
5	Medium Format Recognition (03h)							
6	Reserved							
7	Reserved							
8	(MSB)	Size of Partition 1						
9								(LSB)

Medium Partitions Parameter Page Fields:

The FDP (Fixed Data Partitions) and SDP (Select Data Partitions) fields are not supported and must be cleared to zero.

Page Length	MODE SENSE	This will always return a page length of 8.
	MODE SELECT	This may return a page length of 6, providing the Additional Partitions Defined field is 0.
Max. Additional Partitions	01h	This field is only valid on MODE SENSE where it is used to report the maximum number of additional partitions that are supported by the drive, in this case, 1.
Additional Partitions Defined	0 and 1 are the only valid values. For MODE SENSE, the value is only valid if GOOD status is returned in response to a TEST UNIT READY command. If the page length is 6, this must be set to 0 otherwise CHECK CONDITION is reported.	
	0	For MODE SENSE this means the tape is one-partition. For MODE SELECT, it means the tape is to be formatted as one partition.
	1	For MODE SENSE this means the tape is two-partition. For MODE SELECT, it means the tape is to be formatted as two partitions.
IDP	*Initiator Defined Partitions.*	
	0	The remainder of the page is ignored. No action is taken.
	1	The drive formats the tape into the number and size of partitions given in the Additional Partitions Defined, PSUM and Partition Size fields. See the Glossary for an explanation of partitions.
PSUM	*Partition Size Unit of Measure.* This field defines the units for the Partition Size value. For the HP 35470A, the units are megabytes, which is indicated by 10b. As a result, the drive returns 10b for MODE SENSE and will only accept this value for a MODE SELECT.	
Medium Format Recognition	03h	This must be set to 03h to indicate that the drive is capable of format and partition recognition.
Size of Partition 1	MODE SENSE	This must be 0 if the number of additional partitions is 0. When the Additional Partitions Defined field is set to 1 (so that the tape is two-partition), the Size of Partition 1 field gives the size of partition 1 in megabytes. This is only valid when GOOD status is returned in response to TEST UNIT READY.
	MODE SELECT	Size of Partition 1 indicates the size in megabytes for the drive to format Partition 1.

Data Compression Characteristics Page

Note The HP 35470A does not support data compression. Any compressed data encountered by the drive during a READ command will generate a CHECK CONDITION, with the sense key set to MEDIUM ERROR (03h). If the host supports it, the drive can pass compressed data to the host for *software decompression*. Refer to chapter SF2 for further details.

The Data Compression Characteristics Mode Page is defined as follows:

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved (0)		Page Code {0Fh}					
1	Page Length {0Eh}							
2	DCE [1]	DCC (0)	Reserved (0)					
3	DDE [1]	RED [0]	Reserved (0)					
4	Compression Algorithm [20h]							
5								
6								
7								
8	Decompression Algorithm [00h]							
9								
10								
11								
12	Reserved (0)							
13	Reserved (0)							
14	Reserved (0)							
15	Reserved (0)							

Data Compression Characteristics Mode Page Fields:

DCE *Data Compression Enable*

MODE SELECT This field allows the host to enable or disable data compression.

- 0 The drive will disable data compression, and any subsequent data sent to the drive by the host will be written to tape uncompressed.
- 1 The drive will compress any subsequent data sent to it by the host before writing it to tape. The Algorithm used to compress the data is that specified in the Compression Algorithm field.

MODE SENSE This field allows the host to determine whether compression is enabled or disabled.

- 0 Compression is disabled.
- 1 Compression is enabled.

DCC MODE SENSE This field allows the host to determine whether the drive supports data compression. This field is fixed.

- 0 Compression not supported.
- 1 Compression is supported.

DDE *Data Decompression Enable*

MODE SELECT This field allows the host to enable or disable decompression.

- 0 Decompression is disabled. Any compressed data encountered will be returned to the host as a single variable length record.
- 1 Decompression is enabled.

	MODE SENSE	This field allows the host to determine whether the drive will attempt to decompress any entities it encounters on tape. 0 The drive will not attempt decompression. 1 The drive will attempt compression.
RED	*Report Error on Decompression*	
	MODE SELECT	This field allows the host to specify when CHECK CONDITION is reported to the host. The field only affects a READ command. 0 The drive will generate CHECK CONDITION every time it encounters an entity which it cannot decompress. 1 The drive will only generate a CHECK CONDITION when it encounters data which will require different handling by the host. 2 The drive will generate CHECK CONDITION every time it encounters data which has been processed using a different algorithm. 3 Undefined. The drive will return CHECK CONDITION with the sense key set to ILLEGAL REQUEST.
	MODE SENSE	This field allows the host to determine whether CHECK CONDITION will be generated on format boundaries or on encountering any entity which cannot be decompressed. Note that a host which supports software decompression will generally set this field to 1 when initializing, while a host which does not support software decompression will set the field to 0. 0 CHECK CONDITION will be generated on encountering an entity which the drive cannot decompress. 1 CHECK CONDITION will be generated on format changes only.
Compression Algorithm	MODE SELECT	The Compression Algorithm field determines the algorithm which the drive will use to compress data sent to it by the host when the DCE bit is set to 1. 0 Deselect all compression algorithms. This is only valid if the DCE field is zero, otherwise CHECK CONDITION status is generated with an ILLEGAL REQUEST sense key set. 1 Use compression algorithm DCLZ. This is the only algorithm supported by the drive. n Select compression algorithm *n*. If the drive does not support the algorithm selected, it will issue a CHECK CONDITION with an ILLEGAL REQUEST sense key set.
	MODE SENSE	The field contains the registered algorithm identifier for the currently selected compression algorithm. Note that this field will never be 1.
Decompression Algorithm	MODE SELECT	This field has no meaning and is ignored by the drive.
	MODE SENSE	This field allows the host to determine the type of compression algorithm used to process data sent most recently to the host in response to a READ command. 0 The last data item returned was an uncompressed record. n The last data item returned was an entity compressed using algorithm *n*. Note that this is valid, even if the data was decompressed by the drive.

Command and Timers Page

The drive supports the Vendor-Unique Command Timers Page, with the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	0	0	Page Code {20h}					
1	Additional Page Length {64h}							
2	Command Operation Code							
3	HPC	0	Invalid	(MS bits)				
4	Timer Value							
5								(LSB)
6 – 101	–More Opcode and Timer Values–							

The parameters are in 4-byte groups as shown above (bytes 2–5). Each command implemented by the drive is represented by a 4-byte group.

Command and Timers Page Fields:

Command Opcode	This field contains the SCSI command code of an implemented command.	
HPC	1	HP Common SCSI. This field is set to 1 to indicate that the command complies with the HP Common SCSI specification.
Invalid	0	The Timer Value field is valid.
	1	The Timer Value field is invalid for this command. This is the case for COPY, for example, where it is impossible to make a satisfactory estimate of the time taken for the command to execute.
Timer Value	This indicates the maximum length of time allowed for the command to execute (in tens of milliseconds). The range of the timer is from 10 milliseconds to 5 hours, in 10 millisecond increments. The field assumes that there is no bus contention during the command execution, and that the HP 35470A has full and unrestricted access to the SCSI bus whenever it is required. For commands involving variable length data transfers (such as READ or WRITE), the Timer Value field assumes 2 kilobytes of data with no intervening disconnects.	

Note The Vendor-Unique Command Timers page is read-only. Any attempt to change this page using the MODE SELECT command will result in a CHECK CONDITION status and an ILLEGAL REQUEST sense key.

If the format fails, CHECK CONDITION status is reported with a sense key of HARDWARE ERROR and additional sense of 3101h (format command failed).

MODE SENSE 1Ah

Description:

MODE SENSE allows the drive to return its current configuration and report which configuration parameters can be changed through MODE SELECT

See MODE SELECT for full descriptions of the Mode Parameters.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Ah)							
1	Logical Unit Number (0)			DBD	Reserved			
2	PC		Page Code					
3	Reserved							
4	Allocation Length							
6	Reserved						Flag	Link

CDB Fields:

DBD *Disable Block Descriptors*

0 Allows the HP 35470A to return the Mode Select block descriptor.

1 Prevents the HP 35470A from returning the Mode Select block descriptor.

PC *Page Control*—Indicates the type of page parameter values to be returned to the host as shown in the following table:

7	6	Description
0	0	*Report Current Values*: this is the normal default situation where the drive returns its current configuration to the host. The drive sets any unsupported Page fields to zero.
0	1	*Report Changeable Values*: these are any values which a host can alter through the MODE SELECT command. Any field that the drive allows to be changed is set to one, otherwise the field is cleared to zero.
1	0	*Report Default Values*: these are the default values on power-up.

Page Code This allows the host to select any specific page, or all the pages supported by the drive. The following page codes are supported:

Page Code	Description
00h	Only the 4-byte header and one 8-byte block descriptor are returned. This ensures compatibility with SCSI-1 as well as SCSI-2.
02h	Disconnect-Reconnect page returned
10h	Device Configuration Parameters page returned
11h	Medium Partition Parameters page returned
0Fh	Data Compression Characteristics page returned
20h	Commands and Timers page returned
3Fh	All supported pages returned

The Additional Page Length field of each page returned by the drive indicates the number of bytes supported for that page. Fields not supported by the drive are set to zero.

Allocation Length	Specifies the number of bytes that the host has allocated for returned MODE SENSE data. An Allocation Length of zero means that the drive will return no data. Any other value indicates the maximum number of bytes that can be transferred. The drive finishes the DATA IN phase when Allocation Length bytes have been transferred or when the entire mode page has been transferred to the host, whichever is less. See MODE SELECT for the format of the data returned by MODE SENSE.

PREVENT/ALLOW MEDIUM REMOVAL 1Eh

Description:

PREVENT/ALLOW MEDIUM REMOVAL tells the drive to enable or disable the removal of the tape.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Command Descriptor Block:

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (1Eh)							
1	Logical Unit Number (0)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							Prevent
5	Reserved						Flag	Link

CDB Fields:

Prevent

0 The drive ejects the tape following completion of an UNLOAD. The Unload button is also re-enabled.

1 The drive will not eject the tape following an UNLOAD command. When it receives UNLOAD, the drive unthreads the tape but leaves it in the mechanism. The Unload button is disabled.

It is recommended that the host sends a PREVENT MEDIUM REMOVAL command before it issues a LOAD command, so that the tape will not be unloaded immediately when the Unload button is pressed on the front panel, but only after the load is complete.

PREVENT MEDIUM REMOVAL can only be cleared by the host which originated the command. It cannot be cleared by another host sending an ALLOW MEDIUM REMOVAL command.

By default, media removal is enabled. The drive resorts to this default state following a power-on, SCSI reset, bus device reset.

READ 08h

Description:

READ transfers zero or more data blocks to the host starting with the next block on the tape.

Pre-Execution Checks:

Illegal Field	Fixed Bit	Flag Link	Bad LUN	Reservation
Deferred Error	Unit Attention	Media Access	Diagnostic Status	Humidity

Command Descriptor Block:

		Bit							
		7	6	5	4	3	2	1	0
Byte	0	Operation Code (08h)							
	1	Logical Unit Number (0)			Reserved			SILI	Fixed
	2	(MSB)							
	3	Transfer Length							
	4								(LSB)
	5	Reserved						Flag	Link

CDB Fields:

SILI *Suppress Incorrect Length Indicator*

- 0 The read operation is terminated when the length of a block (on the tape) differs from the Transfer Length. Transfer Length bytes of data will have been transferred. The logical tape position will be the EOM side of the illegal sized block.
- 1 The HP 35470A will not report CHECK CONDITION status if the only error is that the Transfer Length is not equal to the actual block length recorded on the media. This applies for variable block mode reads only.
  Exception: If the block size in the mode block descriptor is not zero and the actual block length exceeds the requested block length, ILI will be reported in the sense data.

Fixed

- 0 The Transfer Length field specifies the length of the transfer in bytes.
- 1 The Transfer Length field specifies the length of the transfer in blocks. The size of each block (in bytes) is specified by the current block length specified in the Mode Parameter block descriptor.

Transfer Length

- 0 No data is transferred. This is not considered an error and the current logical position will be unchanged.
- >0 The amount of data to be transferred, in bytes or blocks as specified by the Fixed field.

Read Specific Status:

Event	Status	Key	Notes
SILI error	CHECK COND'N	NO SENSE	ILI and Valid bits are set. The information bytes will be set as follows: *Variable Block Mode:* The difference between the requested Transfer Length and the actual block size. If the block size is bigger than the Transfer Length, this will be negative (twos complement). *Fixed Block Mode:* The difference between the required number of blocks and the number of whole good blocks transferred. In other words, the illegal length block is not counted.
Filemark encountered	CHECK COND'N	NO SENSE	Mark bit is set. Logical position will be on the EOM side of the filemark. Additional sense is 0001h (filemark detected).
Setmark encountered	CHECK COND'N	NO SENSE	Mark bit is set. Report Setmarks must have been configured by setting the RSmk bit in the Mode Select Device Configuration page to 1. Additional sense is set to 0003h (setmark detected). The logical position is on the EOM side of the setmark.
EOD encountered	CHECK COND'N	BLANK CHECK	Additional sense is set to 0005h (EOD detected).
EOP/M encountered	CHECK COND'N	VOLUME OVER-FLOW	EOM bit is set. Additional sense is set to 0002h (EOP/M detected).
Early warning (EW) EOM detected	CHECK COND'N	NO SENSE	Additional sense set to 0002h (EOP/M detected). Early warning end of medium (EW) information is reported only if the read operation was successful and the REW bit in the Mode Select Device Configuration page is set to 1.
Failure to read data through media error or non-fatal drive error	CHECK COND'N	MEDIA ERROR	Additional sense is set to 3B00h (sequential positioning error).
Incompatible data format	CHECK COND'N	MEDIA ERROR	Additional sense set to 3002h (can't read media, unknown format).
Blank media encountered	CHECK COND'N	BLANK CHECK	Additional sense is set to 1403h (EOD not found). Residual information is as shown below.

Residue Information:

The Valid bit will be set. The information bytes will be as follows:

Variable Block Mode The requested Transfer Length (in bytes).

Fixed Block Mode The difference (in blocks) between the requested transfer size and the actual number of blocks transferred. A partially transferred block is not counted, so for example, if 3.5 out of 10 blocks have been transferred the residue will be 7.
If the last block is an Illegal Length block, it is not counted among those transferred. For example, if 4 Legal Length blocks and 1 Illegal Length block have been transferred out of a total of 10, the residue will be 6.

READ BLOCK LIMITS 05h

Description:

READ BLOCK LIMITS tells the drive to return its limits for block length. The READ BLOCK LIMITS data shown below is sent during the DATA IN phase of the command. The command does not reflect the currently selected block size, only the available limits. MODE SENSE returns the current block size.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (05h)							
1	Logical Unit Number (0)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved						Flag	Link

Read Block Limits Data:

Byte	Bit 7	6	5	4	3	2	1	0
0	00h							
1	(MSB)	Maximum Block Length unsigned (FF FF FFh)						
2								
3								(LSB)
4	(MSB)	Minimum Block Length (0001h)						
5								(LSB)

READ BUFFER 3Ch

Description:

READ BUFFER returns a segment of the drive's data buffer, processor memory, or a buffer descriptor to the host. It is used in conjunction with WRITE BUFFER as a diagnostic function for testing the 1 megabyte data buffer and the SCSI bus integrity of the drive.

Note This command cannot be used to recover buffered data. If the drive receives a READ BUFFER without having had a prior WRITE BUFFER command, only the 4-byte header will be returned, because the drive writes any buffered data to tape before accepting READ BUFFER or WRITE BUFFER for the first time. However, if READ BUFFER is sent *immediately* after WRITE BUFFER, all or part of the data just written can be recovered.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (3Ch)							
1	Logical Unit Number (000)			Reserved			Mode	
2	Buffer ID							
3	(MSB)							
4	Buffer Offset							
5								(LSB)
6	(MSB)							
7	Allocation Length							
8								(LSB)
9	Reserved						Flag	Link

CDB Fields:

Mode

0 *Read header and data.* The HP 35470A returns a 4-byte buffer header followed by buffer data starting from data buffer address 0. The header is identical to the buffer descriptor (see 'Buffer Descriptor A' on the next page). The total length of header and data is Allocation Length

1 *Read processor memory.* The HP 35470A returns Allocation Length bytes of data from an address in processor memory specified by Buffer Offset.

2 *Read data buffer.* The HP 35470A returns Allocation Length bytes of data from the data buffer. The start address of the data in the buffer is specified by Buffer Offset.

3 *Return buffer descriptor.* The HP 35470A returns a descriptor for the buffer identified by the Buffer ID field. For buffer 0, the data buffer, Buffer Descriptor A (see the next page) is returned. For buffer 1, the processor memory, Buffer Descriptor B is returned.

See the Valid Field Values section below for constraints upon the value of Mode imposed by the Buffer ID field.

Buffer ID

0 Read the data buffer

1 Read the processor memory

Buffer Offset	When Mode = 2, the Buffer Offset specifies the address in the data buffer from which to start reading, relative to the start of the buffer. When Mode = 1, the Buffer Offset specifies the absolute address in processor memory from which to start reading.
Allocation Length	When Mode = 1, the Allocation Length specifies the number of bytes of data to be transferred from processor memory. When Mode = 2, it is the number of bytes to be transferred from the data buffer. If the combined length and offset exceeds the size of the buffer, the drive *wraps around* from the buffer end and returns the remainder from the start of the buffer. When Mode = 0, a 4-byte header is returned, followed by (*Allocation Length* − 4 *or* 80000*h* + 4) bytes of data starting at address 0 in the data buffer. If Allocation Length is less than 4, nothing is returned. When Mode = 3, Allocation Length is ignored; the 4-byte descriptor alone is returned.

Valid Field Values:

The following table shows the values of the Buffer ID, Buffer Offset and Allocation Length fields for each valid value of Mode:

Mode	Buffer ID	Buffer Offset	Allocation Length
If Mode = 0 then:	0	0	4
If Mode = 1 then:	1	Within valid controller processor address range	So that the window of processor memory starting at Buffer Offset is valid
If Mode = 2 then:	0	<8 00 00h	≤8 00 00h
If Mode = 3 then:	0 or 1	0	ignored

Returned Data:

The data returned by READ BUFFER depends on the setting of the Mode field. Buffer Descriptor A below shows the 4-byte header returned as part of the data for the Combined Header and Data mode (Mode 0). This is identical to the data returned for Return Buffer Descriptor mode (Mode 3) for the data buffer (Buffer ID = 0).

Note that READ BUFFER cannot be used to read buffered data. Data read from the buffer is undefined unless the command is immediately preceded by a WRITE BUFFER command.

Buffer Descriptor A

Read Buffer Header Descriptor (ID = 0)

Byte \ Bit	7	6	5	4	3	2	1	0
0	00h							
1	(MSB)							
2	Buffer Capacity (08 00 00h)							
3								(LSB)

Buffer Descriptor B

Read Buffer Descriptor (ID = 1)

Byte \ Bit	7	6	5	4	3	2	1	0
0	00h							
1	(MSB)							
2	Buffer Capacity (00 00 00h)							
3								(LSB)

Read Buffer Specific Status:

If READ BUFFER fails, a sense key of HARDWARE ERROR is returned with additional sense code of 4001h (diagnostic failure on component 1). This could be because the hardware has failed, or it could happen when a previously unwritten part of the data buffer is read. This is because the parity bits related to the bytes being read are undefined at power-on, so they cause spurious parity errors.

READ POSITION 34h

Description:

The READ POSITION command returns the current logical position of the drive to the host. The position is given in two parts:

- The current partition.
- The offset from the start of the partition in terms either of blocks (ignoring marks), or the count of all blocks and marks. The BT bit selects which. Block 1 is located at the start of the partition.

Pre-Execution Checks:

Illegal Field	Flag Link	Bad LUN	Reservation	Deferred Error
Unit Attention	Media Access	Diagnostic Status	Humidity	

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (34h)							
1	Logical Unit Number (0)			Reserved				BT
2	Reserved							
:	:							
8	Reserved							
9	Reserved						Flag	Link

CDB Fields:

BT *Block address Type*

0 The First Block Location field is to be the total number of blocks, filemarks and setmarks from the beginning of the partition.

1 The value in the First Block Location field is to be the number of blocks from the beginning of the partition to the current position.

Returned Data:

The format of the 20 bytes of data returned for REQUEST SENSE is as follows:

Byte	Bit 7	6	5	4	3	2	1	0
0	BOP	EOP	Reserved			BPU	Reserved	
1	Partition Number							
2	Reserved							
3	Reserved							
4	(MSB) First Block Location							
7								(LSB)
8	(MSB) Last Block Location *(same as First Block Location)*							
11								(LSB)
12	Reserved							
13	(MSB) Number of Blocks in Buffer (00 00 00h)							
15								(LSB)
16	(MSB) Number of Bytes in Buffer (00 00 00 00h)							
19								(LSB)

Returned Data Fields:

BOP	0 The current logical position is not the beginning of the partition. 1 The current logical position is the beginning of the partition.
EOP	0 The current logical position is not at the end of the partition. 1 The current logical position is at the end of the partition. Note that the EOP and BOP bits are mutually exclusive.
BPU	*Block Position Unknown* 0 First and Last Block Location fields are valid. 1 First and Last Block Location fields are undefined. This will only occur after a "hard" read error which has caused a sense key of MEDIUM ERROR with additional sense of 3B00h (sequential positioning error).
Partition Number	*The value of the current partition.* 0 Valid for 1- or 2-Partition tapes. 1 Valid for 2-Partition tapes only.
First Block Location	The First Block Location specifies either the number of blocks or the total number of blocks plus marks from the beginning of the partition to the current position. The BT bit determines which measure is used.
Last Block Location	This is always set to the value of the First Block Location.

RECEIVE DIAGNOSTICS RESULTS 1Ch

Description:

RECEIVE DIAGNOSTIC RESULTS tells the drive to send analysis data to the host after completion of a SEND DIAGNOSTIC command.

