software integration

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generation 2 SCSI and FC drives

volume 2: software integration guide

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Revision History

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Edition 1		All. HTML Generation 1 version.
Edition 2	Feb 2003	All. PDF Generation 2 SCSI and FC drive version.

This document is frequently revised and updated. To find out if there is a later version, please ask your HP OEM Representative.

The Purpose of this Manual

This is one of five volumes that document HP Ultrium drives. This volume provides background information for driver and application developers. The following products are covered. Capacities are when the drive is using data compression with a compression ratio of 2:1, where applicable:

- HP Ultrium Generation 2 Full-Height SCSI Internal Drive
- HP Ultrium Generation 2 Full-Height FC Internal Drive

Note Throughout this manual frequent reference is made to SCSI commands. For more information on SCSI commands for HP Ultrium drives see volume 3, The SCSI Interface, of the HP Ultrium Technical Reference Manual set. Ordering details are given below.

Related Documents

The following documents provide additional information:

Documents Specific to HP Ultrium Drives

- **Hardware Integration Guide**, volume 1 of the HP Ultrium Technical Reference Manual
- **The SCSI Interface**, volume 3 of the HP Ultrium Technical Reference Manual
- **Specifications**, volume 4 of the HP Ultrium Technical Reference Manual
- **HP Ultrium Configuration Guide**, volume 5 of the HP Ultrium Technical Reference Manual
- **Background to Ultrium Drives**, volume 6 of the HP Ultrium Technical Reference Manual

Please contact your HP supplier for copies.

- The features and benefits of HP Ultrium drives are discussed in the HP Ultrium Technology White Paper.
- For a general backgrounder on LTO technology and licensing, go to `http://www.lto-technology.com`.

Documentation Map

The following will help you locate information in the 6-volume Technical Reference Manual:

Drives—general

	SCSI Drives	FC Drives
Connectors	**1** HW Integration: *ch.* 7	**1** HW Integration: *ch.* 4
Controller architecture	**6** Background: *ch.* 4	
Front Panel LEDs	**1** HW Integration: *ch.* 6	**1** HW Integration: *ch.* 3
Mechanism and hardware	**6** Background: *ch.* 3	
Specifications	**4** Specs	

Installation and Configuration

	SCSI Drives	FC Drives
Connectors	**1** HW Integration: *ch.* 7	**1** HW Integration: *ch.* 4
Determining the configuration	**2** SW Integration: *ch.* 2	**2** SW Integration: *ch.* 2
External drives *(SCSI only)*	**1** HW Integration: *ch.* 5	n/a
In Libraries	**1** HW Integration: *ch.* 1	
In Servers *(SCSI only)*	**1** HW Integration: *ch.* 4	n/a
In Tape Arrays *(SCSI only)*	**1** HW Integration: *ch.* 3	n/a
Modes of Usage *(SCSI only)*	**1** HW Integration: *ch.* 8	n/a
Optimizing performance *(SCSI only)*	**1** HW Integration: *ch.* 8 **2** SW Integration: *ch.* 4	n/a
UNIX configuration	**5** UNIX Config	

Operation

	SCSI Drives	FC Drives
External drives *(SCSI only)*	**1** HW Integration: *ch.* 5	n/a
In Libraries	**1** HW Integration: *ch.* 1	
In Servers *(SCSI only)*	**1** HW Integration: *ch.* 4	n/a
In Tape Arrays *(SCSI only)*	**1** HW Integration: *ch.* 3	n/a

Cartridges

	SCSI Drives	FC Drives
Cartridge Memory (LTO-CM)	**2** SW Integration: *ch.* 5 **6** HW Integration: *ch.* 5	
Cartridges	**1** HW Integration: *ch.* 9	**1** HW Integration: *ch.* 5
Features	**6** HW Integration: *ch.* 5	
Managing the use of cartridges	**2** SW Integration: *ch.* 1	
Use of cartridges	**2** SW Integration: *ch.* 3	

Interface

	SCSI Drives	FC Drives
SCSI Guide	**3** SCSI	
Commands	**3** SCSI: *ch.* 4	
Error codes	**1** HW Integration: *ch.* 10	**1** HW Integration: *ch.* 6
Implementation	**3** SCSI: *ch.* 1	
Interpreting sense data	**2** SW Integration: *ch.* 3	
Messages	**3** SCSI: *ch.* 2	
Mode pages —see the MODE SENSE command	**3** SCSI: *ch.* 4	
Pre-execution checks	**3** SCSI: *ch.* 3	
Responding to Sense Keys and ASC/Q	**2** SW Integration: *ch.* 6	
Sense Keys and ASC/Q —see REQUEST SENSE command	**3** SCSI: *ch.* 4	

Maintenance and Troubleshooting

	SCSI Drives	FC Drives
Cleaning	**2** SW Integration: *ch.* 5 **2** SW Integration: *ch.* 7	
External drives *(SCSI only)*	**1** HW Integration: *ch.* 5	n/a
In Libraries	**1** HW Integration: *ch.* 1	
In Servers *(SCSI only)*	**1** HW Integration: *ch.* 4	n/a
In Tape Arrays *(SCSI only)*	**1** HW Integration: *ch.* 3	n/a
Monitoring drive and tape condition	**2** SW Integration: *ch.* 7	
Software troubleshooting techniques	**2** SW Integration: *ch.* 1	

Dealing with Errors

	SCSI Drives	FC Drives
Error Codes	**1** HW Integration: *ch.* 10	**1** HW Integration: *ch.* 6
Handling errors	**2** SW Integration: *ch.* 5	
How error correction works	**6** Background: *ch.* 4	
Logs—see the LOG SENSE command	**3** SCSI: *ch.* 4	
Recovering from write and read errors	**2** SW Integration: *ch.* 7	
Software response to error correction	**2** SW Integration: *ch.* 3	
Software response to logs	**2** SW Integration: *ch.* 3	
TapeAlert log	**2** SW Integration: *ch.* 7	

Ultrium Features

	SCSI Drives	FC Drives
Adaptive Tape Speed (ATS)	**6** Background: *ch.* 1	
Autoload	1 HW Integration: *ch.* 2	
Automation Control Interface (ACI)	1 HW Integration: *ch.* 2 6 Background: *ch.* 1	
Cartridge Memory (LTO-CM)s	1 HW Integration: *ch.* 2 **2** SW Integration: *ch.* 5 **6** HW Integration: *ch.* 5	
Data Compression, how it works	**6** Background: *ch.* 5	
Data Compression, managing	**2** SW Integration: *ch.* 5	
Design principles	**6** Background: *ch.* 1	
OBDR and CD-ROM emulation	**6** Background: *ch.* 1 **2** SW Integration: *ch.* 7	
Performance optimization	**1** HW Integration: *ch.* 8 **2** SW Integration: *ch.* 1	n/a
Performance, factors affecting	**2** SW Integration: *ch.* 4	
Software design	**2** SW Integration: *ch.* 1	
Supporting Ultrium features	**2** SW Integration: *ch.* 5	
Ultrium Format	**6** Background: *ch.* 2	

General Documents and Standardization

- Small Computer System Interface (SCSI-1), ANSI X3.131-1986. This is the ANSI authorized standard for SCSI implementation, available through ANSI
- Enhanced Small Computer System Interface (SCSI-2), ANSI X3T9.2-1993 Rev. 10L, available through ANSI

Copies of General Documents can be obtained from:

ANSI	11 West 42nd Street New York, NY 10036-8002 USA	
ISO	CP 56 CH-1211 Geneva 20 Switzerland	
ECMA	114 Rue du Rhône CH-1204 Geneva Switzerland	*Tel:* +41 22 849 6000 *Web URL:* `http://www.ecma.ch`
Global Engineering Documents	2805 McGaw Irvine, CA 92714 USA	*Tel:* 800 854 7179 or 714 261 1455

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Designing Backup Applications

1

In today's computer market, software applications that use tape drives to copy the information from a computer's hard disk for safe keeping are readily available for many different operating systems. Unfortunately, not all these applications take advantage of the advances made in tape technology over the past few years. This section examines some of the characteristics that a good backup utility should include.