Data is specific to the last SEND DIAGNOSTIC command received by the drive, whatever host sent it. If no SEND DIAGNOSTIC has been received, the data refers to the power-on self-test.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Ch)							
1	Logical Unit Number (0)			Reserved				
2	Reserved							
3	(MSB) Allocation Length							
4								(LSB)
5	Reserved						Flag	Link

CDB Fields:

Allocation Length

0 No data is to be returned.

>0 The number of bytes which the host has allocated for returned diagnostic data.

The HP 35470A returns Allocation Length bytes or what is available, whichever is less. The amount of data available is always 64 bytes.

Results:

See the Diagnostics section in this manual for information on the returned data.

RELEASE UNIT 17h

Description:

RELEASE UNIT releases the drive if it is reserved by the host making the request.

It is not an error to attempt to release the drive if it is not reserved by the host making the request. However, if it is reserved by another host, the drive is not released.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (17h)							
1	Logical Unit Number (0)			3rd Pty	Third-Party Device ID			Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved						Flag	Link

CDB Fields:

3rdPty	0	The host wishes to release a reservation it has made for itself.
	1	The host wishes to release a reservation it has made for a third-party host.
Third-Party Device ID		If the 3rdPty bit is set to 1, the 3rd Party Device ID field specifies the ID of the device for which the HP 35470A has been reserved by the host. If the 3rd Pty bit is clear, this field is ignored.

Release Unit Specific Status:

Status is returned as follows:

This Host	The HP 35470A	Another Host or 3rd Party	3rd Pty bit	3rd Party ID	Status
	not reserved				GOOD
	reserved by...	another host			GOOD
reserved drive for itself	reserved		Clear		Cleared
reserved drive for itself	reserved		Set		GOOD
reserved drive for 3rd Pty host	reserved for...	3rd Party host	Clear	<> ID of 3rd Party Host	GOOD
reserved drive for 3rd Pty host	reserved for...	3rd Party host	Set	= ID of 3rd Party Host	Cleared

REQUEST SENSE 03h

Description:

Sense data held within the drive for the host is transferred to the host during a data-in phase. The sense data is valid after CHECK CONDITION status has been reported to the host, or when a command is terminated with an unexpected BUS FREE.

Positional sense data is valid whenever a tape is loaded and no higher priority sense data is present. An unsolicited REQUEST SENSE (one without a preceding CHECK CONDITION) returns sense data which reflects the position of the tape; in other words, the Mark, EOM and Additional Sense fields of the sense data are valid.

Note The drive maintains valid positional information for normal read and write commands only (READ, WRITE, SPACE, WRITE FILEMARK, REWIND). If abnormal commands (such as WRITE BUFFER) are received this positional sense information is lost.

The drive clears sense data for the host following execution of the REQUEST SENSE command for that host, unless the data is positional sense data.

Pre-Execution Checks:

Illegal Field Flag Link Bad LUN

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (03h)							
1	Logical Unit Number (0)			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Reserved						Flag	Link

CDB Fields:

Allocation Length	0	No data is returned.
	>0	The maximum amount of sense data in bytes that should be transferred to the host. The drive returns up to Allocation Length bytes of data; any extra sense data is lost.

Request Sense Data

The following diagram shows the format of the data returned for the REQUEST SENSE command. The HP 35470A always has 18 bytes of sense data available to return. Note that separate copies of sense data are maintained for the 7 possible hosts that could share the SCSI bus with the drive.

If the sense data is for a failed COPY command, and the sense key is COPY ABORTED, then HP 35470A returns up to 33 extra bytes of sense data from the copy target.

The returned sense information has the following format:

Byte	Bit 7	6	5	4	3	2	1	0
0	Valid	Error Code (70h or 71h)						
1	Segment Number							
2	Filemark	EOM	ILI	Reserved	Sense Key			
3	(MSB)	Information Bytes						
6								(LSB)
7	Additional Sense Length (normally 0Bh, up to 2Ch if COPY ABORT sense)							
8	(MSB)	Command Specific Information Bytes						
11								(LSB)
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	FRU Code							
15	SKSV	C/D	Reserved		BPV	Bit Pointer		
16	(MSB)	Field Pointer/Drive Error Code						
17								(LSB)
18	Reserved							
19	(Copy Target Status)							
20–51	(Copy Target Sense)							

Returned Sense Data Fields:

Valid	1	Indicates that the information bytes contain valid information as defined in the SCSI specification.
Error Code	70h	Indicates that the error is *current*, that is, it is associated with the command for which CHECK CONDITION status has been reported.
	71h	Indicates that the error is *deferred*. A deferred error occurs when there is a failure for an operation which has already been terminated with a GOOD status, or when failure occurs in "cleanup" activity following an operation which was terminated by BUS RELEASE. The command for which CHECK CONDITION status was reported is therefore unlikely to be the cause of the deferred error. It simply gives the HP 35470A the opportunity to report CHECK CONDITION status for an error which already exists.
Segment Number	This contains the number of the current segment descriptor when the REQUEST SENSE is in response to a COPY command which has produced a CHECK CONDITION. Otherwise the field is cleared to zero.	
Filemark	1	The Filemark bit is set to 1 when the logical position is at a filemark or setmark. See the READ and SPACE commands. The Additional Sense Code and Qualifier fields will indicate which sort of mark it is. Reporting of setmarks is optional and indicated by the RSmk bit in the MODE SELECT Device Configuration Parameters page.
EOM	1	The EOM bit indicates the tape is at BOP or EOP/M. The drive also sets the sense key to NO SENSE with an additional sense code of 0004h for BOP, or 0002h for EOP/M. BOP is reported after a SPACE command encounters BOP. EOP/M is reported when a WRITE or WRITE FILEMARK command leaves the tape positioned in the early warning (EW) region near the end of the partition. It is also reported when a READ or SPACE command actually hits EOP/M. See the READ, SPACE, WRITE and WRITE FILEMARKS commands. See the Glossary for a description of EW regions, BOP and EOP/M.
ILI	1	Indicates that the requested block length did not match the actual block length. Only READ and VERIFY can cause this bit to be set.

Information Bytes	The Information Bytes field is only valid if the Valid bit is set. It contains residue information following the failure of either a READ, WRITE, WRITE FILEMARKS or SPACE command. The field can take a negative value, expressed in twos complement notation. See the description of the command that failed for the contents of the field. The field is not valid for the COPY command, and will contain all zeros.	
Additional Sense Length	0Bh	Specifies the number of additional sense bytes to follow and is always set to 0Bh. It is never truncated to reflect actual transfer length.
Command Specific Information Bytes	0	The normal value for this field.
	1300h	If the sense data is for a COPY command which produced CHECK CONDITION status, and the additional sense is COPY ABORTED, the Command Specific Information Bytes are set to 1300h. The first two bytes (19 decimal) indicate the offset into the sense data at which copy target status and sense data occur.
Additional Sense Code and Qualifier	These two bytes provide additional information about the cause of the CHECK CONDITION, or the current tape position when the REQUEST SENSE is unsolicited. See "Additional Sense Codes" later in this section.	
FRU Code	This will be set to a value to indicate a specific part which has failed. It may take one of the following values: 0 No failing unit 1 Controller PCA failure 2 Mechanism failure	
SKSV	0	The Sense Key Specific Bytes (bytes 15 through 17) are invalid. The CD, BPV and Bit Pointer fields will be zero. The top byte of the Field pointer will be zero, and the bottom byte will contain a product-specific error code.
	1	The Sense Key Specific Bytes are valid. This will only happen when the bytes assume the role of Field Pointer Bytes as defined by ANSI. This occurs when an Illegal Field check detects an error in a command descriptor block or a Parameter List check detects an error in a command parameter list.
C/D	*Command Data* 0 The Field Pointer information applies to the parameter list for the command. 1 The Field Pointer information applies to the command descriptor block.	
BPV	*Bit Pointer Valid* 0 The Bit Pointer field is invalid. 1 The Bit Pointer field is valid. If the SKSV bit is set then the BPV bit must be set as well.	
Bit Pointer	Identifies the bit position of the field in error, whether it is a command descriptor or a command parameter list field. If a multiple-bit field is in error, the pointer marks the most significant bit of the field.	
Field Pointer /Drive Error Code	If SKSV is set, this field identifies in which byte of the command descriptor or parameter list an error was detected. Note that the HP 35470A scans from byte 0 bit 7 of a command or parameter list through to byte *n* bit 0. The field and bit pointers are set to point to the most significant bit of the field that is in error. If SKSV is not set, the top byte of this field will be zero. The bottom byte contains the drive error code associated with the failure of the previous command, or zero in the case of no failure and no appropriate error code.	
Copy Target Status	This field is returned only if the sense key is COPY ABORTED. The field is set to the value of the status byte returned to the HP 35470A from a copy target which resulted in the failure of the last COPY operation.	
Copy Target Sense	This field is returned only if the sense key is COPY ABORTED. The field contains the sense data returned to the HP 35470A by the most recent copy target. The HP 35470A would have requested this by issuing a REQUEST SENSE command to the copy target in response to receiving status other than GOOD from the copy target in response to some previous command.	

Sense Data Management

The HP 35470A maintains three sets of sense data for every host on the bus. For a single host the following sense data is maintained:

- Current Sense.
- Unit Attention sense.
- Deferred Error Sense.

Unless otherwise stated, all the following descriptions apply to the sense data for a single host whose command is being executed.

Current Sense

Current sense is the data which is returned in response to a REQUEST SENSE command.

Current sense is modified or updated in the following circumstances:

- It is cleared in response to the arrival of any command other than REQUEST SENSE or INQUIRY. It is cleared following execution of a REQUEST SENSE command. It is cleared on arrival of an unsolicited REQUEST SENSE command (that is, when no CHECK CONDITION status was reported for the previous command). This ensures the positional sense is updated to reflect current position before returning sense data.
- If the current command fails, sense is set according to the failure and CHECK CONDITION is reported to the host which sent the command.
- If the previous command terminated with an unexpected BUS FREE, current sense is set according to the reason for the bus release.
- If the command fails its pre-execution check for Unit Attention, Unit Attention sense is copied to the Current sense, and CHECK CONDITION is reported to the host which sent the command.
- If the command fails its pre-execution check for Deferred Error, Deferred Error sense is copied to the Current sense, and CHECK CONDITION is reported to the host which sent the command.

Clearing Current Sense

Clearing the Current sense involves setting sense fields as follows:

Valid	0	Error Code	70h	Segment Number	0
ILI	0	Sense Key	0	Information Bytes	0
Command Specific Information	0	Sub-Assembly Code	0	SKSV	0

Unsolicited Sense

Normal sense data is available to a host through the REQUEST SENSE command only when the host's previous command was reported with CHECK CONDITION status. A REQUEST SENSE command is *unsolicited* when there was no preceding CHECK CONDITION, and positional sense information may be set.

This unsolicited sense indicates the current logical and physical position of the media. The sense key will be set to NO SENSE. The Mark and EOM bits will be set depending on whether the tape is at a mark or at end of media. The additional sense will be set to indicate the current position (at a mark or at EOM).

Note If the HP 35470A is performing activities related to a command with immediate report such as REWIND, unsolicited positional sense will give the position *before* the rewind. When the rewind operation genuinely completes, unsolicited positional sense will indicate BOM.

Unit Attention Sense

Unit Attention sense is set when one of the following Unit Attention conditions occur:

- Power On, SCSI Reset, Bus Device Reset. Additional sense will be set to 2900h (power-on, reset or bus clear reset occurred).
- Tape Loaded (possible media change). Additional sense will be set to 2800h (not ready to transition). See LOAD/UNLOAD command Specific Status.
- Mode Sense Parameters Changed. Additional sense will be set to 2A01h (mode parameters changed). See MODE SENSE command Specific Status.
- Microcode Downloaded. Additional sense will be set to 3F01h (microcode downloaded). See WRITE BUFFER command.

Unit Attention sense will persist for a host until the host sends a command which has Unit Attention as part of its pre-execution checks (that is, any command other than IDENTIFY and REQUEST SENSE). When the Unit Attention pre-execution check fails, the Unit Attention sense is moved to the Current sense and CHECK CONDITION status is reported to the host. The host is then expected to issue a REQUEST SENSE command to recover the new Current sense data.

It is possible for multiple Unit Attention conditions to arise (for example, on power-on followed by tape load) so that the host does not read one condition before the next occurs. In this case a prioritizing scheme is used. If a Unit Attention condition exists and a new one occurs, then the Unit Attention sense will be overwritten by the new sense only if the new sense has a higher priority. The order of priority is as follows:

Power-on, Reset	*highest priority*
Tape Loaded	
Mode Parameters Changed	
Microcode Downloaded	*lowest priority*

Unit Attention sense that arises from the execution of a command will not be posted to the host that sent the command, though all other hosts will receive it.

Deferred Error Sense

Deferred Error sense is generated when an operation fails and CHECK CONDITION status cannot be reported to the host for one of the following reasons:

- The operation had immediate-report on (for example, REWIND with the Immed bit set, or LOAD).
- The operation was a write which was immediate-reported on after its data was successfully placed in the write-behind queue.
- The operation was abandoned without status (that is, a bus release occurred) after what the HP 35470A perceived was a catastrophic error or when an error occurred following the HP 35470A's honoring of an ABORT message. Following the bus release, the drive performed "cleanup" activity which failed. The Deferred Error refers to the reason for this failure.

When any one of the above occurs, the sense generated will be Deferred Error sense. This sense persists until the host sends a command which has Unit Attention as part of its pre-execution checks (that is, any command other than IDENTIFY and REQUEST SENSE). When the Deferred Error pre-execution check fails, the Deferred Error sense is moved to the Current sense and CHECK CONDITION status is reported to the host. The host is then expected to issue a REQUEST SENSE command to recover the new Current sense data.

In the unlikely event of a Deferred Error condition arising when one already exists (such as a catastrophic failure on top of a write-behind error) then the most recent Deferred Error sense is kept and the older sense discarded.

Write-Behind Deferred Errors

If the Buffered Mode field of the Mode Select parameter header is not zero, data buffering is enabled. If an error occurs in flushing the write-behind data, Deferred Error sense is set for all those hosts which the HP 35470A thinks have write-behind data in the buffer.

For each host with this sense set, the following occurs when its next command is to be executed:

- If the command is WRITE or WRITE FILEMARKS then the Deferred Error sense is copied to Current sense and the error is changed to a Current error (that is, the Error Code field is set to 70h). The residue information will reflect the size of the write-behind queue plus the transfer size of the current command. CHECK CONDITION status is reported. When the host reads sense data with a REQUEST SENSE command it will see an error for the WRITE command with residue information indicating data lost for that write and previous writes.
- If the command is not a write command and the Deferred Error check is performed as part of the pre-execution checks then CHECK CONDITION status is reported. The Deferred Error sense is copied to Current sense. The Deferred Error sense is cleared. The host is expected to retrieve the sense by sending a REQUEST SENSE command.

Bus Release Deferred Errors

The HP 35470A will release the bus to terminate an operation when the host sends an ABORT message or when the HP 35470A fails to send status due to a catastrophic error (see MESSAGE OUT OVERFLOW, STATUS PHASE ABORT and ILLEGAL PARITY ERROR messages).

In either case, the operation (for example, READ) does not terminate immediately since the logical position will have to be established on the other side of the block that was about to be transferred, or was being transferred. If an error subsequently occurs while trying to complete the read, then the sense generated is a Deferred Error. It is therefore possible but highly unlikely to have Deferred Error sense flagged for a command without immediate report.

Additional Sense Codes

This section contains a list of all the additional sense codes that the HP 35470A can return. Along with each code is a description of the cause of the sense and the associated sense key value.

Code	Description	Sense Key
00 00h	Filemark detected	
	This is returned when the HP 35470A has no additional sense information for the host.	
00 01h	Filemark detected	
	The command failed because a filemark was detected during READ or SPACE.	NO SENSE (0h)
or	Unsolicited positional sense has been set to indicate "At a Filemark". See READ, SPACE, and WRITE FILEMARKS commands.	NO SENSE (0h)
	The Mark bit in the sense data will always be set when this additional sense is returned.	

Code	Description	Sense Key
00 02h	EOP/M detected	
	A READ, SPACE, WRITE or WRITE FILEMARK command encountered EOP/M unexpectedly.	VOLUME OVERFLOW (Dh)
or	A WRITE or WRITE FILEMARK command completed successfully leaving the tape at the early warning point of the current partition. This is reported only if early warning reporting is enabled (through the Mode Select Device Configuration page REW bit).	NO SENSE (0h)
00 03h	Setmark detected	
	The command failed because a setmark was detected during READ or SPACE. This is only possible if setmark reporting has been enabled in the Mode Select Device Configuration page.	NO SENSE (0h)
or	Unsolicited positional sense has been set to indicate "At a Setmark". See READ, SPACE, and WRITE FILEMARKS commands.	NO SENSE (0h)
	The Mark bit in the sense data will always be set when this additional sense is returned.	
00 04h	BOP/M detected	
	A SPACE command encountered EOP unexpectedly.	MEDIUM ERROR (3h)
or	Unsolicited positional sense has been set to report "At BOP". This will occur following a successful REWIND command. It will also occur after clearing CHECK CONDITION status when a SPACE has met BOP, and after clearing UNIT ATTENTION status following a successful LOAD.	NO SENSE (0h)
	Note that unless unsolicited positional sense indicates BOP, a request to format the tape through MODE SELECT will be rejected.	
00 05h	End of data detected	
	A READ command or SPACE command encountered EOD unexpectedly.	BLANK CHECK (8h)
or	Unsolicited positional sense has been set to indicate "At EOD". See SPACE, WRITE, and WRITE FILEMARKS commands.	NO SENSE (0h)
04 00h	Logical unit not ready, cause not reportable	
	This is set if a LOAD/UNLOAD command is received while an unload is occurring with immediate report on, or because the Unload button was pressed.	NOT READY (2h)
	Once the cassette is unloaded, the sense code will be either 3A00h or 0402h.	
04 01h	Logical unit in process of becoming ready	
	This is set if a media access command is received while a load with immediate report on, or autoload, is occurring.	NOT READY (2h)
04 02h	Logical unit not ready, Initializing command required	
	This is set if a command is received and a tape is present but unloaded. A LOAD command is required to access the tape.	NOT READY (2h)
09 00h	Track following error	
	This is set if a read fails due to a fatal positioning error. The error could be related to the tape or the device.	H/W ERROR (4h)
0C 00h	Write error	
	The HP 35470A has failed to write data or marks to tape. The error could be related to the tape or the device. Residue information will normally be supplied.	H/W ERROR (4h)
1100h	Unrecovered read error	
	This is set if a command fails because a tape read failed. The most likely cause is bad media, but it could result from a hardware error.	MEDIUM ERROR (3h)
1403h	End of data not found	
	This is set when the drive encounters blank tape while reading. The most likely cause is a corrupt format tape.	BLANK CHECK (8h)

Code	Description	Sense Key
1500h	Mechanical positioning error	
	This is set whenever the drive has performed a mechanism retry in *successfully* completing a command (READ, WRITE, WRITE FILEMARKS, SPACE or ERASE).	RECOVERED ERROR (1h)
1700h	Recovered data with no Error Correction applied	
	This is set when an unspecified "soft" error occurs while *successfully* completing a command (READ, WRITE, WRITE FILEMARKS, SPACE or ERASE).	RECOVERED ERROR (1h)
1701h	Recovered data with retries	
	This is set if one or more frames has to be rewritten by the drive in order to complete a command successfully (WRITE, WRITE FILEMARKS)	RECOVERED ERROR (1h)
1800h	Recovered data with Error Correction applied	
	This is set when the drive uses C3 ECC to complete a command successfully (READ, SPACE).	RECOVERED ERROR (1h)
1A00h	Parameter list length error	
	This is set when a MODE SELECT parameter list sent to the drive contains an incomplete mode parameter header, mode block descriptor or mode page.	ILLEGAL REQUEST (5h)
20 00h	Invalid command operation code	
	This is set if the HP 35470A does not recognize the opcode of the command it has received.	ILLEGAL REQUEST (5h)
24 00h	Invalid field in Command Descriptor Block	
	This is set if the HP 35470A detects an invalid field during the pre-execution checks in a command it has received.	ILLEGAL REQUEST (5h)
25 00h	Logical unit not supported	
	This is set if an IDENTIFY message is received with a Logical Unit other than zero specified.	ILLEGAL REQUEST (5h)
26 00h	Invalid field in parameter list	
	This is set if the HP 35470A detects an invalid field while scanning command parameters.	ILLEGAL REQUEST (5h)
27 00h	Write protected	
	This is set if an operation which writes data, writes marks, or erases data is requestedfor a write-protected cassette.	MEDIA PROTECT (7h)
28 00h	Not ready to transition	
	This is set following a tape load to indicate that the tape may have changed.	UNIT ATTENTION (6h)
29 00h	Power-on, reset or bus device reset occurred	
	This is set following a power-on, SCSI Reset signal or bus device reset message.	UNIT ATTENTION (6h)
2A 01h	Mode parameters changed	
	UNIT ATTENTION is set for all hosts following a MODE SELECT command, other than the host that issued the command.	
2B 00h	Copy cannot execute since host cannot disconnect	
	A host has issued a COPY command but neglected to set bit 6 of its Identify message out (indicating that the HP 35470A is not allowed to disconnect). Since the HP 35470A cannot execute the COPY command without disconnecting, the command is aborted and this sense posted. Note that if the length of the Copy Parameter List is 0 this error will not occur.	ABORTED COMMAND (Bh)

Code	Description	Sense Key
30 02h	Cannot read media, incompatible format	
	This is set if a READ or SPACE command encounters an unknown tape format.	MEDIUM ERROR (3h)
30 03h	Cleaning cassette installed	
		MEDIUM ERROR (3h)
3100h	Media format corrupted	
	This set if a READ or SPACE command reads data which is not DDS format. Unlike code 3002h, this indicates that the format at DDS group level is bad.	MEDIUM ERROR (3h)
3300h	Tape length error	
	This is set if a tape is found to be too short to format with a partition of the size requested.	MEDIUM ERROR (3h)
37 00h	Rounded parameter	
	This status is generated during execution of a MODE SELECT command, where the HP 35470A has to round a mode parameter specified by the host to match the drive's sensitivity.	RECOVERED ERROR (1h)
3A 00h	Medium not present	
	This is set when a command which accesses the tape is received and no cassette is present in the drive.	NOT READY (2h)
3B 00h	Sequential positioning error	
	This is reported when the HP 35470A has been unable to read a group off tape. There are two possibilities:	
	The current command (such as READ, SPACE, or REWIND) failed to complete successfully.	MEDIUM ERROR (3h)
or	The logical position has been lost. The tape has been positioned on the other side of the bad groups. It is up to the host to determine if it is worth continuing. Note that there is a danger of skipping EOD and running onto old data if the host continues. The host must decide whether the data is old or current.	MEDIUM ERROR (3h)
3B01h	Tape position error at BOM	
	This is set if a LOAD command or a LOCATE/MODE SENSE command to change partitions fails to read the DDS system area of a tape.	MEDIUM ERROR (3h)
3D 00h	Invalid bits in Identify message	
	This is set when the HP 35470A receives an illegal Identify message.	ABORTED COMMAND (Bh)
3E 00h	Logical unit has not self-configured yet	
	This is set during power-on when it is not possible to send commands which access the media to the drive because mechanism tests are being executed. This additional sense changes on completion of the mechanism tests to either 3A00h, 0401h, or 0402h depending on whether a cassette was present at power-on and whether autoload is configured.	NOT READY (2h)
40 XXh	Diagnostic failure on component XX	
	This is set when a self-test command detects an error or when a command is prohibited because of the failure of a diagnostic.	H/W ERROR (4h)
43 00h	Message error	
	This is set when the number of parity errors or problems on inbound or outbound messages exceeds the limit. It is likely that a bus release will occur if excessive parity errors are detected because the HP 35470A will fail to complete the Status phase and COMMAND COMPLETE message. In this case, a Deferred Error is posted.	ABORTED COMMAND (Bh)

Code	Description	Sense Key
44 00h	Internal target failure	
	This code is used to report errors related to the firmware, when the HP 35470A encounters an "impossible" situation. This should never occur.	
45 00h	Select or Reselect failure	
	This is set when the fails to reselect a host to complete an operation. A Check Condition state will be assumed to exist despite the fact that CHECK CONDITION was never reported.	ABORTED COMMAND (Bh)
47 00h	SCSI parity error	
	This is set when the HP 35470A detects a parity error in an unexpected SCSI state. It should never do this, so this error should be treated as a firmware error.	
48 00h	Initiator detected error message received	
	This is set if an INITIATOR DETECTED ERROR message is received and the previous phase (the phase in which ATN was asserted) was invalid.	
49 00h	Invalid message error	
	This is set for a number of reasons related to the host and the HP 35470A not recognizing each others' messages.	ABORTED COMMAND (Bh)
4A 00h	Command phase error	
	This is set if too many parity errors occur during an attempted Command phase.	ABORTED COMMAND (Bh)
4B 00h	Data phase error	
	This is set if too many parity errors occur during the Data-In and Data-Out phases of an operation.	ABORTED COMMAND (Bh)
4E 00h	Overlapped commands attempted	
	This is set when a host selects the HP 35470A when a command already exists for that host.	ABORTED COMMAND (Bh)
5000h	Write append error	
	This is set if a WRITE or WRITE FILEMARKS command fails because the append point was unreadable.	MEDIUM ERROR (3h)
51 00h	Erase failure	
	This is set when an ERASE command fails to erase the area specified.	H/W ERROR (4h)
52 00h	Cassette fault	
	This is set if the drive thinks there is something wrong with the cassette. Possible causes are: tape snapped or invalid combination of identification holes.	MEDIUM ERROR (3h)
53 00h	Media load or eject failed	
	This is set if a load or eject fails.	MEDIUM ERROR (3h) H/W ERROR (4h) or UNIT ATTENTION (6h)
53 02h	Medium removal prevented	
	This is set if an UNLOAD command is received while a tape is present but not loaded *and* medium removal has been prevented.	ILLEGAL REQUEST (5h)
82 80h	Humidity too high	
	This is posted to all initiators when the humidity in which the drive is operating exceeds the specified limit.	H/W ERROR (4h)
82 81h	Dryness	
	This is optionally posted to all hosts when humidity falls to a level permitting tape access.	UNIT ATTENTION (6h)

RESERVE UNIT 16h

Description:

This command enables the host to reserve the HP 35470A. Reserving a device is a way of ensuring exclusive access to that device from a single host for the period of the reservation.

Once reserved, the HP 35470A will execute commands received from the host which reserved it or from a third-party host if the 3rd Pty option has been selected. Commands from other hosts, other than INQUIRY, REQUEST SENSE and RELEASE UNIT, will have RESERVATION CONFLICT reported for them. The INQUIRY and REQUEST SENSE commands are immune to the effects of a reservation and will continue to execute for all hosts. The RELEASE UNIT command will have GOOD status reported for other hosts, but will have no effect on the reservation.

If a third-party reservation is in effect, the host which reserved the drive may only issue INQUIRY, REQUEST SENSE, RESERVE and RELEASE commands.

If the HP 35470A is already reserved by another host, RESERVATION CONFLICT is returned.

If a host which has reserved the drive sends another RESERVE UNIT, the command is still effective so that the host can alter its reservation.

The reservation will stay in effect until:

- The reserving host sends another RESERVE UNIT command.
- The reserving host sends a RELEASE UNIT command, clearing the reservation.
- A power-on, SCSI Reset or Bus Device Reset occurs.

Pre-Execution Checks:

Illegal Field Flag Link Bad LUN Deferred Error Unit Attention

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (16h)							
1	Logical Unit Number (0)			3rd Pty	Third-Party Device ID			Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved						Flag	Link

CDB Fields:

3rdPty	0	The host wishes to reserve the HP 35470A for its own use.
	1	The host wishes to reserve the HP 35470A for a third-party host.
Third-Party Device ID	If the 3rdPty bit is 0, the Third-Party Device ID field is ignored. If the 3rdPty bit is 1, the Third-Party Device ID field specifies the ID of the host that wishes to reserve the HP 35470A.	

REWIND 01h

Description:

REWIND tells the drive to position the tape at the beginning of the currently active partition. Before rewinding, the drive writes any write-behind data in the buffer to tape, and appends an EOD marker. Once a rewind is started, it will complete even if the SCSI command is aborted for some reason.

Pre-Execution Checks:

Illegal Field	Flag Link	Bad LUN	Reservation	Deferred Error
Unit Attention	Media Access	Diagnostic Status	Humidity	

Command Descriptor Block:

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (01h)							
1	Logical Unit Number (0)			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved						Flag	Link

CDB Fields:

Immed

0 Status is returned after the rewind has completed.

1 The drive first writes any unwritten buffered data to tape followed by an EOD marker. It then returns status to the host before beginning the actual rewind operation.

Rewind Specific Status:

If the rewind is successful, unsolicited positional sense will indicate that the tape is at BOP by the EOD bit being set and an additional sense code of 0004h (BOP).

SEND DIAGNOSTIC 1Dh

Description:

SEND DIAGNOSTIC tells the drive to perform diagnostic tests on itself.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Dh)							
1	Logical Unit Number (0)			PF	Reserved	Self-Test	Dev OffL	Unit OffL
2	Reserved							
3	(MSB)			Parameter List Length				
4								(LSB)
5	Reserved						Flag	Link

CDB Fields:

PF *Page Format*

- 0 Parameters conform to SCSI-1 (in other words, all parameters are vendor-specific).
- 1 Parameters conform to SCSI-2 page format standards.

Self-Test

- 0 Perform the diagnostics specified in the parameter list The Unit Offl. bit must be set, otherwise CHECK CONDITION is reported.
- 1 Perform the standard self-test. The Parameter List Length must be 0, otherwise CHECK CONDITION is reported.

Unit OffL

- 0 Indicates that the host is not prepared for the drive to perform tests which could affect logical position.
- 1 Indicates that the host is prepared for the drive to perform tests which could affect logical position, modify the tape or modify cassette status. This bit must be set, if the Self-Test bit is 0.

Parameter List Length This should be 0 or a multiple of 8. If the Self-Test bit is set, the PLL must be 0, otherwise CHECK CONDITION is reported. A zero length Parameter List *is* permitted with the Self-Test bit clear.

The SEND DIAGNOSTIC command is documented in the section covering Diagnostics.

SPACE 11h

Note In this command description the word "mark" covers filemarks and setmarks. "Filemark" and "setmark" are only referred to explicitly when the spacing activity differs.

Description:

SPACE provides a variety of positioning functions that are determined by Code and Count fields in the Command Descriptor Block. Both forward (towards EOM) and reverse (towards BOM) positioning are provided.

Any unwritten data in the buffer is flushed to tape before the space is started. Once the space has started, it will complete even if the SCSI operation is aborted.

Pre-Execution Checks:

Illegal Field	Flag Link	Bad LUN	Reservation	Deferred Error
Unit Attention	Media Access	Diagnostic Status	Humidity	

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (11h)							
1	Logical Unit Number (0)			Reserved			Code	
2	(MSB)							
3	Count (*n*)							
4								(LSB)
5	Reserved						Flag	Link

CDB Fields:

Code The Code field indicates what is to be spaced to (*n* is the value in the Count field):

000 **Blocks**—Space over *n* blocks.

001 **Filemarks**—Space over *n* filemarks.

010 **Sequential Filemarks**—Space until a sequence of *n* consecutive filemarks is found. Logical position on reporting will be on the further side of the sequence of filemarks.

011 **EOD**—Space to the end of data in the current active partition.

100 **Setmarks**—Space over *n* setmarks. The RSmk (Report Setmark) bit of the MODE SELECT Device Configuration page must be set for this option.

101 **Sequential Setmarks**—Space until a sequence of *n* consecutive setmarks is found. Logical position on reporting will be on the further side of the sequence of setmarks. The RSmk (Report Setmark) bit of the MODE SELECT Device Configuration page must be set for this option.

Count When spacing over *blocks* or *marks* this field indicates how many blocks or marks should be crossed. Spacing is forward (towards EOM) unless Count is negative (twos complement) when the spacing is towards BOM.
When spacing over *sequential marks*, this field indicates how many consecutive marks should be encountered. Spacing is forward (towards EOM) unless Count is negative (twos complement) when the spacing is towards BOM.
When spacing to *EOD* the Count field is ignored.
When not spacing to EOD, if Count is zero, the SPACE command is treated as a null operation. The logical position remains unchanged, and unwritten data is not flushed to tape.

Space Specific Status:

The HP 35470A implements the following priority scheme during spacing:

Lowest priority	**Blocks**	
	Filemarks	If the drive meets a filemark while spacing to a block CHECK CONDITION is reported. The Mark bit in the sense data is set, and the sense key is NO SENSE. Additional sense is 0001h (filemark encountered). The final position will be before or after the filemark depending on whether the space was reverse or forward.
	Setmarks	If the drive meets a setmark while spacing to a block or a filemark, and the RSmk bit has been set in the Active Format field of the Mode Select Device Configuration page, CHECK CONDITION is reported. The Mark bit in the sense data is set. The sense key is NO SENSE and additional sense is 0003h (setmark encountered). The final position will be before or after the setmark depending on whether the space was reverse or forward.
	EOD	If the drive meets EOD while spacing to a block or mark, CHECK CONDITION is reported. The EOM bit in the sense data is set. The sense key is BLANK CHECK and additional sense is 0005h (EOD encountered).
Highest priority	**BOP, EOP/M**	If the drive meets BOP or EOP/M while spacing, CHECK CONDITION is reported. The EOM bit in the sense data is set. The sense key is MEDIUM ERROR and additional sense is 0004h (BOP detected) or 0002h (EOP/M detected).

Event	Status	Key	Notes
Early warning (EW) EOM detected	CHECK COND'N	NO SENSE	Additional sense set to 0002h (EOP/M detected). Early warning end-of-medium (EW) information is reported only if the space operation was successful and the REW bit in the Mode Select Device Configuration page is set to 1.
Incompatible data format	CHECK COND'N	MEDIUM ERROR	Additional sense will be set to 3002h (can't read media).
Fail to read data due to a tape error or non-fatal drive error	CHECK COND'N	MEDIUM ERROR	Additional sense will be set to 3B00h (sequential positioning error).
Blank media encountered	CHECK COND'N	BLANK CHECK	Additional sense will be set to 1403h (EOD not found). Residual information is as shown below.

Residue Information:

If SPACE fails when spacing to blocks or marks, the sense data Information Bytes will be set to the absolute value of the difference between the requested number of marks and the actual number of marks spaced over. The residue for a space towards BOP which terminates prematurely will always be a positive value.

TEST UNIT READY 00h

Description:

TEST UNIT READY checks if the drive is ready for commands which access the tape. It is not a request for a self-test. If the drive has a tape loaded, the command returns a GOOD status. Otherwise, CHECK CONDITION is reported and the sense key is NOT READY.

Pre-Execution Checks:

Illegal Field	Flag Link	Bad LUN	Reservation
Deferred Error	Unit Attention	Media Access	

Command Descriptor Block:

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (00h)							
1	Logical Unit Number (0)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved						Flag	Link

Test Unit Ready Specific Status:

If all the pre-execution checks pass, then GOOD status is reported.

Condition	Status	Sense Key	Additional Sense
No tape present	CHECK CONDITION	NOT READY	3A00h
Tape loading	CHECK CONDITION	NOT READY	0401h
Tape unloading	CHECK CONDITION	NOT READY	0402h
Tape unloaded but retained in the drive	CHECK CONDITION	NOT READY	0402h

VERIFY 13h

Description:

VERIFY verifies one or more blocks beginning with the next block on the tape. The verification is media verification only. Data is read from the tape as it would be for a read, but is immediately discarded. No data is transferred between the host and drive. VERIFY has no SILI bit. If an illegal length block is encountered, VERIFY behaves like READ with the SILI bit clear.

VERIFY will not complete until all data has been read. It does not support the ANSI "byte compare" or "immed" options.

Pre-Execution Checks:

Illegal Field	Fixed Bit	Flag Link	Bad LUN	Reservation
Deferred Error	Unit Attention	Media Access	Diagnostic Status	Humidity

Command Descriptor Block:

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (13h)							
1	Logical Unit Number (0)			Reserved				Fixed
2	(MSB)			Verification Length				
3								
4								(LSB)
5	Reserved						Flag	Link

CDB Fields:

Fixed The Fixed bit specifies both the meaning of the Verification Length field and whether fixed-length or variable-length blocks are to be verified.

- 0 Variable Block mode is requested. A single block is verified with the Verification Length specifying the maximum number of bytes that are to be verified. The VERIFY is rejected if the drive is in Fixed Block mode and the Fixed bit is zero. CHECK CONDITION status is returned with an ILLEGAL REQUEST sense key set.
- 1 The Verification Length specifies the number of blocks to be verified by the drive. This is valid only if the logical unit is currently operating in Fixed Block mode, in other words, when it has been instructed to use fixed-length blocks with MODE SELECT. The current block length is the block length defined in the MODE SELECT command. If the Fixed bit is set and the drive is in Variable Block mode, the VERIFY is rejected with a CHECK CONDITION status and an ILLEGAL REQUEST sense key set.

Verify Specific Status:

VERIFY terminates when the Verification Length has been satisfied, or when a filemark, a setmark (if the drive has been configured to Report Setmarks), EOD or EOM/P is encountered. The status and sense data for each of these conditions are listed below. Upon completion of VERIFY, the logical position is located after the last block from which data was verified, or after the filemark or setmark, if one is encountered.

When the Verification Length is zero, no data is verified and the current logical position on the logical unit is not changed.

Event	Status	Key	Notes
Filemark encountered	CHECK COND'N	NO SENSE	Mark bit is set. Logical position will be on the EOM side of the filemark.
Setmark encountered	CHECK COND'N	NO SENSE	Mark bit is set. The RSmk bit in the Mode Select Device Configuration page must have been set. Additional sense is set to 0003h (setmark detected). The logical position is on the EOM side of the setmark.
EOD encountered	CHECK COND'N	BLANK CHECK	Additional sense is set to 0005h (EOD detected).
EOP/M encountered	CHECK COND'N	VOLUME OVERFLOW	EOM bit is set. Additional sense is set to 0002h (EOP/M detected).
Failure to read data through tape error or non-fatal drive error	CHECK COND'N	MEDIUM ERROR	Additional sense is set to 3B00h (sequential positioning error).
Incompatible data format	CHECK COND'N	MEDIUM ERROR	Additional sense is set to 3002h (cannot read media)

Residue Information:

The Valid bit will be set. The information bytes will be as follows:

Variable Block Mode The requested transfer length (in bytes).

Fixed Block Mode The difference (in blocks) between the requested transfer size and the actual number of blocks transferred. A partially transferred block is not counted, so for example, if 3.5 out of 10 blocks have been transferred the residue will be 7.

WRITE 0Ah

Description:

Zero or more blocks of data are transferred from the host to tape starting at the current logical position.

It is recommended that the Buffered Mode field of the Mode Select Parameter is set to either 1 or 2 so that Immediate Report is enabled. Failure to do this could result in a severe performance and capacity penalty. The HP 35470A will report GOOD status on a WRITE command when all the data has been successfully transferred to the data buffer (but not necessarily to tape).

Pre-Execution Checks:

Illegal Field	Fixed Bit	Flag Link	Bad LUN	Reservation	Deferred Error
Unit Attention	Media Access	Media Write	Diagnostic Status	Humidity	

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (0Ah)							
1	Logical Unit Number (0)			Reserved				Fixed
2	(MSB)							
3	Transfer Length							
4								(LSB)
5	Reserved						Flag	Link

CDB Fields:

Fixed	0	The Transfer Length field specifies the length of the transfer in bytes.
	1	The Transfer Length field specifies the length of the transfer in blocks. The size of each block (in bytes) is determined by the current Block Length given in the Mode Select Parameter block descriptor.
Transfer Length	0	No data is transferred. The current logical position will be unchanged.
	>0	The amount of data to be transferred, in bytes or blocks as determined by the Fixed field.

Write Specific Status:

Event	Status	Key	Notes
EOP/M encountered	CHECK COND'N	VOLUME OVER-FLOW	Additional sense will be set to 0002h (EOP/M detected). The logical position will be at EOD. Subsequent unsolicited REQUEST SENSE commands will give the tape position as EOP/M detected. It may still be possible to write a smaller quantity of information at this point (for example, filemarks, setmarks or a smaller block). This is because the logical position after failing to write a block is at the start of the unwritten block.
Early warning end-of-medium (EW) encountered	CHECK COND'N	NO SENSE	This is only reported if the write has been successful. Additional sense is set to 0002h (EOM/P detected). Residue information is valid and indicates zero blocks or bytes.

Residue Information:

Residue information depends on two variables:

- Fixed or Variable block mode.
- Immediate or Non-Immediate Report (Buffered mode).

Block Mode	Buffered Mode	Residue
Variable	0	Number of unwritten bytes
Fixed	0	Number of unwritten blocks
Variable	not 0	Total number of unwritten bytes and marks (including those buffered before the command was received). The size can be greater than the command operation size.
	specifically 1	Contains residues of all initiators with data in the buffer.
Fixed	not 0	Total number of unwritten blocks and marks (including those buffered before the command was received). The size can be greater than the command operation size.
	specifically 1	Contains residues of all initiators with data in the buffer.

Residue information is set in the sense data byte, with the Valid bit set and the information bytes set to the residue.

WRITE BUFFER 3Bh

Description:

WRITE BUFFER is used with READ BUFFER as a diagnostic for testing the 1 megabyte buffer and the SCSI bus integrity of the HP 35470A. The data is placed into either the data buffer or the HP 35470A's controller memory depending on the Mode field of the command. When data is to be placed in the data buffer, the contents of the buffer are flushed to tape first.

Pre-Execution Checks:

Illegal Field | Flag Link | Bad LUN | Reservation | Deferred Error | Unit Attention

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (3Bh)							
1	Logical Unit Number (0)			Reserved		Mode		
2	Buffer ID							
3	(MSB)	Buffer Offset						
5								(LSB)
6	(MSB)	Allocation Length						
8								(LSB)
9	Reserved						Flag	Link

CDB Fields:

Mode

0 *Write header and data.* The HP 35470A transfers a 4-byte buffer header from the host which it ignores, followed by (*Allocation Length* − 4) bytes of data which it will place in the data buffer at address 0.

1 *Write processor memory.* The HP 35470A transfers Allocation Length bytes of data from the host and writes them in processor memory specified by Buffer Offset.

2 *Write data.* The HP 35470A transfers Allocation Length bytes of data from the host, placing them in the data buffer. The start address of the data in the buffer is specified by Buffer Offset.

4 *Download Microcode.* The HP 35470A transfers Allocation Length bytes of data from the host. When this data is decoded by the drive, it produces new firmware which the drive programs into its flash eeproms. If the drive detects any errors in the download data, it reports CHECK CONDITION status with the Sense key set to aborted command, and additional sense set to 2600H (invalid field in parameter list).

5 *Download microcode and save.* This is the same as Mode 4, except that mechanism calibration data in the old eeprom pattern is not preserved.

See the Status section below for constraints upon the value of Mode imposed by the Buffer ID field.

Buffer ID

Specifies which buffer to read.

0 The data buffer

1 Processor memory

Buffer Offset

When Mode = 2, this specifies the address in the data buffer relative to the start of the buffer at which to start writing.
When Mode = 1, this specifies the absolute address in processor memory at which to start writing.

Allocation Length	When Mode = 0, 4 bytes of header are transferred and then (*Allocation Length* − 4) bytes of data are transferred to the data buffer starting at address 0. When Mode = 1, Allocation Length bytes of data are transferred to processor memory. When Mode = 2, Allocation Length bytes of data are transferred to the data buffer. Note that when writing to the data buffer, it is possible for the combined length and offset to exceed the size of the buffer. The HP 35470A will wrap around from the buffer end and place the remainder of the Allocation Length at the start of the buffer. If Mode = 4 or 5, Allocation Length specifies the size of the download.