Optimizing Performance

There are some fundamental things that tape management applications should implement when dealing with Ultrium drives:

- Use large data transfer sizes.
- Control and monitor data compression.
- Ensure directory information is safe and accurate.
- Maximize the use of the tape drive's internal buffering capability.

Each of these is discussed below.

For more information on optimizing performance, see "Factors Affecting Performance" on page 29.

Large Data Transfer Size

Applications should use large data transfer sizes to make better of the Ultrium drive's internal buffers (64 MB). A good goal to set is at least 64 kilobytes each for read or write operation:

- For *fixed-length block mode* reads and writes, provided the block size times the number of blocks to be transferred is at least 64 kilobytes, drives will provide peak performance. Small block sizes (512 bytes) are

acceptable so long as they are written and read in fixed-length block mode in large transfers.

- For *variable-length block mode* reads and writes, the transfer length should be at least 64 kilobytes.

Data Compression Control

Ultrium drives have built-in hardware data compression. Backup applications should incorporate features to:

- Control the compression capability of the drive.
- Report the actual compression ratio achieved during backup operations.

The typical compression ratio achieved during backup operations on PC and UNIX networks is 2:1, but this can vary widely depending on the actual data being compressed.

For more information, see "Controlling Data Compression" on page 39.

Non-Immediate Commands

Performance can be improved by only using immediate Write Filemarks commands.

Note Using immediate mode with other commands does not improve performance and can cause problems when writing a driver.

The SCSI specification requires that if a command is issued with the IMMEDIATE bit set to 0, the drive must flush its data buffer before it carries out the operation. This takes time.

Managing the Use of Tapes

The Ultrium format enables applications to monitor the performance of tapes closely, to indicate when tape heads need cleaning, and when a tape should be discarded.

See "Use of Tapes" on page 23 for more information.

The Tape Log

The LTO Cartridge Memory holds the System Area for each Ultrium tape that contains data about the tape's history. This Tape log can be used to calculate the error-rate history for the tape, which in turn helps to determine the probability of a successful backup. This information can be used to warn against backing up on a tape of dubious quality.

The Tape log also shows how many times a tape has been loaded or unloaded which gives an indication of the condition of the tape. The application can then warn a user to discard the tape and use a new one, if necessary.

Cleaning Tape Heads

The 'Clean' LED on the front of HP Ultrium drives indicates when a cleaning cartridge should be used. This information can be retrieved by a SCSI REQUEST SENSE command looking at the CLN bit in the sense data.

When a backup application sees that the CLN bit in the REQUEST SENSE data is set, it can prompt the user to clean the drive.

In an automation context, the tape drive tells the automation controller that a cleaning tape needs to be used through two bits in the ACI Get Drive Status command.

- The Cleaning Needed bit signals deterioration in the write or read margin of the drive and indicates that a cleaning cartridge should be used as soon as possible. Once the drive has been cleaned successfully, the Cleaning Needed bit will be cleared.
- The Cleaning Required bit indicates that the drive is unable to read or write unless the drive is first cleaned, so a cleaning cartridge should be used immediately. Following a successful clean, the Cleaning Required bit will be cleared.

Monitoring Tape Use

Drives can report the actual amount of data that has been written to the tape, and the amount of available space on the tape. From this information, applications for Ultrium drives can be designed to calculate the percentage of tape used, and give the user feedback on the actual progress of the backup operation. This is a significant improvement over other technologies, such as

DC6000 QIC products, that require the application to estimate what is going on.

See "Tape Capacity Log Page" under the LOG SENSE command in Chapter 3 of The SCSI Interface, Volume 3 of the HP Ultrium Technical Reference Manual for more information.

While the reliability of tape products and applications is getting better all the time, problems do still occur. There are some very simple techniques that could be incorporated by application developers to simplify the process that a user must go through to resolve problems.

For additional information, see "Exception Handling" on page 61.

TapeAlert

The TapeAlert facility in HP Ultrium drives allows applications to help avoid trouble by prompting the user to take remedial action, or in some cases, through the application automatically performing remedial actions itself.

For example, if the drive is experiencing trouble writing, the software can prompt the user to clean the heads, or, if there are several drives or an autoloader, automatically clean the heads without involving the user.

See "Monitoring the Condition of the Drive and Media" on page 62 for more details.

Diagnostic Logs

SCSI tape drives report problems in response to a REQUEST SENSE command from the host. If the backup application stores this information in a log file, it becomes significantly easier to troubleshoot problems, because the data can be used to pinpoint what is wrong.

Displaying Drive Information

Troubleshooting can also be simplified by giving users the ability to look at the drive's firmware revision, and information about the host bus adapter. This information can be found by executing an INQUIRY command, and can then be displayed, or stored in a log file.

Drive Tests

A basic read/write test should be included in a backup application to check the integrity of the hardware. This should also allow the user to scan the SCSI bus and to solve problems concerning the device setup and configuration.

Online Help

Good backup applications should include online help that will allow users to search on key words and to look up error codes reported by the software or the hardware.

Design Goals for LTO Backup Applications

- Use large SCSI read/write transfer sizes (64 kilobytes is recommended).
- Incorporate data compression control and report the compression ratios achieved.
- Consider where to store directory information depending on the nature of the application.
- Only use immediate WRITE FILEMARK commands, but avoid the using other commands in immediate mode.
- Use Tape Log information to measure tape quality before backing up starts.
- Use the TapeAlert log to prompt the user to take remedial action to avoid problems.
- Use “cleaning required” indicators in the software to prompt the user to clean the drive heads.
- Allow users to set custom cleaning schedules.
- Use log files to store Inquiry and Sense Key/Error Code information about error conditions.
- Allow users to access drive firmware revision and HBA characteristic information
- Include the capability to download firmware.
- Incorporate simple diagnostic capabilities, such as Write/Read tests and SCSI bus scanning.
- Incorporate online help.

Configuration and Initialization

2

This section covers the following topics:

- Operating System drivers
- Inquiry string recovery, finding information about the drive through the Inquiry command
- Additional LUN support, for operation with an autochanger device
- Fibre Channel support

Operating System Drivers

Windows NT — HP have a proprietary, performance-optimized driver for Windows NT 4, Windows 2000 and Win.NET. It is intended that the driver will be freely licenced to any software partner that requires it.