Valid Field Values:

The following table shows the values of the Buffer ID, Buffer Offset and Allocation Length fields for each valid value of Mode:

Mode	Buffer ID	Buffer Offset	Allocation Length
If Mode = 0 then:	0	0	≤8 00 00h+4
If Mode = 1 then:	1	Within valid controller processor address range	So that the window of processor memory starting at Buffer Offset is valid
If Mode = 2 then:	0	<8 00 00h	≤8 00 00h
If Mode = 4 then:	1	0	size of download
If Mode = 5 then:	1	0	size of download

WRITE FILEMARKS 10h

Description:

WRITE FILEMARKS causes the specified number of filemarks or setmarks to be written beginning at the current logical position on tape.

Pre-Execution Checks:

Illegal Field	Flag Link	Bad LUN	Reservation	Deferred Status
Unit Attention	Media Access	Media Write	Diagnostic Status	Humidity

Command Descriptor Block:

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (10h)							
1	Logical Unit Number (0)			Reserved			WSmk	Immed
2	(MSB)			Number of Marks				
3								
4								(LSB)
5	Reserved						Flag	Link

CDB Fields:

WSmk	0	Filemarks are written.
	1	Setmarks are written.
Immed	0	The drive returns GOOD status as soon as the Command Descriptor Block has been validated.
	1	Status will not be returned until the operation is complete.
Number of Marks		The number of consecutive marks to be written to tape.

Write Filemarks Specific Status:

Event	Status	Key	Notes
EOP/M encountered	CHECK COND'N	VOLUME OVER-FLOW	Additional sense will be set to 0002h (EOP/M detected). The logical position will be at EOD. Subsequent unsolicited REQUEST SENSE commands will give tape position as EOD. It may still be possible to write a smaller quantity of information at this point (for example, filemarks, setmarks or a smaller block). This is because the logical position after a failure to write a block returns to the start of the unwritten block.
Early warning end-of-medium (EW) encountered	CHECK COND'N	NO SENSE	This is only reported if the write has been successful. Additional sense is set to 0002h (EOM/P detected). Residue information is valid and indicates zero blocks or bytes.
Completes properly and ends adjacent to a mark	GOOD	NO SENSE	The Mark bit is set. Additional sense will be set to 0001h (filemark detected) or 0003h (setmark detected).

Theory of Operations

Theory of Operations Contents

TO1 Theory of Operations

Theory of Operations T01

The HP 35470A uses a tape mechanism which is developed from the principles used in digital audio tape (DAT) recorders, and uses the helical scan recording technique. Data is recorded according to the ECMA DDS standard, and communication with the computer system is by SCSI. This chapter introduces the mechanical functions of the tape drive and provides an overview of the electronics which link SCSI with the DAT mechanism.

Mechanism

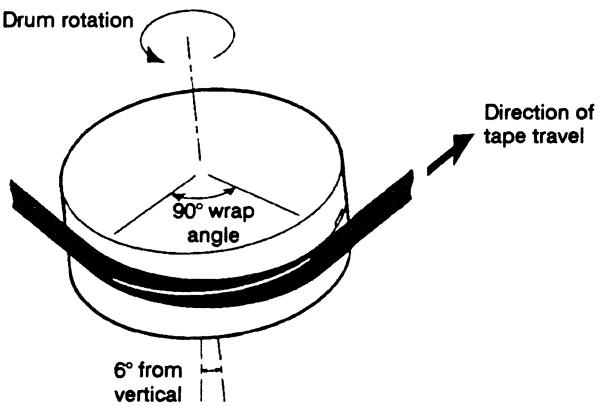
The mechanism used in the HP 35470A is similar to that used in a high quality digital audio tape recorder, however the mechanism used has been specifically designed to suit the special requirements of data storage.

Helical Scan Recording

Most current computer tape drives and typical audio mechanisms (such as compact cassette) record on tracks along the length of the tape. Because of various limitations such as mechanical tolerance and magnetic crosstalk (interaction between signals from different tracks), it is very difficult to increase the data density on these products while retaining data integrity and compatibility.

DAT overcomes this limitation, by recording tracks diagonally across the tape. This is achieved by mounting two heads on a rotating drum with an axis at 6° from the vertical. The drum rotates at 2000 rpm while the tape moves slowly (8 mm/sec) in the same direction. As a result, the heads, which are diametrically opposite, describe portions of a helix on the tape—hence helical scan. See figure TO-1.

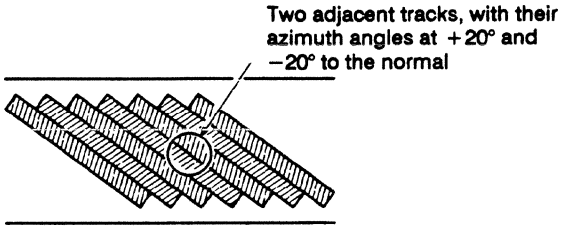
Figure TO-1



Helical Scan Recording

The drum rotates at 2000 rpm while the tape moves slowly (8 mm/sec). Each head writes a track of data on the tape from bottom to top. The heads are wider than the tracks, so the tracks overlap with no wasted space between them. Crosstalk between the tracks is minimized by each head writing its data in angled strips along the track. The angle is called the azimuth angle. Each head is set with a different azimuth angle, so alternate tracks on the tape have their data written at different angles, as shown in figure TO-2.

Figure TO-2

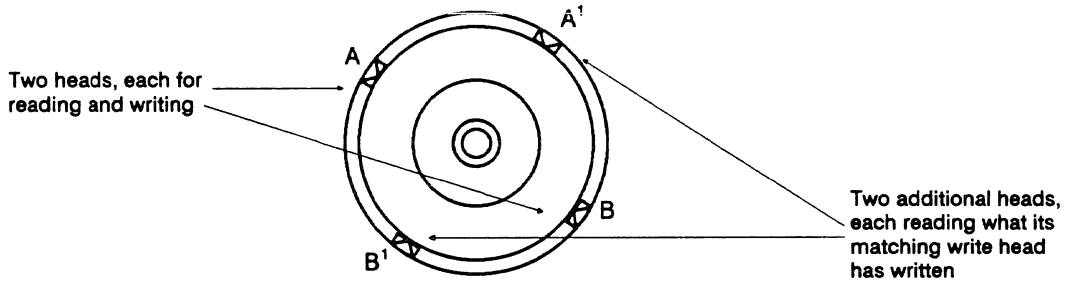


Azimuth Angle

Four-Head design for Read-After-Write

In the DDS-format drive design, two more heads are added to the rotating drum, making four at 90° to each other as shown in figure TO-3. These enable the drive to read data immediately after it has been written. If an error occurs, the drive can rewrite the erroneous frame repeatedly until it is read back successfully.

Figure TO-3



Four-Head Design

Motors Solenoids and Sensors

The locations of the motors, solenoids and sensors are illustrated in figure TO-4. The numbers in this section in italic type refer to items in figure TO-4.

Motors

The HP 35470A has four motors, which drive the following:

- The Head Drum *2*
- The Capstan Roller *6*
- The Supply Reel (S-Reel) *15*
- The Take-up Reel (T-Reel) *18*

They are direct-drive brushless motors which are quiet, reliable and very compact.

There is also a dc motor *4*, which controls the following operations:

- Engagement and disengagement of the Capstan Pinch Roller
- Tape threading
- Loading and unloading of the cassette

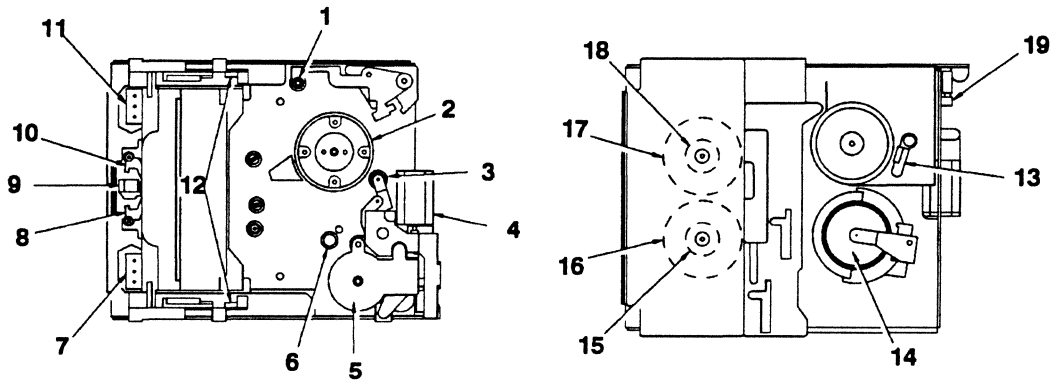
This motor is a high-torque, brush-type motor and also operates the Take-up Reel and Supply Reel brake pawls *10* and *8* which are latched in the on or off position by a small solenoid *9*.

Solenoids

Two solenoids are fitted, the latching solenoid *9*, and a further solenoid which operates the cleaning roller arm.

Figure TO-4

Motors, Solenoids and Sensors



1 Guide pin for monitoring tape tension
2 Head drum
3 Head cleaning roller
4 DC motor
5 Wafer switch for monitoring cam position
6 Capstan roller
7 Cassette recognition switches
8 Supply reel brake pawl
9 Brake pawl latching solenoid
10 Take-up reel brake pawl
11 Cassette recognition switches
12 Optical sensors to identify BOM and EOM
13 Capstan speed monitor
14 Drum position monitor
15 Supply reel
16 Supply reel speed sensor
17 Take-up reel speed sensor
18 Take-up reel
19 Cassette-present sensing switch

Sensors

The HP 35470A has eight mechanical switches which provide the following information:

- Whether a cassette is present 19
- The open or closed state of six recognition holes on the cassette *11 and 7*

Various combinations of open and closed holes provide the tape drive with the following information:

- What type of tape is in the cassette (e.g. Metal Particle)
- What thickness the tape is
- What the length of the tape is
- Whether the cassette is write protected
- Whether it is a cleaning cassette

Two optical sensors *12* are used to identify BOM (beginning-of-media) and EOM (end-of-media) because DAT tapes have transparent leaders and trailers.

A guide pin *1* monitors tape tension. Movement of the guide pin arm is detected by a magneto-resistive element. Another magneto-resistive element *13* monitors the capstan speed.

Hall effect sensors built into the motors are used to monitor drum position *14*, take-up reel speed *17* and supply reel speed *16*.

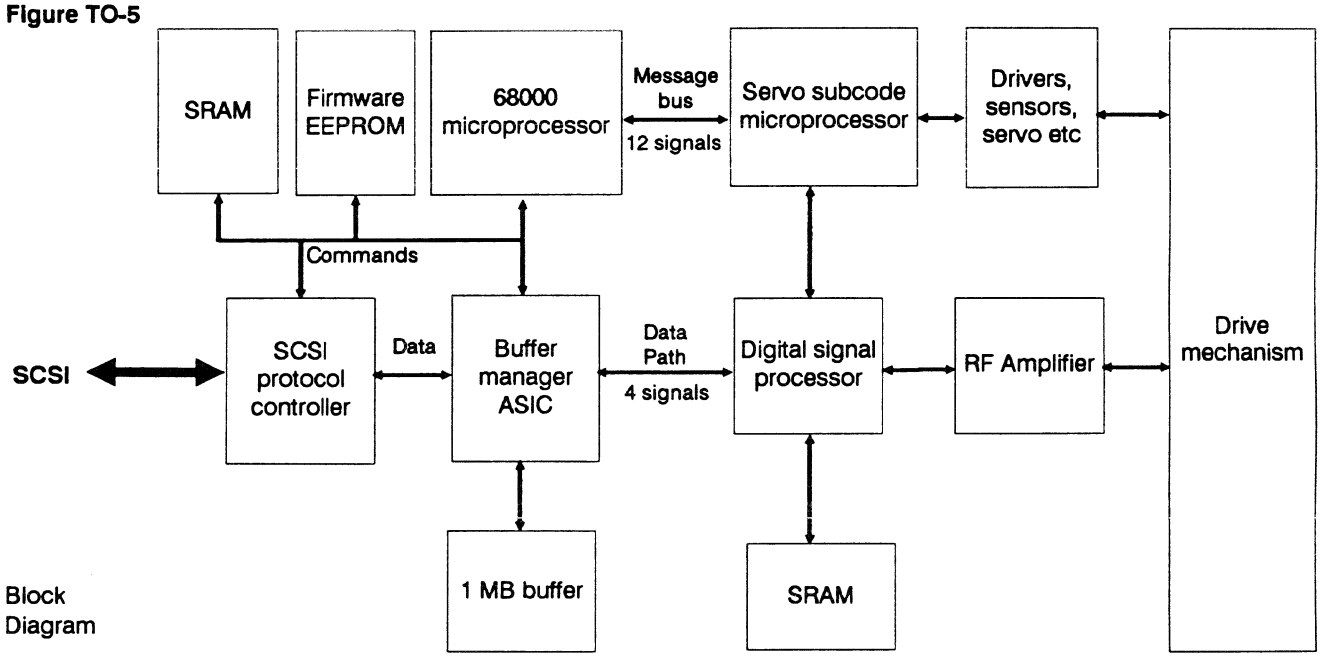
Engagement or disengagement of the capstan pinch roller, tape threading and tape loading are all operations which are controlled by the mechanism mode cams. The mode cams are driven by the dc motor *4* mentioned earlier. Attached to the top of the mode cams is a three wiper wafer switch *5* which monitors the position of the cams, and consequently the mode of the drive.

Electronics

A block diagram of the electronics which link the SCSI interface to the drive mechanism is illustrated in Figure TO-5.

The electronics consist of a main circuit board with components mounted on both sides. To reduce electro-magnetic interference the RF amplification circuitry is mounted on an additional small board. Signals are received through the SCSI interface and are interpreted as tape movement commands or data by the SCSI protocol controller. Data is treated by various encoding techniques to reduce the possibility of recovery errors and to make it compatible with the DDS format. These techniques include:

Figure TO-5



- Group Indexing, which allows the format to map variable length records into fixed group sizes.
- Checksum Generation, where the sum of a series of bytes is written to the tape, so that the figure can be checked against the sum of the same series of bytes when the tape is read.
- Randomization. The error rate for worst case data differs from random data by a factor of 10. Randomization reduces the worst case error rate by providing a stream of data which has a more consistent RF envelope.

Other duties performed by the electronics on the main circuit board are as follows:

- Tape management tasks. These include the following:
  - Mechanism Control
  - ATF (Automatic Track Following)
  - Servo Control
  - Diagnostics
  - Buffer management
  - Error detection
  - Control of the front panel display

Main Circuit Board

The main circuit board contains the following circuitry.

Controller Electronics

Buffer Manager Application Specific Integrated Circuit

The Buffer Manager interfaces the 68000 microprocessor, Digital Signal Processor and SCSI Protocol Controller to the 1 megabyte buffer.

Buffer

The buffer comprises five 1-megabit dynamic RAMs. Four are for data storage and one for parity storage.

Microprocessor

The microprocessor is a 12.5 MHz 68000.

Firmware

The firmware is contained in two "Flash" EEPROMS which can be reprogrammed through the SCSI interface, or by a direct connection with the microprocessor bus at the factory. The firmware has five main components:

- A SCSI task which recognizes SCSI commands, messages and the SCSI phase protocols
- A buffer task which manages the buffering of data and the DDS format
- A device task which manages the reading and writing of data and controls the action of the drive mechanism through the Servo Microcomputer Interface
- A panel task which handles the front panel display and its operation
- An operating system which performs the self-test and schedules the tasks

SCSI Protocol Controller

Tape drives designed for single-ended operation use an HP ASIC (Application Specific Integrated Circuit) which has built-in, single-ended line drivers. The differential version has a different version of this ASIC with external differential drivers. Apart from this, the operation of the two types is the same.

Device Electronics

The Device Electronics perform the following functions:

- Converting of Servo Microcomputer Interface commands sent from the controller electronics into commands which cause movements of the tape drive mechanism
- Taking data from the buffer and writing it to tape
- Recovering data from the tape
- Applying the first two levels of error correction
- Passing recovered frames of data back to the buffer

The major component of the device electronics is a single chip microcontroller. It has an SPC700 processor core, and contains many support functions including eight channel analog to digital conversion and facilities for automatic track following (ATF).

RF Amplification

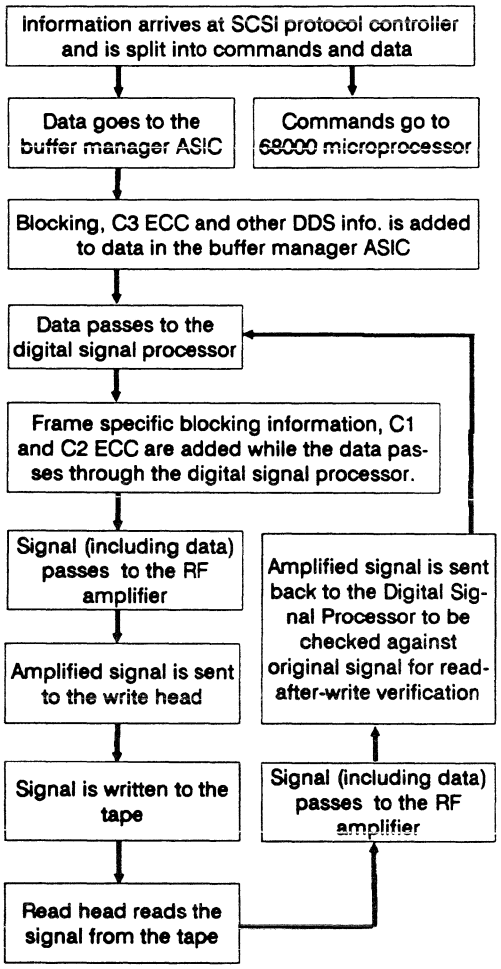
Data from the tape is amplified by an RF amplification stage which is contained on a separate board. The amplified signals are passed to a digital signal processor, in which the first two levels of error correction are applied, and the subcode is separated from the main data.

Typical Signal Path

Figure TO-6 shows the path of a signal from the SCSI to the tape when the drive is writing data.

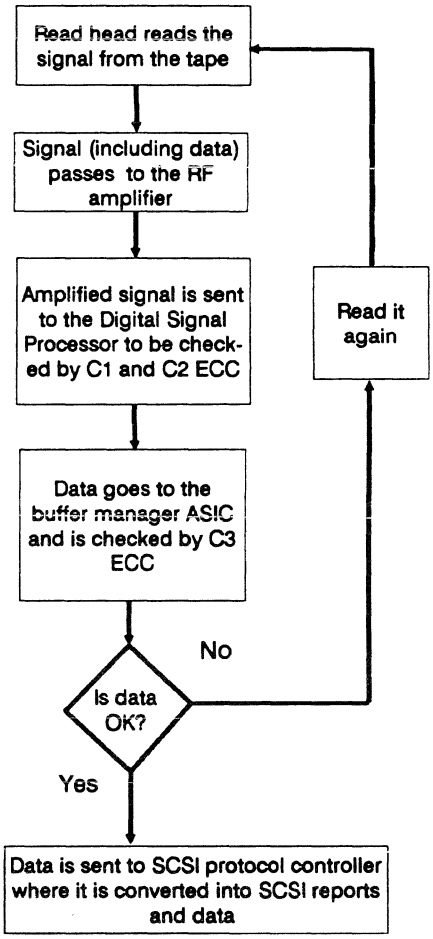
Figure TO-7 shows the path of a signal when it is read from the tape and passes through to SCSI.

Figure TO-6



Typical signal path.
SCSI to tape

Figure TO-7



Typical signal path.
Tape to SCSI

Diagnostics

Diagnostics Contents

Diagnostics Overview D1

This section gives details of the diagnostic capabilities of the HP 35470A.

This chapter provides an overview and details of how to run tests and obtain results.

Chapter D2 covers the Power-Up Self-Test and the Self-Test Diagnostic Sequence which perform a variety of individual tests of the hardware and firmware.

Introduction

For diagnostic purposes, the HP 35470A may be thought of as three distinct parts:

- The drive mechanism and associated electronics
- The media
- The external power supply

If a diagnostic test fails, a number indicates the most likely part where the failure occurred.

Part	Number
No problem found	0
Drive Mechanism and Associated Electronics	1
Media	2
External Power Supply	3

Running a Test

Diagnostic tests can be run through the Power-Up Self-Test (see the next chapter) or through the host.

Invoking a Diagnostic Test from the Host

The SCSI initiator (host) can instruct the drive to run a diagnostic test by sending the necessary parameters through the SCSI SEND DIAGNOSTIC command. The command has a six-byte Command Descriptor Block as follows:

		Bit							
		7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte	**0**	Operation code (1Dh)							
	1	Logical Unit Number (0)			PF	Reserved	Self-Test	Dev Offl.	Unit Offl.
	2	Reserved							
	3	(MSB)	Parameter List Length						
	4								(LSB)
	5	Reserved						Flag	Link

The Flag and Link bits operate as described in Chapter I1 "Control Byte—Flag and Link Bits". Following the command descriptor block, eight bytes of data should be sent during the DATA OUT phase, as follows:

		Bit							
		7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte	**0**	Test Number [00h]							
	1	SOE	CSE	Loop Count Identifier					
	2	Parameter A							
	3	Parameter B							
	4	Parameter C							
	5	Parameter D							
	6	Reserved							
	7	Reserved							

Test Number	The number of the diagnostic test to be performed.
SOE	The SOE (Stop On Error) bit determines how the loop count should be terminated if an error occurs: 1 Stop test execution on detection of an error 0 Log the error and continue testing
CSE	The CSE (Continue Sequence on Error) bit is similar in effect to the SOE bit, in that it is used during a sequence of tests to specify what should happen when an error occurs. The host may specify a sequence of commands to be executed, and this bit determines whether a failure of one test should halt the sequence, or allow it to continue: 0 Log the error and abandon the test sequence 1 Log the errors and continue the test sequence

Loop Count Indentifier The Loop Count Identifier determines how many times the test will be repeated before reporting back to the host, according to the following code:

0 continuous
1 run once
2 run 10 times
3 run 100 times
4 run 1000 times

If the test completes successfully, GOOD status is returned in the Status phase of the SCSI sequence. If the test fails, a CHECK CONDITION status is sent with a HARDWARE ERROR sense key and a DIAGNOSTIC FAIL additional sense key set. The host should then send a RECEIVE DIAGNOSTIC RESULTS command which will return information as to which test failed and the nature of the failure.

Parameters A-D These are test specific, and all four parameters may not be needed for some of the tests. Any unused parameters should be set to 00.

Obtaining Test Results

The SCSI RECEIVE DIAGNOSTIC RESULTS command tells the drive to return the results of a diagnostic test to the host. If CHECK CONDITION status is returned on completion of a SEND DIAGNOSTIC command, together with the HARDWARE ERROR sense key and an Additional Sense Code of DIAGNOSTIC FAILURE, the host should issue a RECEIVE DIAGNOSTIC RESULTS command to obtain the data (indicating the actual failure and the Most Suspect Sub-Assembly). The messages are in the format of the Results Messages described in the next section.

The command has a six-byte Command Descriptor Block as follows:

		Bit							
		7	6	5	4	3	2	1	0
Byte	0	Operation Code (1Ch)							
	1	Logical Unit Number (0)			Reserved				
	2	Reserved							
	3	(MSB)	Allocation Length						
	4								(LSB)
	5	Reserved						Flag	Link

The Flag and Link bits operate as described in Chapter I1 "Control Byte—Flag and Link Bits".

The Results Message

The results are returned as sixty-four bytes of data.

		Bit							
		7	6	5	4	3	2	1	0
Byte	0	Test Number							
	1	Error Code							
	2	Most Suspect Sub-Assembly							
	3	Loopcount Number							
	4	(MSB)	Test Specific Information						
	63								(LSB)

If the command completes successfully, a status of GOOD is returned in the Status phase of the SCSI sequence. If the command fails, CHECK CONDITION status is returned. A REQUEST SENSE command should then be sent. The Sense Key and Additional Sense Codes returned by this command reflect the nature of the failure.

Diagnostic Sequences

The HP 35470A will execute diagnostic sequences sent from the host. To do this, the host repeats the SEND DIAGNOSTIC parameter list, modifying the list for each diagnostic test required.

Once the drive has received the complete list, it can be left to execute each diagnostic in turn without further host intervention and report when the sequence is complete, or when an error occurs.

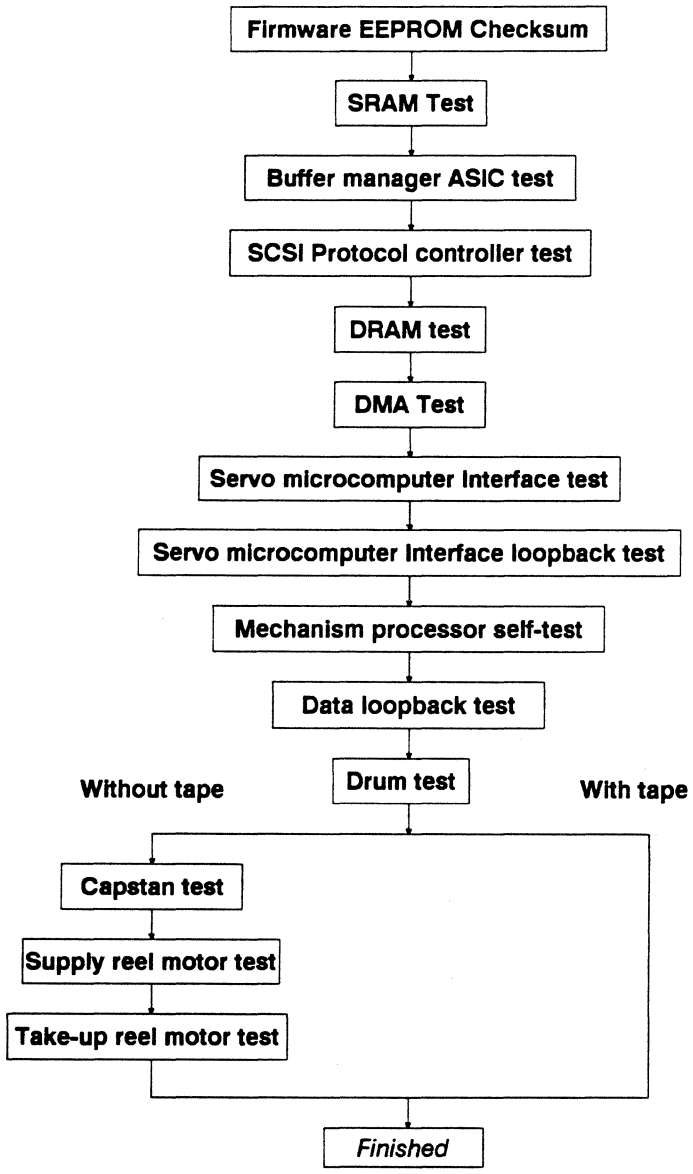
Because the tests run without host intervention, no reports are available apart from the final test executed. This will either be the last test on the list, or when the sequence is terminated by an error. The results are obtained using the RECEIVE DIAGNOSTICS RESULTS command, as described earlier.

Diagnostic Tests D2

This section covers the Power-Up Self-Test and the Self-Test Diagnostic Sequence (00h), which run a series of tests of the hardware and firmware.

The Power-Up Self-Test

When the drive is power-cycled, a series of tests are run.This is shown schematically in the following diagram. Note that the last 3 tests are only run if there is no tape present in the drive.



Results of the tests are retrieved by the RECEIVE DIAGNOSTIC RESULTS command, described in Chapter D1. The tests are described below, together with the hexadecimal number of each test. This number is referred to in the Results Message if the sequence of tests failed.

	Test Name	Description	Test Specific Results
01h	**EEPROM checksum**	Checks content of EEPROM by performing a word-wide checksum	If the test fails the drive hangs.
02h	**Processor SRAM Test**	Non-destructive test of the processor SRAM. Includes writing a walking 1s and walking 0s pattern over the entire RAM area	If the test fails the drive hangs.
03h	**Buffer Manager ASIC test**	Checks the operation and registers or the Buffer Manager Application Specific Integrated Circuit, but not registers relating to the Servo microcomputer interface	If the test fails the drive hangs.
04h	**SCSI protocol controller test**	This checks the functionality of the SCSI protocol controller to ensure correct operation. It exercises all the registers and control lines on the processor and then cycles the processor through a sequence of tests which mimic operation of the SCSI bus.	If the test fails the drive hangs.
05h	**DRAM test**	Verifies basic operation of DRAM buffer. Walking 1s and 0s patterns are used in a few locations and the RAM area around the base of each 1Kbyte page is checked	
06h	**DMA test**	Performs internal data transfers between the buffer and the the SCSI protocol controller	
10h	**Servo micro-computer interface register test**	Checks all registers in the buffer manager ASIC which relate to the servo microcomputer interface between the controller and mechanism electronics. Various patterns and values are tested, along with cross-register corruption.	Test specific bytes indicate which test failed, what value was written or expected and what value was actually read.
11h	**Servo micro-computer interface loopback test**	Tests the communication path between the buffer manager ASIC and the servo microcomputer. Subcode area of message buffer (55bytes) is filled with data by the controller. Microcomputer then reads the bytes, inverts each one and replaces the inverted bytes in the buffer. The buffer manager ASIC then reads back the bytes and checks that they are the inverse of the original data.	If the compare fails the test specific bytes contain a copy of the bytes returned in the subcode area. If a failure report is generated, it is copied to the test specific resuits area.
12h	**Mechanism processor self-test**	The buffer manager ASIC instructs the mechanism processor to carry out an internal self-test. Test includes performing checksum of ROM, RAM,and checking the voltage.	If the self-test finds a failure, a report is saved for diagnosis.
14h	**Data loopback test**	Full, three frame data loopback test. Data is transferred from the buffer manager ASIC across the servo microcomputer interface data bus into the signal processor, then back again.	The failure report includes the stage at which the failure occurred, the last report received from the servo subcode microprocessor and contents of the interrupt status register.
15h	**Drum test**	Tests operation of drum, sensors and drivers. Drum is accelerated to normal speed then stopped. The time taken to accelerate to normal speed is checked.	If the drum takes too long to reach the target speed, the test specific results area will contain the time taken for the acceleration.
16h	**Capstan test**	Tests operation of capstan, sensors and drivers. The capstan is accelerated to a given speed then stopped. The time taken to accelerate is checked. Note: *This test cannot be performed with a tape present.*	If the capstan takes too long to reach the target speed, the test specific results area will contain the time taken for the acceleration.
17h	**Supply reel motor test**	Tests operation of supply reel, sensors and drivers. The supply reel is accelerated to a given speed then stopped. The time taken is checked. Note: *This test cannot be performed with a tape present.*	If the supply reel takes too long to reach the target speed, the test specific results area will contain the time taken for the acceleration.
18h	**Take-up reel motor test**	Tests operation of take-up reel, sensors and drivers. The take-up reel is accelerated to a given speed then stopped. The time taken is checked. Note: *This test cannot be performed with a tape present.*	If the take-up reel takes too long to reach the target speed, the test specific results area will contain the time taken for the acceleration.

Host Action if the Power-Up Self-Test Fails

If the Power-Up Self-Test fails, the drive returns a CHECK CONDITION status with a HARDWARE ERROR sense key set. In this state, the host is only permitted to unload the tape or execute diagnostics. The host should execute a REQUEST SENSE command to find out which self-test failed, the error code and the suspected sub-assembly. The display persists until the drive is reset.

The Self-Test Diagnostic Sequence (sequence 00h)

The Self-Test Diagnostic Sequence is a sub-set of the Power-Up Diagnostic Sequence described earlier. When the diagnostic sequence 00h is run, only tests 11h-18h are performed. Refer to the table in the previous section for test details.

Special Features

Special Features Contents

SF1 Supporting DDS Features

SF2 Software Decompression

Supporting DDS Features SF1

This section provides information and advice for software engineers who are involved in developing applications for the HP 35470A DDS Tape Drive.

The HP 35470A is based on Digital Audio Tape (DAT) technology, and uses a recording format which has been specifically developed for computer applications.

It is particularly suitable for:

- Archive and Retrieval
- Unattended Backup
- Data Interchange
- Software Distribution

— as well as standard backup applications.

This chapter deals with the SCSI-2 commands which are used to support the following:

- Partitioning
- Managing Blocks and Tape Marks
- Fast-Search
- Error Handling

Full details of all the supported SCSI commands can be found in the Interface section of this manual. Information is also provided on Check Conditions which may occur during normal operation of the drive.

Chapter SF2 provides additional information on decompression of compressed data under host control.

Partitioning

Creating two partitions allows a single tape to contain two separate areas which can be written and read independently. The size of each partition can be defined to suit application needs, and redefined later if necessary.

If a blank tape is loaded in the drive, it is used as a 1-Partition tape unless the host formats it as two partitions through the Medium Partitions Parameter page of the MODE SELECT command. The Medium Partitions Parameter page gives the host the following options:

- To generate two partitions on a blank tape
- To convert a 1-Partition tape to a 2-Partition tape
- To convert a 2-Partition tape to a 1-Partition tape
- To change the size of Partition 1 on a 2-Partition tape

Note When a tape is formatted, any data already on the tape is lost, including the Tape Logs.

When formatting two partitions, the drive writes the Reference and System area of Partition 1, the Vendor Group, EOD frames up to Partition 1's EOP, the Reference and System area of Partition 0, the Vendor Group and a normal EOD area. All this is written as a continuum.

Re-formatting

When a 2-Partition tape is re-formatted as 1-Partition, a new Reference and System area and Vendor Group are created at the front of the tape. In addition, a normal EOD Area, preceded by Data area amble frames, is written immediately after the Vendor Group.

Making or Modifying Two Partitions

If you want a blank tape formatted as two partitions, or you want to change the number or size of partitions on an existing tape, follow these steps:

1. Determine the size required for Partition 1, which will depend on the intended usage.
2. Issue the SCSI MODE SELECT command, setting the appropriate values in the Medium Partition Parameters page (page code 11h) as follows:

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (11h)							
1	Additional Page Length (08h)							
2	Maximum Additional Partitions (01h)							
3	Additional Partitions Defined							
4	FDP (0)	SDP (0)	IDP (1)	PSUM (10)		Reserved		
5	Medium Format Recognition (03h)							
6	Reserved							
7	Reserved							
8	(MSB) Size of Partition 1							
9								(LSB)

The Size of Partition 1 field is rounded to the nearest whole group value and an algorithm is applied to allow additional capacity for writing C3 ECC frames, RAW error recovery, and formatting requirements. This amounts to about 25% more than was originally requested. Thus a request for a 1 megabyte partition size will result in approximately 1.25 megabytes being allocated.

The time taken to format Partition 1 of a 2-Partition tape can be calculated as approximately 6.5 seconds per megabyte, plus an overhead of 2 minutes and 40 seconds.

The minimum space allocated for Partition 1 is 1 megabyte. This allows sufficient space for the Reference and System area, Vendor Group, one data group before EW, the EW-to-EOP distance and the EOP-to-Boundary distance.

The page code 11h settings for converting a 2-Partition tape to 1-Partition are similar to those shown above, except that the Additional Partitions Defined field and the Size of Partition 1 field should both be set to 0. The tape will be initialized to contain one partition—Partition 0—spanning the whole tape.

Determining the Number of Partitions

To determine the number of partitions, and the size of Partition 1 on a 2-Partition tape, send the MODE SENSE command with Page Code set to 11h, the Medium Partitions Parameter page. The number of partitions will be returned in the Additional Partitions Defined field (0 or 1). If the tape is 2-Partition, the size of Partition 1 (in megabytes) is returned in the Size of Partition 1 field.

Selecting the Active Partition (2-Partition tapes)

When using a 2-Partition tape, the host must select the desired partition before issuing any read or write commands. This partition then becomes the Active Partition.

This is done by using the MODE SELECT command, and setting the appropriate values in the Device Configuration Page (page code 10h). The entries used are the Change Active Partition (CAP) bit and the Active Partition field. To select Partition 1, set the CAP bit to 1 and change the value of the Active Partition field to 10h.

Any values other than 00h or 01h in the Active Partition field will be rejected by the drive. Also, if the tape has not been formatted into two partitions, any attempt to change partitions will be rejected.

When a tape has just been loaded, the Active Partition field will be set to 00h regardless of how the tape has been formatted. The drive will also default to Partition 0 if there is a power cycle, BUS DEVICE RESET message or hard reset.

Once the Active Partition has been selected in this way, any subsequent read, write or tape positioning commands only apply to this partition.

Determining the Current Active Partition

To determine the currently active partition on a 2-Partition tape, use the MODE SENSE command and select the Device Configuration Page (page code 10h). The currently active partition number will be returned in the Active Partition field.

Suggested Uses

A possible use of the 2-Partition structure is for Partition 1 to contain a directory of the data files held in Partition 0. The directory could then be accessed very rapidly by the drive to get information about the location of data files. Such a directory could be written to Partition 1 after the data files have been written to Partition 0.

Check Conditions during Normal Operation

The following section describes the error conditions which may occur during normal operation of the drive, using either a 1-Partition or a 2-Partition tape.

Table SF-1 provides a list of SCSI commands which will return a CHECK CONDITION whenever EOD, EW and EOP/M are detected by the drive when not expected. This list also applies if EW and EOP are detected for Partition 1 on 2-Partition tapes when not expected.

Table SF-1 SCSI Commands involving EOD, EW and EOP/M

EOD	EW	EOP/M
ERASE	LOAD/UNLOAD	LOCATE
LOCATE	WRITE	READ
MODE SELECT	WRITE FILEMARKS	REQUEST SENSE
READ		SPACE
SPACE		VERIFY
VERIFY		WRITE
		WRITE FILEMARKS

Note For full details of all SCSI commands supported by the HP 35470A, refer to the Interface sections.

EW

The early warning mark (EW) is generated internally by the drive when there is approximately 500 mm of tape remaining before the End-of-Partition/Medium (EOP/M). This is approximately 10 megabytes of data capacity. EW will be signalled as a CHECK CONDITION by the commands listed in table SF-1.

Normally, when an EW warning is received by the host, it will stop sending data to the drive and issue a REWIND command. This will force the buffer to flush and write EOD. The 10 megabytes remaining are adequate to take the contents of the buffer and allow for any rewrites due to poor media. Note that it is up to the host to decide what action should be taken when the EW warning is generated.

Note EW warnings are not generated on read passes.

The EW used in the first partition of a 2-Partition tape is generated 2045 frames before the EOP of Partition 1.

EOP/M

Two conditions within the drive cause a EOP/M CHECK CONDITION:

1 When using a 2-Partition tape, it indicates EOP, the point in Partition 1 beyond which the drive will not allow data to be written within that partition.

2 When using a 1-Partition tape, or writing in the second partition (Partition 0) of a 2-Partition tape, it signals the physical end of the media.

See table SF-1 for a list of EOP/M handling commands.

Managing Blocks and Tape Marks

This section describes the SCSI-2 commands which are used to handle blocks and tape marks. Full details of all SCSI commands supported by the HP 35470A can be found in the Interface sections.

Writing Fixed-Length or Variable-Length Blocks

The MODE SELECT command (15h) is used to select either fixed-length or variable-length block mode of operation.

If fixed-length blocks are required, enter the desired block length in bytes in the Block Length field of the MODE SELECT Parameter Block Descriptor. If variable-length blocks are required, enter 0 in the Block Length field.

Note Selecting variable-length mode in this way is not mandatory. The READ, WRITE and VERIFY commands may force variable-length mode by setting the Fixed Bit to 0.

When issuing the READ, WRITE or VERIFY commands in fixed-length mode, the Fixed Bit field in the Command Descriptor Block (CDB) must be set to 1. The number of blocks to be transferred is entered in the Transfer Length field of the CDB. If the Fixed Bit is set to 1, but the Block Length value of the MODE SELECT command is 0, the command will be rejected with a CHECK CONDITION status and an ILLEGAL REQUEST sense key set.

When issuing READ, WRITE or VERIFY commands in variable-length mode, the Fixed Bit field in the CDB must be set to 0. The number of bytes to be transferred must be entered in the Transfer Length field. Note that it is permissible to select variable-length mode even if the Block Length value of the MODE SELECT command is not zero.

Writing Filemarks and Setmarks

Both types of tape mark are created using the WRITE FILEMARKS command (opcode 10h).

If the WSmk bit in the CDB is 1, a setmark is written to tape.
If the WSmk bit in the CDB is 0, a filemark is written to tape.

Multiple filemarks or setmarks can be written by entering the number required in the Number of Marks field.

Note Details of the maximum number of setmarks, filemarks and blocks that can be written to a single tape are given in the section "How Indexing Works" of chapter DF2.

The setmark is considered hierarchically superior to the filemark. It allows the host software the freedom to include any number of blocks and filemarks within a set and be able to search to the end of it in one motion. Searching to setmarks automatically invokes the drive's fast-search capability.

The host software does not need to know the number of blocks or filemarks contained within a set in order to position past it.

When writing setmarks or filemarks, the timing for the command will vary considerably depending on the mode chosen. The performance within a chosen mode will vary depending on whether or not the Immediate bit is set.

Buffered Mode—Immediate bit set

In this mode the filemarks are included in the data stream from the buffer to the tape, and streaming performance can be maintained.

Buffered Mode—Immediate bit not set

If the Immediate bit is *not* set, the following sequence will occur:

1. Any separator marks are appended to the data in the buffer.
2. The buffer is then flushed to tape. GOOD status will not be returned until the tape mark has been successfully written using the read-after-write capability.

EOD Handling

Marking the end of the recorded data serves two purposes:

1. It limits fast-searching to the area of the tape containing recorded data, and no time is wasted searching unrecorded areas.
2. It shows which data is valid. When data is written to the tape it may either be appended to the tape's existing contents, starting at the current EOD, or it may be written over existing data. If no overwriting is done, the Data area grows and the EOD area is written nearer the end of the tape. If existing data is overwritten, and there is less new data than was originally on the tape, the EOD area is written closer to the beginning of the tape. In this case, any recorded data beyond the new EOD area is no longer valid.

The drive flushes the write buffer to tape and appends an EOD marker under the following conditions:

1. Receipt of the following non-write commands:

LOAD/UNLOAD	MODE SELECT	READ
READ BUFFER	REWIND	SEND DIAGNOSTIC
SPACE	VERIFY	WRITE BUFFER

The buffer can be maintained through the following media commands, assuming that no other flush condition has been met—for example, write hold-off timeout:

ERASE WRITE FILEMARKS (Immediate) WRITE

2 If buffered mode is not selected, the drive's internal data buffer is flushed after every write-type command. Buffered mode can be configured by setting the Buffered Mode field to 1 or 2 in the Parameter Header of the MODE SELECT command. If it is not used, the drive suffers a significant degradation in performance with respect to transfer rate and capacity, because each block will be written as a partial group. In non-buffered mode, partial groups are not appended to automatically, but are left on the tape.

3 The write hold-off time limit is exceeded. This value defaults to 5 seconds.

The tape can be positioned at EOD by using the SPACE command (see "Finding Blocks, Filemarks, Setmarks and EOD" later in this chapter). It follows that the convention of using two filemarks to signify end of data need not be used with DDS drives, though spacing to sequential filemarks is supported. If EOD is detected by the drive when not expected, a CHECK CONDITION will be returned for the commands in table SF-1.