For the latest driver support for HP tape drives, please visit the following HP web site: `http://www.hp.com/support/ultrium`

NetWare — Using the NWPA model of NetWare 4.2/5.0, HP are working with Novell to provide in-box support for HP's Ultrium products.

UNIX — See the UNIX Configuration Guide for details of how to implement Ultrium support under the popular UNIX flavors.

Inquiry String Recovery

HP Ultrium devices should not be recognized solely by the contents of their SCSI INQUIRY strings. In the past, hard-coded recognition of Inquiry strings has meant that software support for follow-on products from HP has been delayed when, to all intents and purposes, the new product was practically

identical to the previous generation. For Ultrium, it is recommended that software applications 'key off' only the first eight bytes of the Product ID field—the text "Ultrium". The only use for the remainder of the bytes in this field is that they will be visible on-screen during the boot process of PC systems. As with HP's DDS products, there will be very little difference between the first Ultrium drives and succeeding generations in terms of their basic SCSI characteristics; they will just be bigger and faster.

Standard INQUIRY Page Data	full-height SCSI	full-height FC
Vendor ID (bytes 8–15)	"HP"	"HP"
Product ID (bytes 16–23)	"Ultrium"	"Ultrium"
Product ID (bytes 24–31)	"2-SCSI"	"2-SCSI*"
Product Revision Level (bytes 32–35)	CYMV	CYMV

*This is not a typo!

Product ID, first 8 bytes

"Ultrium" This will be the same for all HP Ultrium products, regardless of generation or model.

Product ID, last 8 bytes

1st byte:	Generation identifier:	
	"2"	Generation 2 (400 GB at 2:1 compression)
2nd byte	"-"	Hyphen separator (ASCII 2Dh)
3rd–6th bytes	"SCSI"	Parallel SCSI interface (and Generation 2 FC drives)
	"FC"	Fibre Channel interface, although not for Generation 2 drives

Product Revision Level

1st byte:	Product codename ID:	
	"F"	Generation 2 full-height drive
2nd byte	Firmware year:	
	"0"—"9"	2000—2009
3rd byte	Firmware month:	
	"1"—"B"	January—December
4th byte	Firmware variant:	
	"D"	Standard distribution firmware

Example

If new drive families or variants support features that are not available in previous generation products, you can detect the existence of these features through the SCSI Mode Sense and Log Sense commands. Exact details will become available as new products are defined. There is no need to limit driver or application connectivity to a single HP Ultrium product type.

To determine the drive technology family:

Examine only the first eight bytes of the Product ID field (the text "Ultrium").

To determine the Ultrium format generation:

Use one of the following two methods, of which the second is preferred:

- Examine the single character following the text "Ultrium". A "1" indicates format generation 1 (200 GB capacity at 2:1 compression) and so on.
- Preferred method: Use the SCSI Report Density Support command. For a generation 1 product, the following will be returned:

Primary Density Code:	42h	Vendor-unique Density Code
Assigning Organization:	LTO-CVE	Linear Tape Open Compliance and Verification Entity
Density Name:	U28	Ultrium Generation 2, 8-channel

Support for Additional LUN

Enabling Additional LUN Support

When enabled by an internally-connected autochanger device, an extra Logical Unit Number (LUN) will be available at the target's SCSI ID. This allows the attached autochanger device to be addressed via the tape drive. See "Automation Control Interface (ACI)". The normal tape drive LUN will always be LUN0, and the automation LUN will always be LUN1.

No other LUNs are available on the drive, although HP is looking to provide new functionality throught the use of additional LUNs in future products.

Supporting Additional LUNs

When working with a library vendor who is incorporating HP Ultrium drives in products, software developers should liaise directly with the vendor about the functionality of the hardware available through the ACI.

Use of Tapes

3

The HP Ultrium user documentation and “Cartridges”, Chapter 9 of the **Hardware Integration Guide**, Volume 1 of the HP Ultrium Technical Refernence Manual, also contain information on Ultrium cartridges.

Timing considerations are discussed in “Time-Out Values” on page 31.

LTO Cartridge Memory

Cartridge Memory has been added to the LTO cartridge for the following reasons:

- It speeds up load and unload times by removing the need to read system areas.
- It speeds up movement around tape by storing the tape directory (physical to logical mapping).
- It increases tape reliability because fewer tape passes are needed.
- It stores diagnostic and log information for tracking purposes.

Most of these uses are invisible to applications and handled internally by the drive. There is potential for some other applications to use the “Application Specific Data” area. This is being investigated.

For more details, see “Using Cartridge Memory” in “Using Special Features in Libraries”, Chapter 2 of the **Hardware Integration Guide**, Volume 1 of the HP Ultrium Technical Refernence Manual.

Tape Status and Capacity

Following autoload or a load command, the software can determine the state of the tape and its capacity from the Tape Usage Log and Tape Capacity Log

pages retrieved through the LOG SENSE command. The information can also be invoked as a console operation at any time to find the status and condition of the media.

Tape capacity figures can be used for two purposes:

- To give an application or user an indication of whether the tape has enough capacity for a proposed backup. When using data compression, however, this is of little value, since the compression factor cannot be predicted accurately.
- Periodically during a backup to give an approximation of the amount of tape left.

Caution An application should not use the capacity reported in the Tape Capacity log to fix the backup size. This will result in permanent capacity truncation that could represent a significant percentage of the available capacity.

Finding the Remaining Capacity

Examine the Tape Capacity Log to estimate the effective remaining capacity of the tape (data-compression factors are not considered).

Interpreting Log Sense Data

The following points affect the values returned in the data:

Units

- Capacities are given in kilobytes of user data.

General

- If data compression is used, the capacities are specified as though the drive is in pass-through mode. The data compression factor is not considered.
- System log area, vendor group and EOD areas are *not* included in capacities specified. In other words, values are conservative.
- An allowance for read-after-write retries is made.

Maximum Capacity

- Maximum capacity values are only valid when the tape has completed a load sequence. If an immediate mode LOAD is made, LOAD SENSE will not return valid information until the tape has been successfully loaded and tape motion has ceased.

Remaining Capacity

- The remaining capacity value is the amount of tape remaining calculated from the current position. As a result, unless the tape is positioned at EOD,

the calculated value ignores the fact that there may be more data written further up the tape.

- Remaining capacity values are only valid after the successful completion of the following commands in non-immediate mode:

LOAD	LOCATE	MODE SELECT	READ	REWIND
SPACE	VERIFY	WRITE	WRITE FILEMARKS	

The values after any subsequent command cannot be relied on unless the command is a sense type that does not cause any tape motion.

Calculations of capacity are inaccurate in two ways:

- Random errors can be caused by tolerances in tape length, hub diameter, and so on. These are described below.
- Systematic errors are caused by ignoring system areas, and so on. They ensure that the calculated capacity is actually available to the user. It is usually possible to write considerably more data than the calculated capacity.

Tape Length Tolerance—Random Errors

Tape length is subject to significant tolerances in its calculation. These derive from tape thickness, capstan diameter, supply reel hub diameter and supply reel velocity measurements. Tolerances vary from BOM to EOM due to the increasing effect of the supply reel hub diameter tolerance.

The existence of these tolerances can cause apparent anomalies in returned values:

- Successive loads of the same tape may return different maximum capacities.
- At BOM, remaining capacity may be less than maximum capacity. This is because maximum capacity is determined when the tape is loaded. Remaining capacity is determined when the request is made (from the most recent tape motion data). As a result, the tolerances for these measurements may cause a discrepancy between the reported values.

Responding to Tape Log Data

Note Software should use the TapeAlert log in preference to the Tape logs to detect conditions which require the user or host to take preventative action. See "Monitoring the Condition of the Drive and Media" on page 62.

These guidelines indicate how host applications should make use of the data contained in the Tape logs during normal operation (that is, when tapes are not permanently write-protected, not constantly re-formatted).

The console messages triggered by these criteria should clearly indicate a course of action to the end-user, such as the following:

1. Clean the tape heads using a cleaning cartridge.
2. Insert a new tape cartridge.
3. Archive the data.

Load Count

Note This only applies when non-write-protected cartridges are used.

The *load count* is the number of times the cartridge has been loaded into a drive and accessed.

Hewlett-Packard recommends a maximum use for a tape of 20,000 passes over any particular area of the tape. This conservative estimate is also influenced by the quality of the application and the driver software in being able to maintain streaming, thereby preventing repositioning over the same area of tape, without data being transferred.

RAW Retry Counts

Data is read immediately after being written to tape to establish that it has been written correctly. Increases in RAW retries can be due to four factors:

- Deterioration in the media
- Dirty heads
- Drive malfunction
- The operating environment

Corrective Action The recommended criteria for corrective action are as follows:

RAW Retries > 5% Total groups written

When using tapes without write-protection, use the Total count.

The corrective action should be as follows:

1. Use another tape and, for a write operation, try repeating the write. For a read operation, try reading data from the tape.
2. See whether the current RAW value is within the recommended limit.
3. If the values are now within the limit, you can assume that the original tape is nearing the end of its useful life. Proceed as follows:
   - For a write operation, discard the tape and use a new one.
   - For a read operation, transfer the data to a new tape.
4. If the value is still outside the limit, clean the tape heads with a cleaning cartridge and try repeating the operation with the original tape.

Factors Affecting Performance

4

This chapter contains techniques and information to help you design software applications so that they use the tape drive's potential as efficiently as possible.

- Techniques of optimizing performance:
  - Detecting the drive's speed
  - Ensuring the recommended minimum transfer sizes
  - Using Cartridge Memory instead of tape headers
  - Tuning performance using the Performance Log page
- Time-out values to help you tune timings in backup applications
- Log pages. This page gives recommendations on the use of information from the log pages.
- Factors affecting performance. This page examines factors relating separately to the host, the drive and the format, and how they can affect performance.

Ways of Optimizing Performance

HP's Ultrium drives are high-performance products. The drive's native speed is 30 MB/s. With a typical compression ratio of 2:1, this doubles to 60 MB/s. Application software may require significant enhancement in order to capitalize on this speed. There are a number of areas to look at and these are discussed below.

Further details can also be found in the "How to optimize the performance of hp ultrium tape drives" white paper.

Detecting the Drive's Speed

Applications should not key off Inquiry strings in order to tell the difference between different speed drives. It is better to use the Performance Log page see under the LOG SENSE command in Chapter 4, "Commands", of **the SCSI Interface**, Volume 3 of the HP Ultrium Technical Reference Manual.

In the Performance Log page (34h), parameter 04h (Native drive speed) gives the native speed of the drive in units of 100 KB/s. Drives give the value 12Ch, indicating 30 MB/s.

Ensuring the Recommended Minimum Transfer Sizes

In general, the larger the SCSI transfer sizes for Reads and Writes the better. When operating in fixed block mode, the actual block size used is largely immaterial, but the size of each SCSI transfer needs to be maximized. HP recommends a minimum transfer size of 64 kilobytes in order to minimize bandwidth lost to SCSI commands overheads. Note that most SCSI cards working under Windows NT do not support transfer sizes greater than 64 KB without making changes to the Registry.

Maximum Block Size

The Read Block Limits command indicates that block sizes and variable length transfer sizes are supported for values between 1 byte and 16,777,215 bytes.

Media Type Identification

HP recommends that you use the Report Density Support command (with the Media bit enabled) to identify the type of media loaded in the drive. The Medium Type field in the Mode Parameter Header is not used and will always be a blank field.

Using Cartridge Memory Instead of Tape Headers

For optimum performance, it is also important that the host writes application tape header information to the Cartridge Memory (see "Cartridge Memory (LTO-CM)" on page 37)rather than to the actual tape. This allows cartridges to load and unload quickly and prevents excessive media wear at the beginning of the tape. As the access method to Cartridge Memory data is an open standard, it also permits other software systems to identify alien media positively in shared storage environments.

Tuning Performance Using the Performance Log Page

The Performance Log page (34h) contains data that should allow application software to tune the data-rate being sent to the drive dynamically.

Time-Out Values

SCSI Command	Recommended Time-Out Value
Load	10 minutes
Unload	10 minutes
Rewind (full tape length)	10 minutes
Space/Locate	20 minutes
Erase (long)	5 hours
Erase (short)	5 minutes
Write/Write Filemarks	5 minutes
Read	5 minutes
Read/Write Attribute (MAM), with 1 KB of attribute data	1 minutes
Non-tape movement (such as TEST UNIT READY, INQUIRY)	1 minutes

Notes:

- These values are for a single SCSI command in non-Immediate mode. As most commands will be sent in Immediate mode, status will be received by the host typically within 20 ms. In such cases, the time-out given indicates when the drive will have completed the operation and be ready for the next tape movement command.
- All of these values may be subject to change.
- There is no retension facility.
- Where relevant, the figures above apply to 200 GB (at 2:1 compression) media.

Recommended Support of Log Pages

Some of the media-related data items on the log pages are duplicates of data that is available through the Read Attributes command using the Media Auxiliary Memory (MAM) access specification. We recommend that you use MAM commands as the primary source for such data, because this access method is portable to tape drives from other vendors, that is, the data is not in a vendor-unique format.

In the long term, HP intends to expose all tape usage and drive hardware usage information via the industry-standard MAM-format commands, so it is wise to start to implement this approach now.

For full details of the Ultrium log pages, see the LOG SENSE command in Chapter 4, "Commands", of **the SCSI Interface**, Volume 3 of the HP Ultiorum Technical Reference Manual.

Factors Affecting Performance

Further details on improving performance can be found in the "How to optimize the performance of hp ultrium tape drives" white paper.

Host-Related Factors

Performance Factor	Detail
Host SCSI performance	The execution of each SCSI command involves a number of bus phases, of which the data phase is only one. The key phases are as follows: ■ Intra-command bus-free time ■ Arbitration and selection ■ Message out ■ Command
Recommendation:	To achieve the highest performance, the host must execute the phases that it controls quickly.