Finding Blocks, Filemarks, Setmarks and EOD

The SCSI SPACE command (opcode 11h) is used for positioning the drive in relation to the blocks and tape marks on the tape. A 3-byte code is entered in the Code field of the CDB to indicate what is to be spaced over. The code is as follows:

DB1(2)	DB1(1)	DB1(0)	Description
0	0	0	Blocks
0	0	1	Filemarks
0	1	0	Sequential Filemarks
0	1	1	End-of-Data (EOD)
1	0	0	Setmarks
1	0	1	Sequential Setmarks

When spacing over blocks or marks, the Count field of the CDB is used to determine the direction of movement and the number of items to be spaced over. It is interpreted as follows:

- A positive value of *N* causes forward movement (towards EOM) over *N* blocks or marks. The tape is logically positioned after the *N*th block or mark on the EOM side.
- A zero value causes no change in the logical position, except when spacing to EOD.
- A negative value $-N$ (twos complement notation) causes reverse movement (towards BOM) over *N* blocks or marks. The tape is logically positioned on the BOM side of the *N*th block or mark.

Implementation of the SPACE Command

Spacing to	Event Detected	Valid	Mark	EOM	Sense Fields		Note
					Sense Key	Additional Sense	
Blocks	Filemark	1	1	0	NO SENSE	0001h Filemark detected	a, b
	Setmark	1	1	0	NO SENSE	0003h Setmark detected	a, b, d
	EOD	1	0	0	BLANK CHECK	0005h EOD detected	b, e
	BOP	1	0	1	MEDIUM ERROR	0004h BOP/M detected	b, f
	EOP/M	1	0	1	MEDIUM ERROR	0004h BOP/M detected	b, g
Filemarks	Setmark	1	1	0	NO SENSE	0003h Setmark detected	a, b, d
	EOD	1	0	0	BLANK CHECK	0005h EOD detected	b, e
	BOP	1	0	1	MEDIUM ERROR	0004h BOP/M detected	b, f
	EOP/M	1	0	1	MEDIUM ERROR	0002h EOP/M detected	b, g
Sequential Filemarks	Setmark	0	1	0	NO SENSE	0003h Setmark detected	a, d
	EOD	0	0	0	BLANK CHECK	0005h EOD detected	e
	BOP	0	0	1	MEDIUM ERROR	0004h BOP/M detected	f
	EOP/M	0	0	1	MEDIUM ERROR	0002h EOP/M detected	g
Setmarks	EOD	1	0	0	BLANK CHECK	0005h EOD detected	b, e
	BOP	1	0	1	MEDIUM ERROR	0004h BOP/M detected	b, f
	EOP/M	1	0	1	MEDIUM ERROR	0002h EOP/M detected	b, g
Sequential Setmarks	EOD	0	0	0	BLANK CHECK		e
	BOP	0	0	1	MEDIUM ERROR	0004h BOP/M detected	f
	EOP/M	0	0	1	MEDIUM ERROR	0002h EOP/M detected	g
EOD	BOP	0	0	1	MEDIUM ERROR	0004h BOP/M detected	c, f
	EOP/M	0	0	1	MEDIUM ERROR	0002h EOP/M detected	c, g

Note a The final position will be located on the EOM side of the mark if the movement was forward (towards EOM), and on the BOM side of the mark if the movement was backwards (towards BOM).

Note b The Information field is set to the absolute value of the difference (residue) between the requested count and the actual number of blocks or marks spaced over.

Note c The Information field will contain no residue count and therefore the Valid bit is not set.

Note d The drive will only report that a setmark has been detected, while spacing over blocks or filemarks, if it has been configured through MODE SELECT to Report Setmarks (The RSmk bit set to 1 in the Active Format field of the Device Configuration page). Otherwise the drive will continue the space operation and the presence of the setmark will be transparent to the host.

Note e The tape is positioned such that a subsequent WRITE would append data after the last entity that has been written to the tape before EOD.

Note f The tape is physically positioned at BOP/M.

Note g The tape is physically positioned at EOM/P.

Use of the SPACE command may or may not involve the drive's fast-search capability. The conditions for invoking fast-search are described in the next section.

Fast-Search

The DDS format encodes information about the locations of separator marks in the Sub-Code areas of the tape. The Sub-Code area information can be read very rapidly, allowing the drive to find any block, filemark or setmark on the tape in an average time of 20 seconds. After the data group has been located, the data is read at normal speed. The decision to invoke fast-search is the drive's responsibility; it cannot be invoked by a command from the host system.
See chapter DF2 for further details.

Note The timing of fast-search will depend on where the desired block is located on the tape. When the drive is at BOP, the search time for blocks near the beginning of the tape which require fast-search will be approximately 7 seconds. For blocks near the end of the tape, the search time will be approximately 50 seconds.

Implementing Fast-Search

Fast-search is only used under certain conditions. When a SPACE command is issued, and the operation cannot be completed within the contents of the drive's 1 megabyte buffer, the drive will move the tape either by reading groups or by searching. The decision about which to use is made by an algorithm in the drive's firmware.

Error Handling

The HP 35470A has three error-rate improvement features which can be selected by the host system. These are as follows:

- Read-After-Write (RAW)
- Third Level Error Correction (C3 ECC)
- N-Group Writing

By default, RAW and C3 ECC are enabled, and N-Group writing is disabled.

Read-After-Write (RAW)

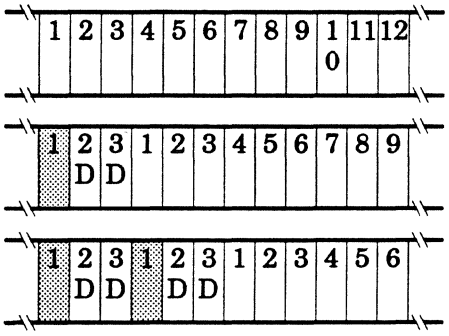
The DDS format supports a Read-After-Write technique to ensure that any data written to the tape can be read back without error. Each frame is examined after it has been written to check that it has been recorded correctly.

When a frame is identified as bad, it is rewritten later down the tape after two other dummy frames have been written. Each frame, and the two in sequence after it, can be rewritten multiple times, thus having the effect of skipping over bad areas on the tape. The number of instances of a repeated sequence is set at a default value in the drive's firmware. When this number is exceeded, the writing of that group is aborted and the drive reports a hard error.

Also, in order to limit the physical group size, the maximum number of RAW frame rewrites that are allowed is set in the drive's firmware.

When reading a group, any rewritten frames need to be identified. If a frame has been rewritten, there will be more than one frame with the same Logical Frame Number. To recover the data in the group, all that is required is to make sure that at least one of each logical frame is read in the correct order. Any duplicates are ignored. If any frame is unreadable, the drive reads ahead up to six frames to see if the frame has been rewritten. If it has, the rewritten frame is used and the drive continues reading from that point.

The following diagrams show examples of different frame rewrite conditions. The numbers in the boxes represent the Logical Frame Numbers.



Normal writing sequence

Frame 1 bad.
Two dummy frames written (frames 2 and 3).

Frame 1 bad. Rewrite also bad.
Four dummy frames written (two per rewrite)

To perform Read-After-Write, two extra heads have been added to the drum, making a total of four at 90° to each other.

Implementing RAW

RAW is switched on or off through the MODE SELECT command (opcode 15h) by changing the RAW bit (byte 2 bit 4) of the Device Configuration Parameters page (page code 10h).

If the RAW bit is 1, RAW is enabled—this is the default.
If the RAW bit is 0, RAW is disabled.

C3 ECC

C3 ECC introduces an extra level of error correction in addition to those offered by the audio DAT format. This feature has the ability to correct any two tracks which are bad in a group. The error correction bits are stored in an additional (ECC) frame at the end of each group.

Implementing C3 ECC

C3 ECC is switched on or off through the MODE SELECT command (opcode 15h) by changing the value of the C3 ECC bit (byte 2, bit 3) of the Device Configuration Parameters page (page code 10h).

If the C3 ECC bit is 1, C3 ECC is enabled—this is the default.
If the C3 ECC bit is 0, C3 ECC is disabled.

N-Group Writing

N-Group Writing is a technique that writes every group more than once. Each group is repeated on the tape a number of times before the next group is written. Each set of rewritten groups is contiguous and contains instances of only one group.

The data and indexes of the rewritten groups are identical.

The maximum number of times a group can be repeated is 7; that is, up to 8 instances may be written.

Implementing N-Group Writing

N-Group Writing is controlled through the MODE SELECT command (opcode 15h) by changing the N-Group field (byte 2, bits 0–2) of the Device Configuration Parameters page (page code 10h).

To enable N-Group Writing, enter a value from 001b to 111b in the N-Group field to define the number of times that each group must be repeated.

To disable N-Group Writing, enter 0 in the N-Group field. This is the default.

Verify

The HP 35470A also supports the SCSI VERIFY command (opcode 13h), which provides an additional error-handling feature. This command verifies one or more blocks, beginning with the next block on the tape. This provides media verification only; no data is transferred between the host and the drive.

Software Decompression SF2

The HP 35470A does not support on-board data compression or decompression. This chapter provides information about how the HP 35470A handles a tape containing compressed data.

Entities and Software Decompression

On a typical DDS-DC tape, two different data item types may be encountered:

- An uncompressed block
- An entity of compressed data

Entities are written by DDS-format drives which support on-board data compression. An entity is made up of a number of blocks of the same size compressed using the drive's compression algorithm. They are prefixed by an entity header which is an uncompressed descriptor containing information about the data within the entity.

A drive which supports compression algorithm *N* can decompress entities of type *N* and return the decompressed data to the host transparently. It can also return uncompressed records to the host if it finds them on the tape.

If this same drive finds an entity of type *M* (written by a different drive using a different compression algorithm), it will not usually be able to decompress it. Similarly, if a drive which does not support data compression at all finds an entity on tape, it cannot decompress it.

Some hosts may support software decompression; that is, the host computer is capable of decompressing entities. In these circumstances, the drive must be able to return a compressed entity to the host without decompressing it. The host must be aware that the data it is receiving is compressed and not a normal uncompressed record.

The following sections describe the use of the Data Compression Characteristics Page by both DDS and DDS-DC drives.

Interaction Between Host and Drive for Software Decompression

DC Drive—initial operating mode example

After drive reset, a drive which supports data compression can be configured to power-up with compression enabled and algorithm *N* selected. The Data Compression Characteristics Page contains the following values:

Field	Value	Meaning
DCE	1	Compression enabled
DCC	1	Compression capable device
DDE	1	Decompression enabled
RED	1	CHECK CONDITION returned on format change only
Compression Algorithm	*N*	Compression algorithm *N* enabled

Non-DC Drive—initial operation mode example

A drive which does not support data compression will typically power-up with the Data Compression Characteristics Page containing the following values:

Field	Value	Meaning
DCE	0	Compression disabled
DCC	0	Non Compression capable device
DDE	0	Decompression disabled
RED	0	CHECK CONDITION returned on encountering compressed data
Compression Algorithm	0	No compression algorithm selected

Example of Software Decompression Control

The host issues a number of READ commands to the drive, all of which are successful. On the next READ command, however, the drive detects an entity of type *M* on the tape, where *M* is an algorithm which the drive does not support. The drive cannot decompress the entity, but returns either the number of bytes in one block, or the total number of bytes in the entity, whichever is smaller. It is necessary for the drive to inform the host that it has found a data item on the tape which it cannot decompress. It does this by issuing a CHECK CONDITION to the host and setting the sense data as follows:

Field	Value	Meaning
Valid	1	Indicates that the Information field contains residual information from the failed READ command. Note that this will only be set if the entity length was different from the requested block length.
Sense Key	(00h)	NO SENSE. If encountered data is uncompressed.
	(01h)	RECOVERED ERROR. If encountered data is decompressable (and has been decompressed) by the drive.
	(03h)	MEDIUM ERROR. If encountered data is compressed and not decompressable by the drive.
Information	READ residue	The READ command failed with a residue as given in this field. Note that this will only be set if the entity length was different from the requested block length.
Command-Specific Information	Number of blocks in data item	The number of blocks in the entity is obtained from the entity header, which the drive can read. Note that in the case of a compressed-to-uncompressed format change, this field will contain 1 to indicate that one uncompressed record was encountered.
Additional Sense Code	(70h)	This ASC indicates the reason for the CHECK CONDITION as being a DECOMPRESSION EXCEPTION.
Additional Sense Code Qualifier	NN	Algorithm identifier for compressed entity encountered. Note that in the case of a compressed-to-uncompressed format change, this field will contain 0 to indicate that uncompressed data was encountered.

The drive is now positioned on the EOP side of the entity. If the host does not support software decompression, the drive can continue reading, if the host wishes. Note that in most cases, this type of host would clear the RED bit during initial device configuration, so that it would only ever receive a DECOMPRESSION EXCEPTION when the drive found an entity. Any blocks would be returned without this type of CHECK CONDITION.

If the host supports software decompression, it must check the sense data to see if it has received all the data from the entity. If it is reading in variable mode, it does this by looking at the residual count in the Information field. If this field is not negative, the host

has received all the compressed data and so will not need to SPACE reverse and re-read the entity.

On the other hand, if the Information field is negative, the requested block length is less than the actual entity length, and the host must SPACE reverse and re-read the whole entity in order to perform the software decompression successfully. The host does this by looking in the Command-Specific Information field in order to find the number of blocks in the entity. It then issues a SPACE reverse with the Count field set to the twos complement of this value. This will position the tape at the start of the entity. (Note that by subtracting the Information field—that is, the residual count—from the requested block length, the host can determine the actual entity size and reserve enough buffer space to receive the data.) Because the RED bit is set, the host will be able to READ the entity without the drive generating a CHECK CONDITION.

As long as the RED bit is set, the host will be able to continue reading entities from the drive until either an entity is found which has been compressed using a different algorithm, or uncompressed data is found.

Note that in fixed mode, the host will not be able to determine the size of the encountered entity from the Information field, because the residual information will be in terms of blocks, not bytes. It is up to the host in this case to take the appropriate action.

Note also that whenever the host needs to SPACE reverse over an entity because it has not managed to read all the data the first time round, the drive will return to its initial state as far as the RED bit is concerned. It will therefore issue a DECOMPRESSION EXCEPTION CHECK CONDITION in response to the following READ command.

Summary

The example outlined above illustrates the requirements from both a host and a drive if software decompression is to be supported within a system. The interaction depends upon the drive being aware of compression/non-compression data boundaries and being able to report them, upon the host having the capability to perform software decompression, and upon the drive's ability to return compressed data items to the host without decompressing them.

DDS Format

DDS Format Contents

DF1 Digital Data Storage (DDS)

DF2 Fast-Search, Indexing, Error Correction

DDS Format

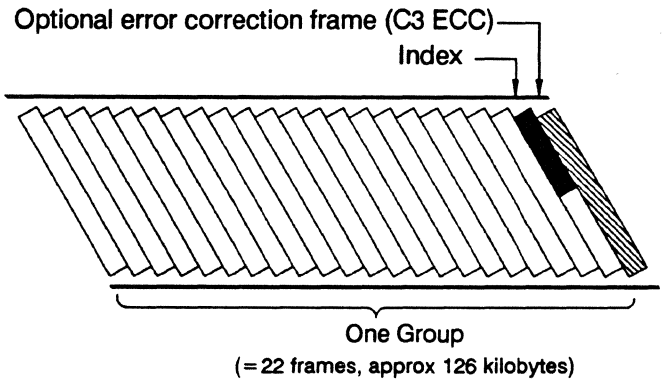
Digital Data Storage (DDS) is a recording format which supports the use of Digital Audio Tape (DAT) for computer applications. DDS tape drives make use of DAT features like helical-scan recording (see "Theory of Operations") and sophisticated error-correction techniques developed for use in the audio market.

In addition to the error-correction and data-integrity features provided by DAT, the DDS format has the following features:

- A fast-search capability at up to 200 times the normal read/write speed.
- The option of formatting the tape into a one-partition or two-partition structure.
- A third level of error correction (C3 ECC), which can recover errors that are too severe for the basic DAT format techniques (C1 and C2 ECC) to correct.
- A Read-After-Write (RAW) facility which checks the data for errors immediately after it is written, and rewrites it if necessary.
- The option of N-Group Writing (Multiple Group Writing), where each group of data is repeated a specified number of times before the next group is written.

The DDS format is structured to overlay the basic audio format. It does this by organizing the frames (pairs of tracks) of the audio format into a sequence of data groups on the tape, each group with a fixed data capacity. Figure DF-1shows the construction of a group.

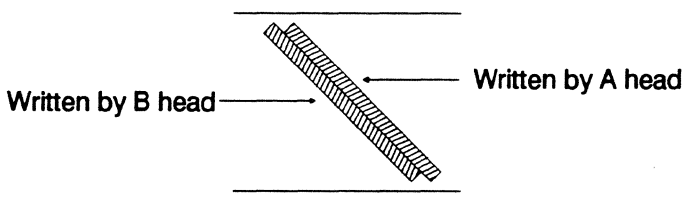
Figure DF-1



Construction of a Group

Each group consists of 22 frames-worth of data, where a frame is a pair of tracks across the tape. See figure DF-2.

Figure DF-2



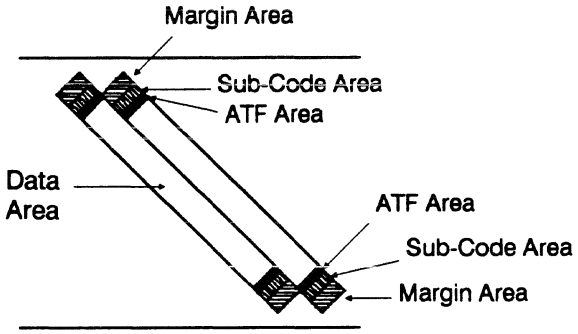
One Frame

As with the audio format, 60% of the length of a track is user data. The rest consists of:

- Margin Areas, which are used as guard bands.
- Sub-Code areas, which are used to enable fast-searching at up to 200 times the normal read/write speed. This enables the drive to access any file on the tape rapidly, on average within 20 seconds. (See "Fast-Search" in chapter SF1 for more information).
- ATF (Automatic Track Finding) areas, which are used to center the head on the track.

Figure DF-3 shows the structure of a frame.

Figure DF-3



The Structure of a Frame

A host computer sends data and separator marks to a tape drive which supports the DDS format. The separator marks identify where logical collections of data (for example, files and sets of files) begin and end. The tape drive organizes the information into groups and writes it to tape. An index in each group identifies and locates the data blocks and separator marks contained in the group, and each group can be followed by an optional error-correction frame. (See "Error Handling" in chapter SF1 and "How Error Correction Works in DDS" in chapter DF2 for details of Error Correction techniques).

The method of indexing allows for fixed and variable length blocks and for separator marks to be encoded onto the tape without significantly affecting the amount of data that can be stored on a particular cassette.

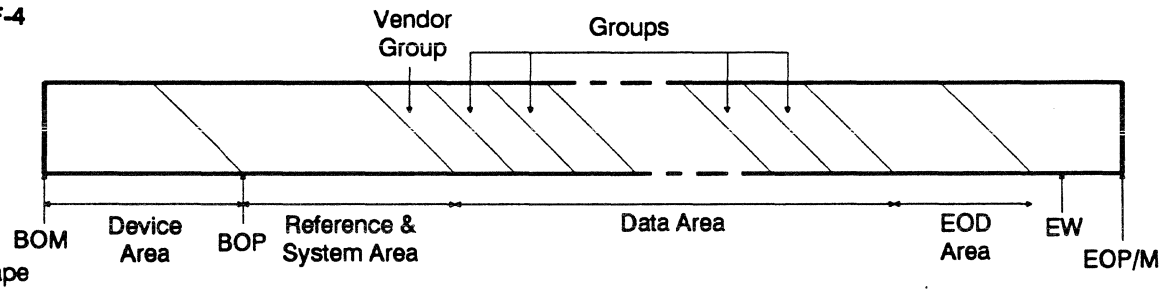
Tape Layout

The DDS format supports the formatting of tapes into a 1-Partition or 2-Partition structure. These are described in the following sections.

One-Partition Tape

The overall tape layout consists of four areas: the Device area, the Reference and System area, the Data area and the EOD area. Figure DF-4 shows the different areas.

Figure DF-4



Overall Tape Layout

Beginning-Of-Medium (BOM) and End-Of-Medium (EOM) are the points where the magnetic tape is joined to transparent leader and trailer tapes respectively.

Note In the following, write operations can only occur if the tape is write-enabled.

Device Area

This has three sections:

1. The *load section*, which is the part of the tape that is wrapped around the drum when the tape is first loaded.
2. A *test section*, where read and write tests of the drive's electronics and servo are performed.
3. A *guard section*, which provides a safety zone between the test section and the start of recorded frames.

Reference and System Area

Reference Area The Reference area defines the Beginning-Of-Partition (BOP), and facilitates efficient positioning when updating the System area.

System Area The tape logs of usage and soft error occurrence are stored in the System area. This logged information is lost whenever a tape is formatted (see "Partitioning" in chapter SF1).

Data Area

The Data area is written as a sequence of groups (see "DDS" earlier in this chapter), starting with a special Vendor Group which is written automatically by the drive. The Vendor Group holds details of the drive which created the partition, and the date. It is followed by data groups, which have a fixed capacity, and are used to store blocks, filemarks and setmarks written by the host. Fixed-length or variable-length data blocks may be written. These, together with tape marks, are mapped into the fixed capacity groups by a method known as Indexing, which uses a minimal amount of the data capacity of the tape (see chapter DF2).

Blocks

The host has the option of writing either fixed-length or variable-length blocks to the drive. The drive maps these blocks into the fixed-length group structure using the index in each group. A block may be written within a single group or span several groups, depending upon its size. The mapping process is invisible to the host system.

Separator Marks

DDS provides for two types of separator marks—filemarks and setmarks—which are each represented by 4 bytes in the index of a group. It is the responsibility of the application developer to define the logical significance of these marks.

Filemarks The meaning of filemarks is defined by the host.

Setmarks Setmarks provide an additional method of data segmentation. This new type of mark gives the host the freedom to include any number of blocks and filemarks within a set, and the ability to search to the end of it in one motion. Searching to setmarks automatically invokes the drive's fast-search facility, unless the setmark is in the buffer. The host does not need to know the number of blocks and filemarks contained in a set in order to position past it, before appending more data.

The use of the setmark is not restricted to marking the end of a set of data. The host is free to assign any meaning to this mark it wishes.

See "Managing Blocks and Separator Marks" in chapter SF1 for more information.