Performance Factor	Detail
Host Burst Rate	During the data phase of each SCSI command, data is transferred to or from the drive at the host's burst rate. If the host's burst rate is slow, then it takes longer to transfer the data. Extra time during this phase is simply added to the total command time, and so it can affect the overall performance. Even if the burst rate is much faster than that required to maintain streaming, the total command time may prevent the commands from being issued fast enough. *Example:* Consider an 8 kilobyte transfer at burst rates of 8 MB/s and 1 MB/s. The fast transfer takes 1 ms, while the slow transfer takes 8 ms. Since the rest of the command may only take 4–5 ms, the difference of 7 ms is very significant.
Disk Subsystem Performance	The speed and configuration of the disks used will have a significant impact on the backup speed of the whole system. *Recommendation:* Using RAID can have a significant effect on the throughput of the whole system, by the use of interleaved disk reads.
File System Efficiency	Operating systems vary in the efficiency with which they retrieve files sequentially for backup applications. Most operating system development effort is put into speeding up access times within files rather than file seek times. UNIX seems particularly bad at this.
Hardware Configuration	If the disk and tape drives are on separate buses, the effective available bandwidth can be doubled. *Recommendation:* Use one HBA for disks, and put the tape drive on a separate bus.
Host CPU Speed	Faster hosts can typically transfer data quicker. *Recommendation:* Use as fast a processor as possible for the backup system.
Network Transfer Time	If backup involves transferring data over the network, network performance is often a major bottleneck. Even on the fast systems at present, the maximum effective EtherNet bandwidth is only about 1 MB/s, and not all this bandwidth is usable. However the introduction of 100 MB/s networks will make this factor of much less significance. *Recommendation:* ■ For large datasets, use a tape drive attached directly to the server in order to maximize throughput. ■ Minimize the number of clients that require backup.

Performance Factor	Detail
Application Throughput	Some applications move data much quicker than others. Select your application with care.
Write Commands	Do not interleave write commands with other commands, such as READ POSITION and LOG SENSE. Do not, for example, attempt to read the TapeAlert log page during a long write.

Drive-Related Factors

Performance Factor	Detail
Drive's SCSI Performance	In order to minimize SCSI bus loading, the drive must execute its SCSI phases quickly. The phases are as follows: ■ Selection ■ Message-out identification ■ Receipt of the command ■ Disconnection ■ Mid-command bus-free time ■ Arbitration and reselection ■ Message-in identification *Recommendation:* The host must always ensure the following: ■ Disconnects are enabled ■ Synchronous negotiation is enabled and established between the drive and the HBA ■ The drive is in buffered mode ■ When reading and verifying, always use the same block size as that in which the tape is written, otherwise performance will be very seriously affected.
Transfer Mode	The transfer mode can be *fixed* or *variable*, selectable through the MODE SELECT command. *Fixed Mode:* The transfer size is equal to the (block) size multiplied by the number of records (blocks) in the transfer. *Recommendation:* A good transfer size to aim at is 64 kilobytes. For an application that uses 512-byte records, each fixed-mode transfer should transfer 128 records. *Variable Mode:* Only one block is transferred at a time. The size of the block determines the size of the transfer.

<table>
<tr><th>Performance Factor</th><th>Detail</th></tr>
<tr><td></td><td>Recommendation: In variable block mode, the application should use 64-kilobyte blocks.</td></tr>
<tr><td>Records (Block) Size</td><td>The size of the transfer impacts the performance, rather than the size of the record (blocks) in the transfer.</td></tr>
<tr><td></td><td>Recommendation: As above, aim to use 64-kilobyte transfers.</td></tr>
<tr><td>Transfer Size</td><td>Transfer size is the amount of data transferred for a single command, whether the drive is in fixed or variable block mode.

In both fixed and variable modes, the drive works best if it receives a large amount of data for each command, so a large transfer size for write commands is recommended.

At small block size, the transfer rate is substantially degraded. This is because the drive controller and the host spend too much time handling SCSI overhead instead of writing data to tape, resulting in stream-fails. The block size at which this happens varies between drives, but generally the faster the drive, the larger the block size needed to stream.</td></tr>
<tr><td></td><td>Recommendation: Use 64-kilobyte transfers as a minimum.</td></tr>
<tr><td>Data Compression Ratio</td><td>The bandwidth of the data compression engine will determine the drive's streaming capabilities based on the compression ratio of the data it is handling. This is specified in the following table:

<table><tr><th>Product</th><th>Compression Engine bandwidth</th><th>Max Streaming Compression Ratio</th></tr><tr><td>Generation 2 full-height drive</td><td>120 MB/s</td><td>3:1</td></tr></table>
The drive will match the throughput of any host up to the maximum native transfer rate multiplied by the current compression ratio. There will not be any performance penalty for hosts that are slower than the maximum. This capability is accomplished with a 64 MB buffer and use of an Adaptive Tape Speed (ATS) algorithm.</td></tr>
<tr><td>Transfer Direction</td><td>There are some noticeable performance differences between reads and writes, caused by the extra device CPU time needed by the drive to read frames.</td></tr>
<tr><td></td><td>Recommendation: The drive is less likely to stream-read small transfer sizes than it will when writing transfers of the same sizes.</td></tr>
<tr><td>Raw Tape Data Rate</td><td>This is the maximum rate at which data can physically be written to tape. This is 30 MB/s.</td></tr>
</table>

Performance Factor	Detail
	Recommendation: Select the maximum data transfer rate for the type of application used.

Format-Related Factors

Performance Factor	Detail
Tapemarks	Tape marks (filemarks) have many different uses to give a logical structure to data on a tape. The SCSI Standard specifies certain actions that the drive must take when it is told to write a filemark. If the drive is told to write a filemark when the Immediate bit is not set, the standard insists that the drive must flush all data to tape. If used unnecessarily this will adversely affect performance and waste tape capacity.

Supporting Ultrium Features

5

This section covers the following features of HP Ultrium drives:

- LTO Cartridge Memory
- Automation Control Interface (ACI)
- Controlling data compression
- Other Mode page information: the Buffer Size at EW-EOM field and partition size
- Use in tape libraries

Cartridge Memory (LTO-CM)

LTO Contactless Memory (LTO-CM) is EEPROM memory that is embedded in every LTO Ultrium tape cartridge. It is non-volatile and is contactless in that it is read by RF coupling rather than electrical contact.

Further Information

- For general information about LTO-CM, see "LTO Cartridge Memory" in Chapter 5, "Cartridges" in **Background to Ultrium Drives**, Volume 6 of the Ultrium Technical Reference Manual.
- For suggestions of how to make use of cartridge memory in libraries, see "Using Cartridge Memory" in "Using Special Features in Libraries", Chapter 2 of the **Hardware Integration Guide**, Volume 1 of the HP Ultrium Technical Reference Manual.

Cleaning

The tape drive tells the automation controller that a cleaning tape needs to be used through two bits in the ACI Get Drive Status command. The Cleaning

Needed bit indicates deterioration in the write or read margin of the drive and hence it is recommended that a cleaning cartridge be inserted into the drive at the earliest opportunity. Following a successful clean, the Cleaning Needed bit will be cleared. The Cleaning Required bit indicates that the drive is unable to read or write unless the drive is first cleaned with a cleaning tape. It is recommended that a cleaning cartridge be loaded into the drive immediately. Following a successful clean, the Cleaning Required bit will be cleared.