EOD Area

The EOD area specifies the point on the tape where the host stopped writing data. The host does not specifically command the writing of this section of the tape. It is the *drive's* responsibility to detect conditions which indicate that the host has stopped writing data, and generate the EOD area at this point.

EW and EOP/M

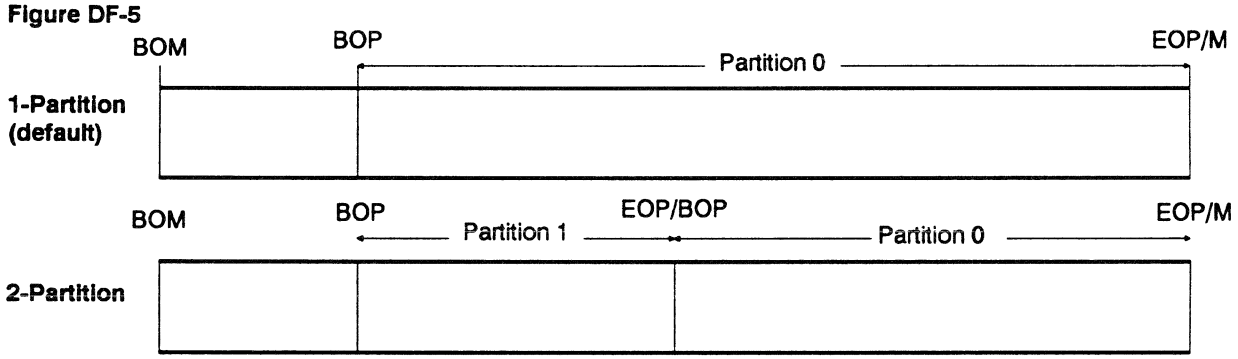
At the end of the tape are the Early Warning (EW) mark and End-of-Partition/Medium (EOP/M). EW is a fixed distance (2045 frames—at least 500 mm) from EOP/M, and is generated automatically by the drive. When the drive detects the EW point while writing, it indicates to the host that it should stop writing data to the tape.

Tape Partitions

The DDS format provides the option of formatting the tape into a 1-Partition or 2-Partition structure. The host decides whether a blank tape is to be formatted into one or two partitions before writing any data. If no format command is sent by the host before writing to a blank tape, the tape will default to a 1-Partition structure.

If two partitions are created, the partition closest to the beginning of the tape is known as Partition 1, and the partition closest to the end of the tape is known as Partition 0. The size of Partition 1, in megabytes, is determined by the host during formatting (see "Making or Modifying Two Partitions" in chapter SF1). Each partition may be written and read independently. Figure DF-5 shows the available partition structures.

Figure DF-5



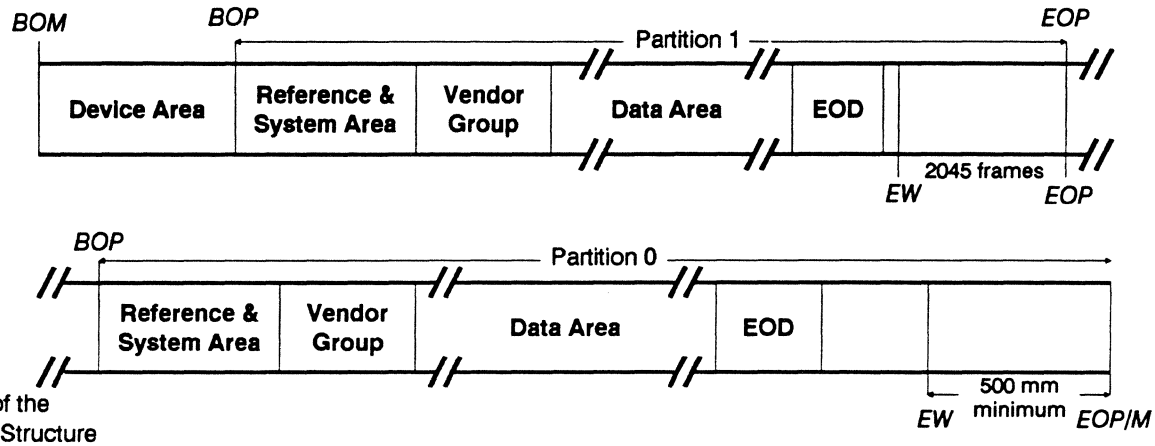
Available Partition Structures

Note In each of the two partitions, new data may be appended to existing data at any time. However, when data is written to a partition, any existing data which is beyond the current writing point in that partition will be lost.

Two-Partition Structure

A 2-Partition tape has a single Device area, the same as a 1-Partition structure. Each partition has its own Reference and System area, Data area and EOD area. In addition, an EW mark and EOP are defined for Partition 1 and BOP is defined for Partition 0. See figure DF-6.

Figure DF-6



Contents of the 2-Partition Structure

Two System areas are provided in order to maintain separate logs of usage and soft error occurrence for each partition. It is likely that the partitions will experience different degrees and types of use, and so show different error occurrences. The existence of two sets of logs allows the data to be retained separately for each partition; a single log might mask significant differences between the two partitions.

Each System area is preceded by a Reference area.

Separate Vendor Groups are written automatically by the drives that write each partition. They provide information about the drive, the time the partition was initialized, and the type of interface.

6 DDS Format

Fast-Search, Indexing, Error Correction . DF2

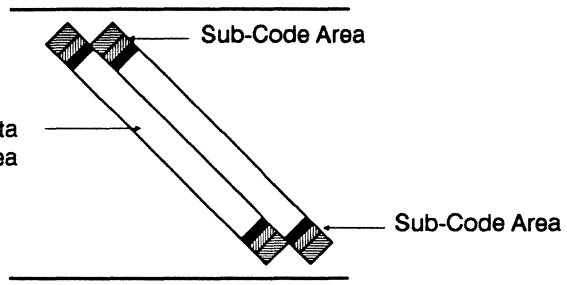
This chapter contains details of how fast-search, indexing and error correction techniques work in DDS-format drives.

How Fast Search Works

The drives uses information encoded in the Sub-Code areas of each track (see figure DF-7) to perform fast-searching at up to 200 times the normal read/write speed.

Figure DF-7

Location of Sub-Code Areas

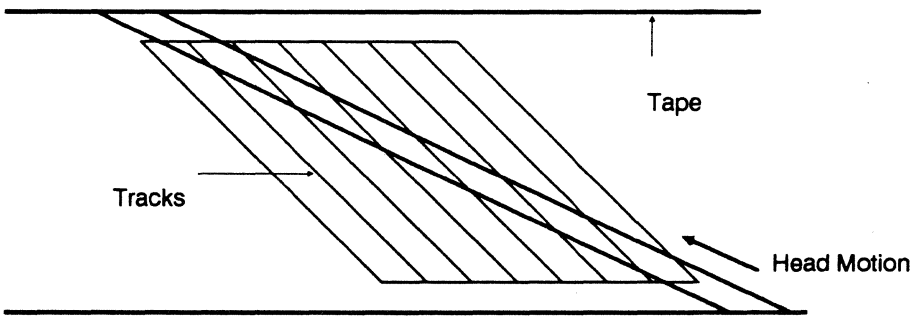


The information in the Sub-Code areas includes a group count, setmark count, filemark count and block count. Fast searching is done in response to a SPACE command from the host to find a specified setmark, filemark or block.

When fast-searching, the tape head follows a different path to that in the normal read mode, because both the head rotation rate and tape speed are changed. (See figure DF-8).

Figure DF-8

Path of head during Fast Search



To allow the drive's electronics to lock on and acquire the positional information required for fast-search, the information in the Sub-Code areas is repeated for each frame in a group.

Once the target group has been found, the drive uses the information in the group index to find out where specific setmarks, filemarks or blocks are located within the group.

Fast-searching is invoked by an internal algorithm making decisions about what is in the buffer, and depends on whether the command is a SPACE forward or reverse of a number of blocks, filemarks or setmarks.

How Indexing Works

The method of indexing in DDS used in a group allows the format to map variable-length blocks into fixed group sizes.

The index contains two special blocks:

1 *The Group Information Table.* This has a fixed size of 32 bytes, containing the following information:

- The Group Count
- The Block Count
- The Filemark and Setmark Counts
- The size of the Block Access Table

2 *The Block Access Table.* This is of variable length, and contains the following information:

- The start and end of entities and blocks in the group
- The position of filemarks and setmarks in the group

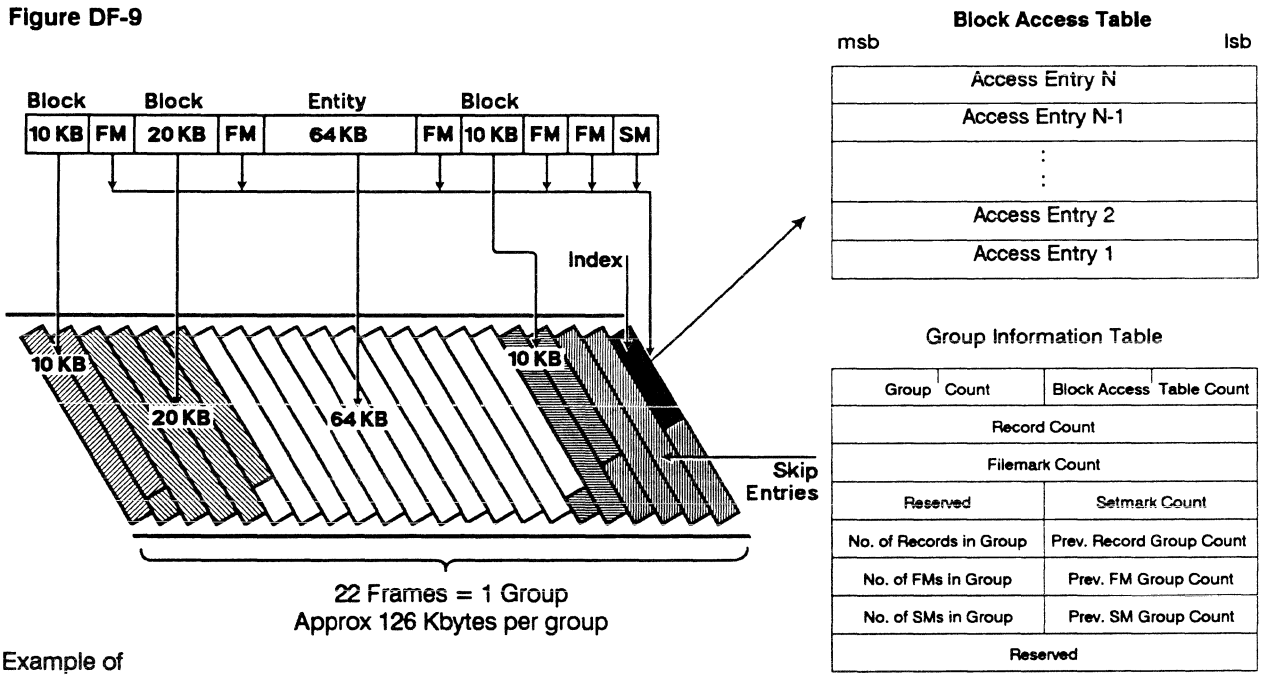
The minimum supported length for an entity or block is 1 byte

The maximum supported length for an entity or block is $2^{24} - 1$ bytes

This limit is imposed by the 3 bytes allocated in the Block Access table for block length.

Figure DF-9 shows an example of Indexing, and table DF-1 shows the Block Access entries which correspond to the example.

Figure DF-9



Example of Indexing

Table DF-1. Block Access Entries

	Flag Byte	Count (dec)	Remarks
Access Entry 1	01100011	10240	10 Kbyte Block
	00000111	0	Filemark
	01100011	20480	20 Kbyte Block
	00000011	0	Filemark
	01110011	65536	64 Kbyte Entity
	00000111	0	Filemark
	01100011	10240	10 Kbyte Block
	00000111	0	Filemark
	00000111	0	Filemark
	00000111	1	Setmark
Access Entry 11	10000000	20136	Skip Entry

The skip entry is computed as the difference between group capacity and total count. In the above example:

skip entry count = 126632– (10240+ 20480+ 65536+ 10240) = 20136.

The figure of 20136 includes the 32 bytes of the Group Information Table and the 44 bytes (11× 4) of the Block Access Table entries.

Block Access Table

The Block Access Table describes the contents of the group and contains an entry for each block, entity, filemark and setmark. Partial entities and blocks contained in the group also have an entry. The size of the table varies according to the contents of the group. The access entries are in reverse order, with the latest entry first and the first entry last, immediately before the Group Information Table.

Access Entries

Each access table entry is 4 bytes, consisting of a Flag byte followed by a 3-byte Count field:

Byte	*Bit:* 7	6	5	4	3	2	1	0	
0	Transfer Skip	Transfer Data	End of Data-Block	Transfer Compressed	After EW	Mark	Block Begin	Block End	⇐ *Flag Byte*
1	(MSW)								
2				Count					
3								(LSW)	

Transfer Skip	1	The number of bytes specified by the Count field should *not* be sent to the host. This is used to specify the number of bytes in the group to remove the index and any "padding" bytes.
Transfer Data	1	The number of bytes specified in the Count field *should* be sent to the host. The sum of all Count fields in the Block Access Table with either the Transfer Skip or Transfer Data bits set is 126632 bytes.
End of Data-Block	1	The entry specifies the end of a data block.
Transfer Compressed	1	Signifies that the item is an entity.
After EW	After Early Warning when the block was written.	
	1	Allows the drive to return EW status to the host during reading at the same point at which it wasdetected during writing.
Mark	Specifies that the item was a type of mark. A Count field of zero indicates that it was a filemark. A Count of one specifies a setmark.	
Block Begin	1	The entry specifies the beginning of a block.
Block End	1	The entry specifies the end of a block.

Both Block Begin and Block End are set for filemarks and setmarks. However, End of Data-Block is only set for the end of a block of data, not for marks.

If Block End is set and Mark is not set, then the Count field contains the number of bytes in the block.

If Block End is set but neither Mark nor Transfer Data are set, then the Count field contains the total number of bytes for a block which spans one or more groups. The count must equal the sum of the Count fields of the constituent elements of the block, specifically the first part, any middle parts, and the last part of the block.

The maximum block length supported is $2^{24} - 1$ bytes.

Note More detailed information on format is available in the DDS Format Description, available from Hewlett-Packard Computer Peripherals, Bristol,UK.

The maximum number of blocks, filemarks and setmarks that can be written is governed by the byte allocations in the Group Information Table.

These are as follows:

Blocks	$2^{32}-1$	
Filemarks	$2^{32}-1$	
Setmarks	$2^{16}-1$	
Number of Groups	$2^{16}-1$	(excluding the group designated as the Vendor Group, which is written automatically by the drive)

Example of Indexing

The following calculation shows the effects of indexing on tape capacity when writing fixed-length 512-byte blocks.

	126632 bytes	Capacity of a group
–	*32 bytes*	Group Information Table (fixed overhead)
–	*4 bytes*	Skip Entry (fixed overhead)
	126596 bytes	Available data and index space

Capacity $= \dfrac{\text{available data and index space}}{\text{length of data block} + \text{block entry}} = \dfrac{126596}{512+4}$

$= 245$ data blocks + 176 bytes extra

The 176 extra bytes for a partial block must include another index entry (4 bytes) leaving 172 bytes for the partial block data.

Data size = 245 blocks + 1 partial block
$= (245 \times 512) + 172 = 125612$ bytes/group

Index size = Group Information Table + Skip Entry
+ Index Entries for 245 blocks and 1 Partial block

$= 32 + 4 + 4 + (245 \times 4) = 1020$ bytes

Index overhead $= \dfrac{1020}{126632} \times 100 = 0.8055\%$

Tape capacity = 1.3 gigabytes (nominal) – 0.8055% of 1.3
$\approx$ 1.289 gigabytes

How Error Correction Works in DDS

This section reviews the ability of the Audio DAT format and the DDS format to correct errors. Audio DAT has two levels of ECC—C1 and C2. DDS format uses the same levels as Audio DAT format but adds extra error-correction techniques: C3 ECC, N-group writing, read-after-write, data randomizer and checksums.

Audio Format C1 and C2 ECC Performance

C1 ECC is (32,28) Reed Solomon code and can detect and correct errors in any two symbols, or it can correct four symbols where the error location is known. A symbol is basically equivalent to one byte. C2 ECC is (32,26) Reed Solomon code and can correct errors up to three symbols long, or six symbols when the error location is known.

To minimize the probability of faulty detection of an error, the C2 code decoder typically corrects two symbols and six symbols where the error location is known, using C1 error condition flags. The research papers listed in the Bibliography review the performance. Their conclusions are summarized as follows:

Random Error Performance

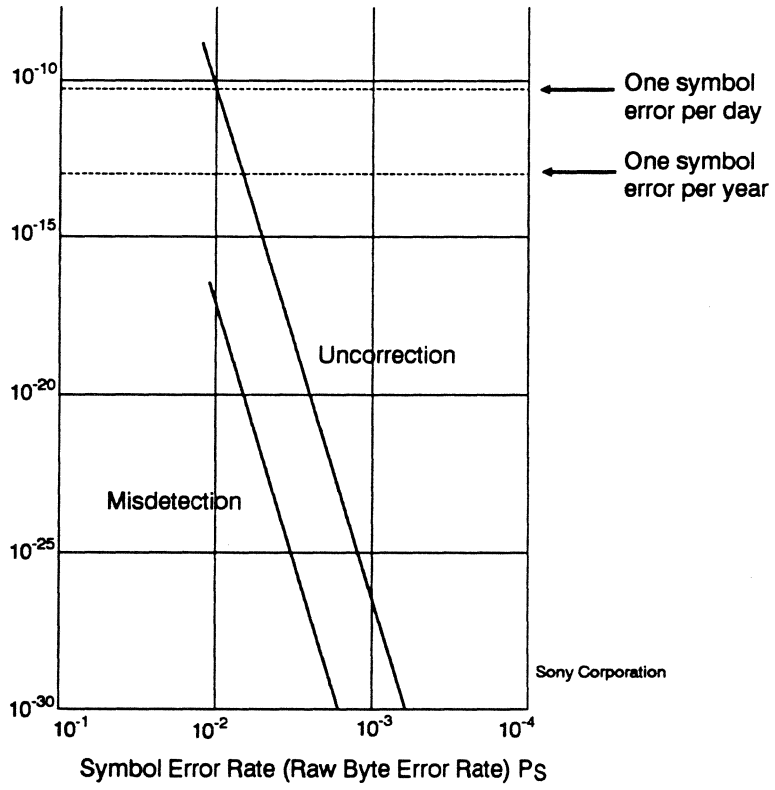
In the following, P_s = Symbol error rate.

Probability that a symbol error is uncorrectable: $P_{un} \approx 3.8 \times 10^{23} P_s^{17}$

Probability that a symbol error is misdetected: $P_{mis} \approx 8.8 \times 10^{16} P_s^{17}$

This performance is shown in figure DF-10.

Figure DF-10



Audio DAT Random Error Correctability

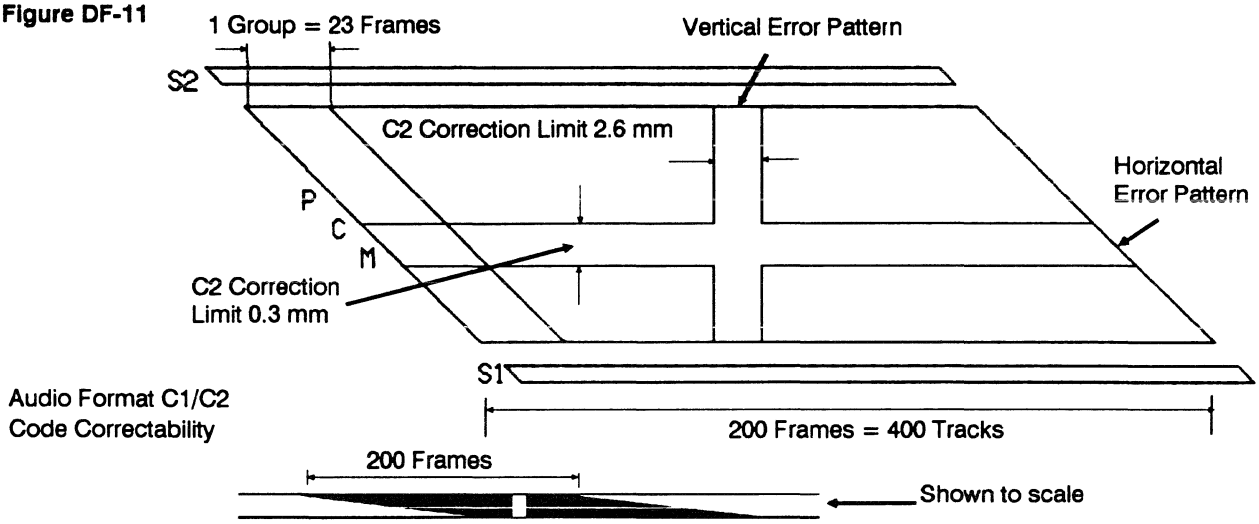
Burst Error Performance

Maximum correctable burst error length = 792 symbols (6336 bits)

Since the linear recording density of DAT is 61,000 bits/in., this is equal to 2.64 mm along a helical track.

The horizontal correctable error width is $2.64 \times \sin 6.25° \approx 0.3$ mm, and the vertical correctable error width is $2.64 \times \cos 6.25° \approx 2.6$ mm (see figure DF-11).

Figure DF-11



DDS-Format C3 ECC Performance

In the DDS format, C3 code can be added to improve data integrity. C3 ECC is (46,44) Reed Solomon code and can detect and correct errors as follows:

Correctable	Detectable but Uncorrectable	Misdetection or Miscorrection
1 error	1 error + 1 erasure error	≥2 errors
≤2 erasure errors	≥3 erasure errors	≥2 errors + 1 erasure error
		≥1 error + ≥2 erasure errors

error: an uncorrected and misdetected, or miscorrected symbol error after C1/C2 correction. Refer to the curve "Misdetection" in figure DF-10.

erasure error: a symbol error detected but uncorrected by C1/C2 correction. Refer to the curve "Uncorrection" in figure DF-10.