Cleaning cartridges can be used for 50 cleanings.

Resetting Drives

The tape drive can be reset by the automation controller via the ACI Reset command or by pulling the ACI_RST_L line low (see "Rear Panel and Connectors", Chapter 7 of the **Hardware Integration Guide**, Volume 1 of the HP Ultrium Technical Reference Manual). Two levels of reset via the ACI interface are provided, namely ACI Reset and Drive Reset. The former resets the ACI port and all SCSI parallel/Fibre Channel ports. The latter is equivalent to a power-on reset. Either reset method will interrupt the interface between the drive and host, with the Drive Reset potentially resulting in no End of Data written to tape.

It is therefore strongly recommended that an ACI reset command is not sent unless all other recovery methods have failed. Note that certain ACI commands (see Table 5) can be queued behind outstanding SCSI commands giving the impression that the drive has stopped responding over the ACI bus. (All command packages will be still be ack'ed even though the command will be queued.)

Following an ACI Reset command with reset control set to Drive Reset or after pulling the ACI_RST_L line low, the drive will behave as if it has powered up and will go off bus and lose all ACI configurations.

A SCSI interface reset will not affect the ACI interface.

Note that following an upgrade of the drive firmware either via tape or SCSI the drive will be reset as if it had been powered up.

The implementation details are beyond the scope of this document currently.

Backup Software

You need backup application software that supports your Ultrium drive and tape library. For the latest list of backup packages that support your Ultrium drives, please contact your tape library supplier.

Suitable backup applications will include driver software that establishes the interface between the tape drive and the software. Applications usually recognize tape drives by their manufacturers' ID string rather than their model number, so check the table below for the appropriate reference.

Drive Model ID String

Generation 2 FC drive "`HP Ultrium 2-SCSI`" ("SCSI" is not a typo!)

Generation 2 SCSI drive "`HP Ultrium 2-SCSI`"

Controlling Data Compression

The data compression hardware in HP Ultrium drives can detect whether incoming data is already compressed and will not attempt to compress it again. The drive can switch silently and with great agility between the compressing and non-compressing modes, thereby optimizing both compression ratio performance and data rate. As this mode of behavior is embedded in the Ultrium format, there is no need for host application software to switch the drive's data compression on and off.

Support of Data Compression

Host applications may read the Data Compression Mode Page (0Fh) to determine that the drive is capable of data compression; the DCC bit is set to indicate this. It is not recommended that the host attempts to modify either the Data Compression Enable (DCE) or Data Decompression Enable (DDE) bits. Similarly, the Select Data Compression Algorithm (SDCA) field in the Device Configuration Page (page 10h) is set to 1 (on) and it is not recommended that this is changed by application software.

Other Mode Page Information

Buffer Size at EW-EOM

The Buffer Size at EW-EOM field in the Device Configuration Mode page (10h) is set to zero as with HP DDS tape drives and other tape technologies. HP Ultrium tape drives automatically allow sufficient space between EW-EOM and “physical” EOT to satisfy backup applications.

Partition Size

The LTO Ultrium format only supports a single partition. There is no Medium Partition Mode page (11h). In the Device Configuration Mode page (10h), the Change Active Partition (CAP) flag and the Active Partition field should both be zero since multiple partitions are not supported.

Sense Keys and Codes

6

Sense Keys—Actions to Take

Ultrium drives follow the ANSI definition of sense keys. The following table explains how the drives interpret sense key descriptions.

As sense keys and additional sense codes are intended to be hierarchical errors, the table recommends action for the host when a particular sense key is reported.

For more detailed recovery actions, see "Additional Sense Codes—Actions to Take" on page 45.

Code	Sense Key	Interpretation
0h	NO SENSE	These are informational/positional codes. The Additional Sense Codes are not generally considered errors; they usually indicate some condition (such as hitting a filemark). The tape positional codes are mandatory for all sequential access devices. This use complies with SCSI-2, so it is generic. For additional sense codes, see "0h—NO SENSE" on page 46. *Action:* The host will know what to do with this information, depending upon the I/O operation at the time. If CHECK CONDITION occurs with this Sense Key, and the Additional Sense code is not recognized by the host, the software should just log the occurrence and continue. It will not be considered an error. The I/O should have completed without an error. The use of Additional Sense 8000h (Cleaning Request) is recommended. *Console Message:*

Code	Sense Key	Interpretation
1h	RECOVERED ERROR	These errors have been recovered by the drive. The drive may report any type of recovered error Additional Sense code. RECOVERED ERROR is returned is a MODE SELECT parameter is truncated or if a TapeAlert event is being reported. RECOVERED ERROR is the lowest priority Sense Key; it is only reported when the I/O has completed with no other type of CHECK CONDITION having occurred. For additional sense codes, see "1h—RECOVERED ERROR" on page 46.
	Console Message:	None
2h	NOT READY	This Sense Key generally means the host will have to wait for the drive to become READY. Media access is not possible. Click here for additional sense codes. Also see the Media Access pre-execution check.
	Action:	The host needs to take one of the following actions: ■ Wait until the drive becomes available. ■ Issue some type of initializing command. ■ Perhaps instruct the user to put the drive online. The handling of this Sense Key will depend upon the host's operating system and the Additional Sense code.
	Console Message:	`Drive not ready - media access not possible`
3h	MEDIUM ERROR	This sense key indicates a failure that is probably due to a problem with the tape. The I/O did not complete. The I/O may have been partially attempted and data on the tape may have been altered. The drive will have retried an optimal number of times before reporting this sense key. For additional sense codes, see "3h—MEDIUM ERROR" on page 49.
	Action:	Recovery depends on the operating system or application. At the very least, whatever the additional sense code, the software should log the error, terminate I/O to the drive, and pass the appropriate error to the calling application. On read, the driver should discriminate between hard read failures caused by the media, and those resulting from an inability to decompress data.

Code	Sense Key	Interpretation
	Console Message:	On write (Additional Sense = 0C00h): `Write to tape failure` On read (Additional Sense = 70NNh): `Decompression exception` On read (otherwise): `Read from tape failure`
4h	HW ERROR	This indicates that the current I/O operation has failed due to a hardware failure.The FRU code in the sense data should indicate which part of the hardware is bad. The drive should not be used again until corrective action has been taken. Specific recovery depends on the operating system and application. For additional sense codes, see "4h—HW ERROR" on page 53.
	Action:	Whatever the additional sense code, the software should log the error, terminate the I/O, and report the appropriate error to the calling application. Whether the drive requires any further corrective action before it can be used again (such as a reset or manual intervention) depends on the additional sense code.
	Console Message:	`Tape drive hardware failure`
5h	ILLEGAL REQUEST	The last command sent to the drive, or the data sent because of the command, could not be accepted by the drive because it violated conditions imposed by the drive. For additional sense codes, see "5h—ILLEGAL REQUEST" on page 54. Also see the Illegal Command, Illegal Field, Fixed Bit, Reservation and Parameter List pre-execution checks.
	Action:	The software can retry the I/O, or else it can terminate the I/O and report an error to the calling application, particularly if the I/O has been retried a number of times and continues to fail with the same sense key. The specific retry or recovery strategy depends on the operating system.
	Console Message:	`Illegal SCSI command requested`
6h	UNIT ATTENTION	The operating conditions of the drive have been changed in some manner that the host should be aware of. For example, the drive may have gone online or been reset, the Mode parameters may have been changed, a second host may have changed the drive's operating conditions, and so on. For additional sense codes, see "6h—UNIT ATTENTION" on page 56. Also see the Unit Attention pre-execution check.