Each C3 codeword symbol is interleaved and corrected by the Audio DAT C1/C2 code. As a result, the C3 code symbol error rate is the error rate after C1/C2 correction.

C3 code performance can be estimated as follows:

Random Error Performance

Probability of a symbol being uncorrectable by C3 ECC after C1/C2 correction:

$$P_{unC3} \approx {}_{46}C_3 P_{un} \approx 1.5 \times 10^4 P_{un}^3$$ (See figureDF-12)

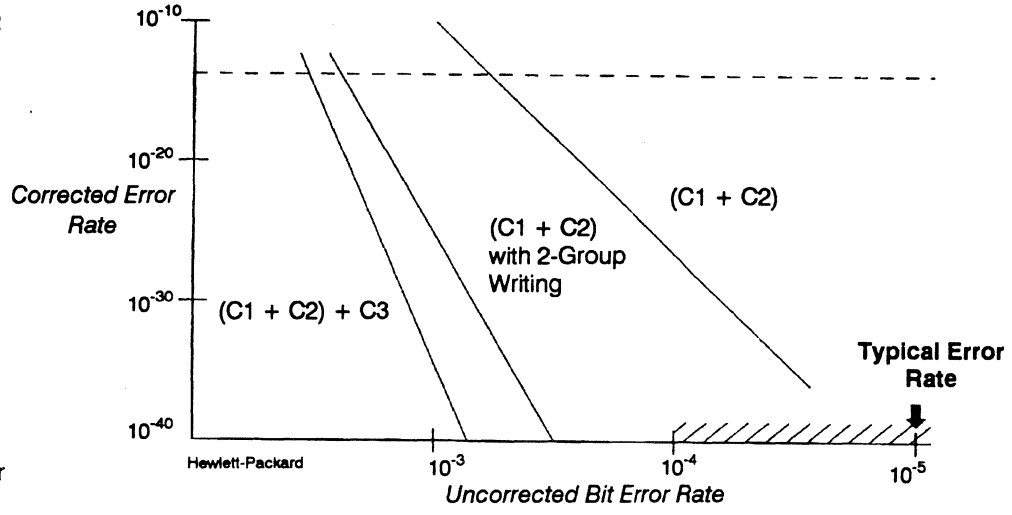
where P_{un} is the error rate after C1/C2 correction.

Figure C-3 shows that random error performance is more than adequate. The shaded area represents the actual bit error rates seen in media testing.

Burst Error Performance

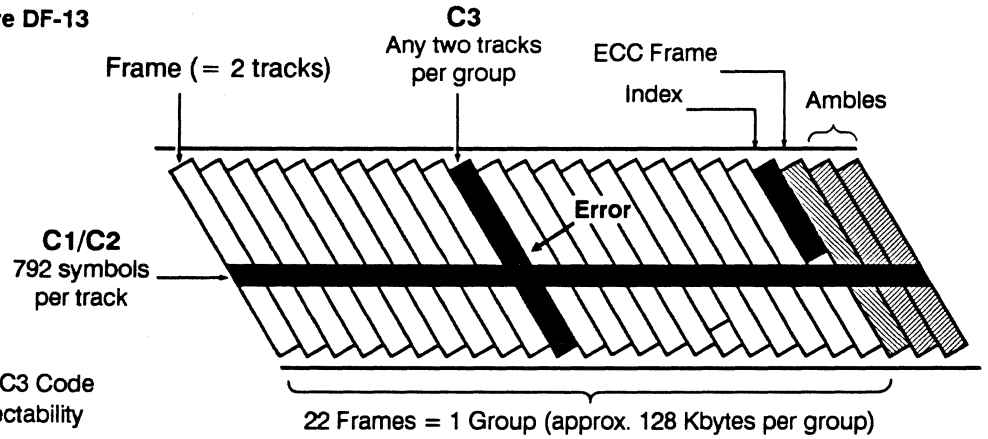
The most dangerous errors are burst errors caused by horizontal, vertical and helical error patterns. C3 can correct any two tracks in a group (see figure DF-13).

Figure DF-12



DDS Format Random Error Correctability

Figure DF-13



DDS C3 Code Correctability

The code copes with the errors as follows:

Horizontal error pattern

C1/C2 code can correct up to 0.3 mm width horizontal error pattern. If the error exceeds this limit, all the tracks become uncorrectable, and so no type of C3 ECC can help.

Vertical error pattern

C1/C2 code can correct up to 2.6 mm width vertical error pattern. Outside this limit, about 190 tracks become uncorrectable simultaneously, assuming circular defects. Correcting an error like this using a track-based correction scheme would require a C3 capable of correcting more than 190 tracks.

Helical error pattern

C3 is well suited to correct helical errors (soft errors caused by head clog). One way of removing the error is through 'retry', but this affects the data transfer rate.

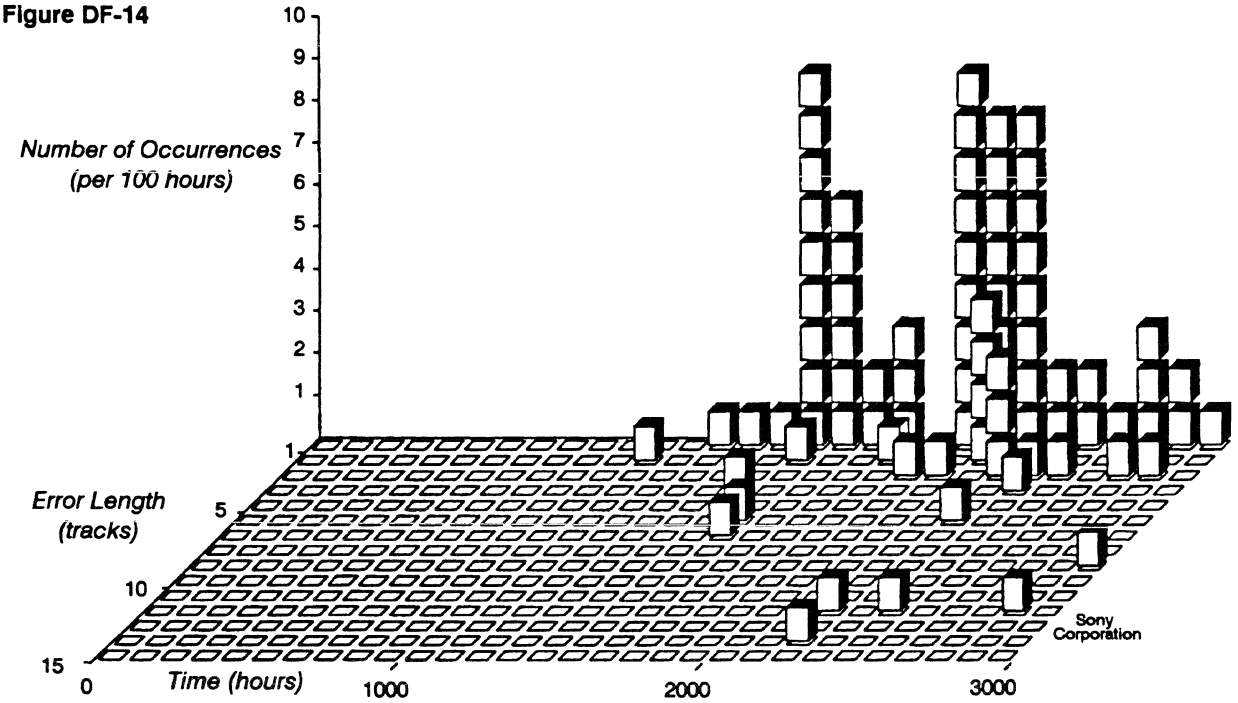
Using C3 code:

- The drive can continue streaming.
- Hard errors which may occur during writing without read-after-write can be detected and corrected.

The chance of a head clog occurring depends very much on the condition in which the drive is maintained.

As a worst case, consider figure DF-14. 84 head clogs were observed during 3000 hours reading—in other words, 1.6×10^{13} bits read without maintenance. The probability of needing a retry is 23%, that is 19 cases during the last 1400 hours reading. This gives a rate of once in each 74 hours use, and this is quite acceptable in a worst case where there is no maintenance. With proper maintenance, the retry rate will be much lower.

Figure DF-14



Head Clog Data

For the data illustrated in this graph, a new tape was used, written to once and then put through 1500 read passes (FWD for 2 hours, then REW). A Sony DTC-1000 tape drive was used with a 4-head drum. It was cleaned before the first pass; after that there was no cleaning and no maintenance.

Because of the nature of head clogs, there is no limit to their length. C3 can only reduce the occurrence of retries.

N-Group Writing Performance

N-group writing is an additional technique to improve data integrity with or without C3 code. Each group is duplicated N times, and the probability that each symbol of the C3 code becomes uncorrectable is improved as follows:

$$P_{un:N-group} = P_{un}^{N}$$

Random error performance for 2-group writing is shown in figure DF-12 as well.

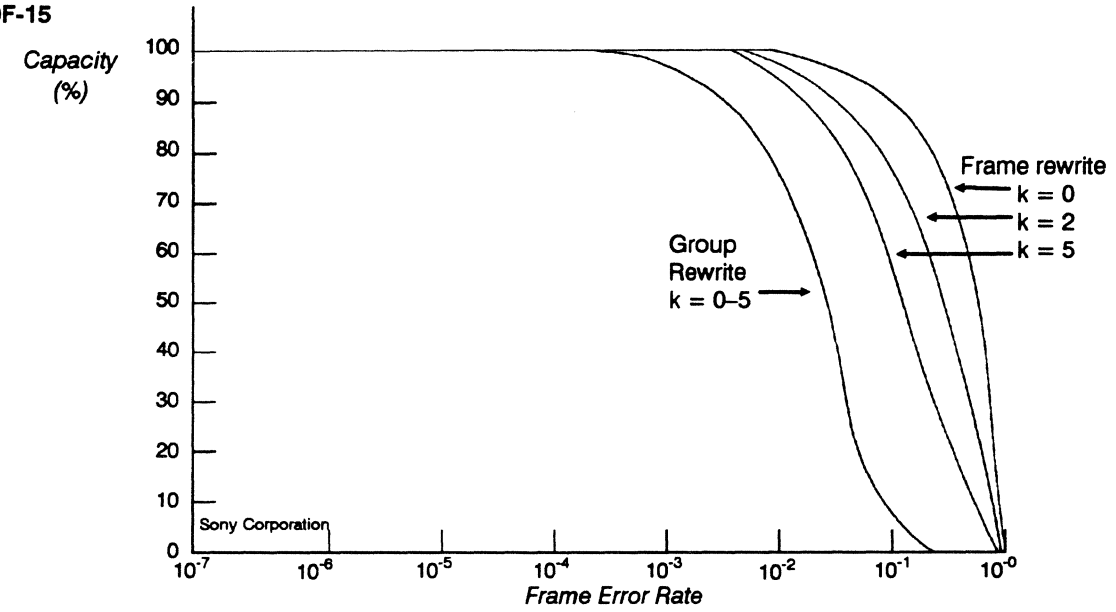
This technique is beneficial, especially when writing without read-after-write, and can recover up to $23(N-1)$ tracks head clog per head, and up to $46(N-1)$ tracks tape damage. Thus 2-group writing can recover up to 23 tracks of head clog and 46 tracks of tape damage, 3-group up to 46 and 92 tracks respectively, 4-group up to 69 and 196, and so on,

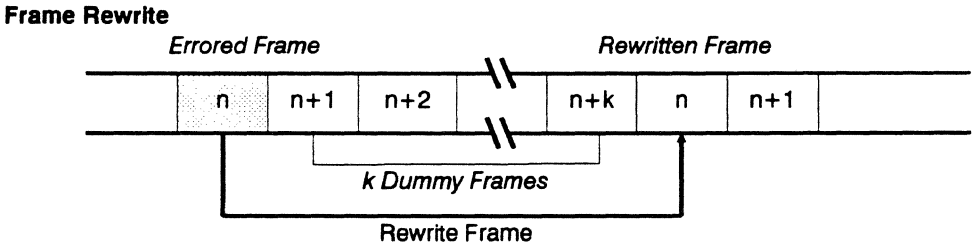
up to 8-group, which could recover up to 161 tracks head clog per head and 322 tracks of tape damage.

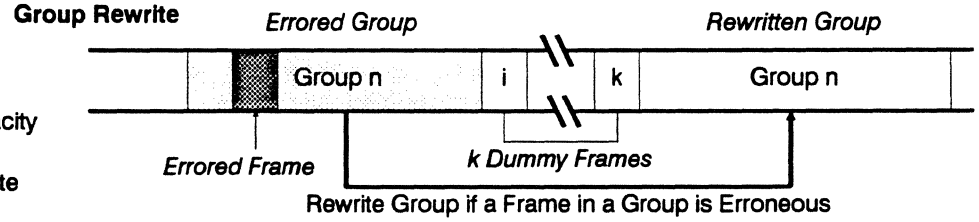
Read-After-Write

This is the most popular and proven method of improving data integrity. In the DDS format, frames are rewritten because this is more efficient than rewriting groups (see figure DF-15).

Figure DF-15







Effective Capacity versus Read-after-Write Scheme

A bad frame can be rewritten after up to five other frames have been written. This allows a variety of read-after-write sequences with existing and future LSI chips, and using mechanisms with a drum diameter of 30 mm and a 90° wrap angle or a drum diameter of 15 mm and a 180° wrap angle.

Attempts can also be made to rewrite each frame up to 128 times to allow the drive to skip damaged areas equivalent to several tracks.

Data Randomizer

The error rates between random data and worst-pattern data differ by a factor of 10. By using a data randomizer, it is possible to reduce the worst-case error rate. The randomizer also produces data with a spread of transitions which have a more consistent RF envelope, allowing accurate RF level detection as a read-after-write criterion.

Checksum

If a head clog occurs during writing, there is a chance that the previously recorded data is not overwritten but remains intact. This is called *drop in*. It is important to check for this type of error occurring during both writes and reads, because it will not be detected by the track-based C1 and C2 codes.

The structure of the C3 ECC is such that it will correct any two tracks if the location of the erroneous tracks is known, but only one track if the track location is unknown. By recording the track checksum in four subcode areas, the location of a drop-in is sure to be detected using the track checksum. This allows us to provide a full two tracks-worth of ECC with the C3 algorithm.

Glossary

AFC Absolute Frame Count.

amble A frame used to separate groups.

ANSI American National Standards Institute, which sets standards for, amongst other things, SCSI and the safety of electrical devices.

area ID Defines the area of the tape and specifies which type of frames are written.

ATF Automatic Track Following—a method of ensuring the head is in the center of the track being read. There are ATF areas at the beginning and end of each track, with the user data in between. The head is wider than a track and so reads the ATF areas of the two tracks on either side as well as that of the track it is supposed to be reading. By comparing the content and strength of the signals from the ATF areas, the servo system adjusts the drum and tape speeds so that the read-head passes directly over the center-line of the track being read.

BAT Block Allocation Table

bit error rate $\frac{\textit{Number of errors}}{\textit{Number of bits written or read}}$

block A set of adjacent logical records treated as a unit of information.

block count The number of blocks written since the beginning of the tape. Filemarks and save-set marks are included in the Block Count.

BOM Beginning Of Media. The first point on the tape which can be accessed by the drive.

BOP Beginning Of Partition. The position at the beginning of the permissible recording region of a partition.

buffered mode A mode of data transfer in write operations which facilitates tape streaming. It is selected by setting the Buffered Mode Field to *1* or *2* in the SCSI Mode Select Parameter List header.

burst error A series of contiguous symbols on the tape which are incorrect.

C1 ECC C1 error correction code is (32,28,5) Reed-Solomon code with an interleave depth of two bytes. This enables it to correct up to two byte error or burst errors up to four bytes long. The code is stored in the same track as the data.

C2 ECC C2 error correction code is (32,26,7) Reed-Solomon code with an interleave depth of four blocks (1 data block = 288 data bits). This enables it to correct up to a three byte error, six byte erasure error, or 792 byte burst error. The code is stored on the same track as the data.

C3 ECC A third level of error correction code covered by the DDS format. C3 allows any two tracks in a group to be corrected, and is used only when a raw data error is too big to be corrected by C1 and C2. C3 code is stored in an extra frame at the end of the twenty-two frames of data in each group.

checksum The sum of a series of bytes which is written to the tape, so that it can be checked against the sum of the same series of bytes when the tape is read.

crosstalk The condition in which the signals from one track on a tape interfere with the signals from an adjacent track.

DAT Digital Audio Tape

data format ID Specifies which data format is being used on the tape.

device area The first area on the tape used by the device for drum spin-up and testing.

DDS Digital Data Storage, a standard format originally developed by Hewlett-Packard and Sony for DAT used for data storage.

dropout An area of tape where the signal level of the medium has fallen off to a level where data recovery is no longer possible.

ECC Error Correction Code

ECMA European Computer Manufacturer's Association

envelope A waveform composed of the instantaneous peak values of an alternating signal which indicates the variation in peak amplitude of the signal.

EOD End Of Data

EOM End Of Media. The last usable point on the tape.

EOP End Of Partition. The position at the end of the permissible recording region of a partition.

EW Early Warning. A physical mark or a device computed position on the tape which tells the drive that it is approaching EOP.

fast searching The process of reading just the sub-areas to locate an item on the tape at a speed up to 200 times faster than normal read speed.

FRU Field Replaceable Unit, an assembly or group of components which is replaced in its entirety by Service Engineers when it contains a fault.

filemark A mark written by the host. It does not necessarily separate files. It is up to the host to assign a meaning to the mark.

filemark count The number of filemarks written since the beginning of the current partition up to and including the current group.

frame Two adjacent tracks, one positive azimuth and one negative azimuth.

group A fixed capacity set of frames written to or read from the tape, defined in the DDS format.

group count The number of user data groups that have been written following the Vendor Group, starting with one. The Vendor Group has a group count of zero.

hard error An uncorrectable data error. During writing, this is defined as being uncorrected after the RAW retry limit has been exceeded. During reading, a hard error is logged if a group is uncorrectable by C1, C2 or C3 ECC.

head clog Particles from the tape or from outside the drive adhere to the head gap on a read or write head and obstruct the reading or writing of data. The particles will often become dislodged again with continued use.

index Information stored at the end of a group which specifies the contents of the group. Every group except the Vendor Group contains one index.

interleaving The process of shuffling the order of data bytes before writing them to tape so that consecutive bytes are recorded as far away from each other as possible. This minimizes the impact of any burst error, so that C1 and C2 ECC have the maximum chance of recovering the data.

lead-in area The first section of the tape used for loading, BOP positioning, and tape usage logging.

load To accept a cassette into the drive, open the lid, and go online.

logical frame number A unique number for each unique frame of a group. An amble frame has a Logical Frame Number of zero. Any repeated frames will have the same Logical Frame Number.

LUN Logical Unit Number, by which a device is identified on the SCSI bus. The drive has a fixed LUN of 0.

N-group writing Sometimes called multiple group writing, N-group writing repeats each group of data so that there are N consecutive copies of each group on the tape. This is a simple way of improving data integrity, but speed and capacity are sacrificed in writing all data several times.

noise Any kind of unwanted magnetic or electric interference detected by the electronics.

online The drive is online when a tape is loaded. The host has access to all command operations, including those which access the tape, set configurations and run diagnostic tests.

offline The drive is offline if the tape is currently unloaded or not in the drive. The host has limited access, and cannot perform any commands which would cause tape motion. The host can, however, load a tape, if one is inserted, and can execute any diagnostic tests which do not require tape motion.

partition A part of a tape which can be treated as a complete and independent whole.

PCM Pulse Code Modulation. A technique of converting an analog signal into a series of numbers (a digital signal) representing the signal's amplitude at successive instants of time.

QIC Quarter-Inch Cartridge. An industry committee for standardization of Quarter-Inch Cartridge formats.

randomizing A recoding of data symbols before they are written to tape in order to provide a consistently high RF envelope level. A consistent RF envelope is one of the criteria for rewriting a frame on read-after-write.

RAW *see* Read-After-Write

raw bit error rate The probability of a bit being an error, without using any error correction techniques (*see* bit error rate).

read-after-write RAW improves data integrity by reading data immediately after it is written and writing the frame again if an error is found. The Audio DAT two-head drum is replaced by a four-head drum for this, with two read-only heads and two write-only heads. Frames are only re-written as necessary, so speed and capacity are affected minimally. RAW is included in the DDS format.

record *see* block

reserved Not generally available for use with the drive. A reserved field should contain all zero bits.

setmark A special recorded element within a partition, which allows fast searching to a point on the tape without having to know the number of records or filemarks that precede this point.

setmark count The number of setmarks that have been written since the beginning of the current partition.

SCSI Small Computer System Interface

soft error A soft error is a data error which can be corrected by a RAW rewrite during writing to tape, or by C1, C2 or C3 ECC, or a read-retry during reading.

spacing Spacing is moving along the tape over a specified number of blocks, filemarks or setmarks, or to EOD, in order to find the data you want quickly.

system area A section in the Lead-in Area used to store the tape usage information.

tape log The tape log contains details of the history of a tape, the total number of groups written, of RAW retries, of groups read, of C3 ECC retries, and of loads. The log is copied into RAM when the tape is loaded into the drive, updated as the tape is used, and loaded back into the System area on the tape when it is unloaded.

tape mark Same as filemark (filemark is the preferred term).

vendor unique The addition of commands to SCSI that are not included in the standard.

writebehind Also called "Immediate reporting during writes". A drive operating in writebehind mode accepts data from a host and reports to the host that the data has been written to the media when actually the data is still in the drive's buffer waiting to be written to tape. This has the advantage that the host can continue with other tasks, based on the assumption that the data has been written.

writebehind condition A condition where the drive's buffer contains data which it has reported as having been written, but in fact still remains to be written.

writebehind queue Data (host data, filemarks and setmarks) held in the drive's buffer which has yet to be written to tape, despite the drive having reported to the host that the data has been written.