Code	Sense Key	Interpretation
		Action: Recovery depends on the device class and the additional sense code. For most codes, the software should re-initialize the drive. The driver should repeat the command. If additional sense code = 290Xh, the driver should renegotiate SDTR and reconfigure the drive through MODE SELECT.
		Console Message: `Tape drive operating conditions may have changed`
7h	DATA PROTECTION	This is an error if the I/O operation is attempting to access the media in some manner and failing because the media is write-protected. For additional sense codes, see "7h—DATA PROTECTION" on page 58. Also see the Media Write pre-execution check.
		Action: Depends on the operating system. If this sense key occurs with other than an additional sense code of 2700h, the software should log the error, terminate the I/O, and then send an error (operating system specific) to the calling application. Data on the tape will not have been altered.
		Console Message: `Media write-protected`
8h	BLANK CHECK	An attempt was made to read unwritten media. Recovery from this sense key depends on the operating system. It may be regarded as an error because more data was expected by the host, or it may be an expected condition. For additional sense codes, see "8h—BLANK CHECK" on page 58.
		Console Message: `End-of-Data encountered`
Bh	ABORTED COMMAND	The drive has "given up" on a command. This is normally due to a problem related to the SCSI bus. For example, it is reported if a target or LUN receives a second command from the same host before the previous command from that host has completed. For additional sense codes, see "Bh—ABORTED COMMAND" on page 59.
		Action: Recovery depends on the additional sense code and the operating system. In some cases, the host may want to retry the current I/O. If the additional sense code is 4E00h (overlapped commands attempted), the host may not want to retry the current I/O because the previous I/O will not have been completed.
		Console Message: `SCSI protocol problem`

Code	Sense Key	Interpretation
Dh	VOLUME OVERFLOW	Data could not be written because of a lack of remaining space on the tape. See the Write and Write Filemark commands. Recovery from this depends on the device class and the operating system. It is a "generic" sense key—the host should be able to recover from it without knowing the additional sense code. For additional sense codes, see "Dh—VOLUME OVERFLOW" on page 60.
	Console Message:	`Physical End-of-Tape reached, unable to fit remaining information on tape`

Additional Sense Codes—Actions to Take

These tables provide information about sense data, so that software can know which additional sense codes can be reported under which sense keys. It is important that the operating system makes all Request Sense data available to applications and, in interpreted form, to the end-user.

Actions are suggested for software to use when determining the recovery action for different sense keys and additional sense code and qualifying codes (ASC/ASCQ).

It is strongly recommended that the operating system and/or application use the entire ASC/ASCQ data to determine the appropriate recovery action.

The tables are in numerical order, not order of priority. That is, they do not suggest which sense keys should be checked first, nor do they recommend priorities for the devices to report errors.

Note When the sense, additional sense code and qualifying sense keys are listed, the software may look at all three keys to determine action. The drive should use that exact combination to report that particular error.

For example, a drive will report that it is not ready when there is no cartridge present by setting the sense key to NOT READY with additional sense of 0402h (LUN not ready, initializing command required). No other combination of sense key and additional sense may be used to report that particular condition.

0h—NO SENSE

The following action applies to most additional sense codes in this group:

Action: For all Additional Sense codes except 82 82h, the action of the software depends on the current I/O and what the operating system has been expecting. Recovery depends on the operating system. As a minimum, the software should pass an error to the calling application indicating the positional mark that has been encountered. The I/O can be retried if desired.

Code	Meaning	Comments
00 00	No additional sense info	The drive has no additional sense information for the host. The flags in the sense data indicate the reason for failure.
	Action:	see above
00 01	Filemark detected	This indicates one of the following: ■ A READ or SPACE command was terminated early because a filemark was encountered. ■ Unsolicited Positional Sense has been set to indicate “at a filemark”. The Mark bit in the sense data will always be set.
	Action:	see above
00 02	End of tape detected	A command completed early because End of Tape or the physical end of the tape was encountered. The EOM flag in the sense data will be set.
	Action:	see above
82 82	Drive requires cleaning	The drive has detected that the heads need to be cleaned to maintain good operation.
	Action:	Optionally, log the occurrence for information. It will not be considered an error and the software will continue.

1h—RECOVERED ERROR

Note Reporting of recovered errors defaults to OFF.

Action: In all cases, action depends on the device class and operating system.

Code	Meaning	Comments
37 00	Rounded parameter	The drive needs to round off the value of a parameter sent by MODE SELECT because it cannot store it to the degree of accuracy sent by the command.
5D 00	Failure prediction threshold	Failure Prediction thresholds have been exceeded indicating that a failure may soon occur.

2h—NOT READY

Code	Meaning	Comments
04 00	LUN Not Ready, no cause to report	This is set if a LOAD/UNLOAD command is received while a load or unload is already occurring with immediate report on, or initiated through the front panel. It is present for the duration of the unload or eject, after which the additional sense changes to 3A 00h (medium not present) or 0402h (logical unit not ready, initializing command required). *Action:* 1 Issue a message to the console stating that the tape is currently being unloaded from the drive. 2 Poll waiting until the Additional Sense changes to 3A 00h or 04 02h. 3 Instruct the user what to do, based on the application and the previous sequence of commands. 4 Depending on the application, the software may terminate the current I/O.
04 01	LUN in process of becoming ready	A media access command has been received while a load or unload is already occurring with immediate report on, or initiated through the front panel. *Action:* 1 Effectively poll the drive by re-sending the command until the media is loaded, when UNIT ATTENTION with Additional Sense of 28 00h will be set. At this point the command can be executed. 2 Report to the console that the drive is in the process of loading tape.

Code	Meaning	Comments
04 02	LUN not ready, initializing command required	A cartridge is present in the drive but is not logically loaded.
		Action: 1 The software must issue a LOAD before media access is permitted.
		2 Issue a message to the console to request a user-initiated load, or to indicate drive status, or both.
04 10	Media Auxiliary Memory is not accessible	The Media Auxiliary Memory is not accessible
30 03	Cleaning cartridge installed.	A medium-access command has been sent to the drive while a cleaning cartridge was loaded.
		Action: 1 Terminate the current I/O, and return the appropriate error.
		2 Send a message to the console indicating that a cleaning cartridge is in the drive and a cleaning cycle is being performed.
		3 Prompt the user to wait for the cartridge to be ejected. In a library, the cartridge will be ejected when requested by the library or host. In an internal or external single drive, the cartridge will be ejected automatically.
		4 Prompt the user to proceed with the next application-specific activity.
		5 Log the cleaning cycle in the system log.
37 00	Cleaning failure	A cleaning operation was attempted but could not be completed for some reason.
		Action: Use another cleaning cartridge because the current one has expired.
3A 00	Medium not present	A medium-access command has been received when no cartridge is in the drive.
		Action: As a minimum, issue a message to the console indicating that a drive is present but no tape is loaded.

Code	Meaning	Comments
3A 04	Media Auxiliary Memory not ready to access	MAM is not ready to be accessed. This is likely to be because there is no cartridge present.
3E 00	LUN has not self-configured yet	This is set during power-up when it is not possible to send medium-access commands to the drive because mechanism tests are being executed. When the tests are complete, the Additional Sense changes to 3A 00h, 04 01h or 04 02h depending on whether a cartridge was present at power-on. *Action:* 1 Issue a message to the console indicating that the drive is powering up. 2 Effectively poll the drive until the drive transitions to another state, at which point either execute the command or terminate the I/O.

3h—MEDIUM ERROR

Code	Meaning	Comments
00 02	End of tape detected	A READ, SPACE, WRITE or WRITE FILEMARKS command found EOT unexpectedly. This typically occurs when a drive cannot locate the target object on tape because the block count is too great.The EOM flag will be set. *Action:* 1 Recovery action depends on the initiating action. As a minimum, tell the calling application that physical EOP/M has been encountered. Also display this information as a console message. 2 Send any residue information to the calling application.
00 04	Beginning of tape detected	A SPACE command terminated early because it reached BOT. This typically occurs when a drive cannot locate the target object on tape because the block count is too great. The EOM flag will be set. *Action:* 1 Recovery action depends on the initiating action. As a minimum, tell the calling application that physical BOP has been encountered. Also display this information as a console message. 2 Send any residue information to the calling application.

Code	Meaning	Comments
0C 00	Write error	The drive has failed to write data or filemarks to tape. This is probably due to bad media, but may be hardware-related. Separate additional sense is reported in the case of an Erase failure. Residue information will normally be supplied. *Action:* 1 Terminate the current I/O and return the appropriate error. 2 The software should disable all further transactions to the drive and mark the drive as 'bad'. 3 The software should tell the user that a serious fault has been detected with the drive and advise them to call their technical support. 4 Log the incident in the system log.
0C 0B	Media Auxiliary Memory write error	An error has occurred while attempting to write to MAM. The cartridge should not be used for further backups but should be able to be used for restoring data.
11 00	Unrecovered read error	A read from tape has failed. This is probably due to bad media, but may be hardware-related. *Action:* 1 Terminate the current I/O and return the appropriate error. 2 Send a console message that an unrecovered error on write has occurred. 3 Determine whether the error is deferred, and report the last successful operation and the failed operation to the calling application. 4 Log the error and all recovery actions in the system log. Recovery action is as follows: 1 Use LOG SENSE to find the age and state of the tape and the drive. Based on this, ask the user to clean the drive or replace the tape. 2 If the fault is drive-related, ask the user to retry the operation after the drive has been cleaned. 3 If the fault is with the media, prompt the user to back up the data to a new tape, restart the application and discard the current tape.

Code	Meaning	Comments
11 12	Media Auxiliary Memory read error	An error has occurred while attempting to write to MAM. The cartridge should not be used for further backups but should be able to be used for restoring data.
14 00	Recorded entity not found	A SPACE or LOCATE command failed because of the drive could not find the target of the operation because of a format violation.
	Action:	?
30 01	Cannot read media, unknown format	A LOCATE or SPACE command has found the tape is in a format not supported by the drive.
	Action:	1 Terminate the current I/O, and return the appropriate error. 2 Send a message to the console indicating that the tape is in a format not supported by the drive. 3 Prompt the user to eject the cartridge and insert a valid one. 4 Log the incident in the system log.
30 02	Cannot read media, incompatible format	A READ command could not be completed because the logical format is not correct.
	Action:	1 Terminate the current I/O, and return the appropriate error. 2 Send a message to the console indicating that the tape is wrongly formatted. 3 Prompt the user to eject the cartridge and insert a valid one. 4 Log the incident in the system log.
31 00	Medium format corrupted	READ or SPACE has tried to read data that is in a format that is recognized but which is not valid.
	Action:	1 Terminate the current I/O, and return the appropriate error. 2 Send a message to the console indicating that there is a problem with the format of the tape in the drive. 3 Prompt the user to eject the media and insert a valid Ultrium tape. 4 Log the incident in the system log.

Code	Meaning	Comments
3B 00	Sequential positioning error	The drive has failed to read groups off tape. There are two possibilities: ■ The current command (such as READ, SPACE, REWIND, or WRITE) failed to complete successfully. ■ The logical position has been lost. The tape has been positioned on the other side of the bad groups. The host must determine if it is worth continuing, which presents a danger of missing EOD and running into old data. The host must also decide if the data is old or current. *Action:* 1 Attempt to recover by executing a REWIND command to return to a known position such as BOT. 2 Space to the position of the last known successful command and retry the failing command. 3 If this is unsuccessful, terminate the current I/O, and return the appropriate error. 4 Prompt the user to back up the data to a new cartridge and discard the old one. 5 Log the incident in the system log.
50 00	Write append error	A write-type command failed because the point at which to append data was unreadable. This was probably caused by a powerfail or SCSI bus reset, preventing the drive from completing a write operation properly and appending an EOD. *Action:* 1 Terminate the current I/O and return the appropriate error. 2 Tell the user that the append point is unreadable 3 Advise the user to back up the data to new media and reformat the failing tape. 4 Log the incident in the system log.

Code	Meaning	Comments
52 00	Cartridge fault	A command could not be completed because of a fault with the tape cartridge. *Action:* 1 Terminate the current I/O and return the appropriate error. 2 Tell the user that a serious fault has been detected with the tape cartridge. 3 Advise the user to discard this cartridge and select a new one. 4 Log the incident in the system log.
53 00	Media load/eject failed	A load or eject has failed. *Action:* 1 Terminate the current I/O and return the appropriate error. 2 Inform the user that a serious fault has been detected with the media. 3 Advise the user to discard this cartridge and select a new one. 4 Log the incident in the system log.

4h—HW ERROR

The following actions apply to most Additional Sense Codes for HW ERROR Sense Key:

Action: 1 Terminate the current I/O and return the appropriate error.

2 The software should disable all further transactions to the drive and mark the drive as 'bad'.

3 The software should tell the user that a serious fault has been detected with the drive and advise them to call their technical support.

4 Log the incident in the system log.

Code	Meaning	Comments
14 03	Manual intervention required	A tape is present in the drive but cannot be loaded or unloaded without manual intervention.
	Action:	?
40 *XX*	Diagnostic failure on component *XX*	A self-test command has detected an error, or a command is prohibited from execution due to failure of a previous diagnostic. "*XX*" is a vendor-specific code indicating the failing component.
	Action:	see above
44 00	Internal target failure	This code is used to report hardware and firmware related hard errors that occur when the drive encounters an "impossible" situation.
	Action:	see above
51 00	Erase failure	An ERASE command has failed to erase the specified area.
	Action:	see above
53 00	Media load/eject failed	A load or an eject has failed because of a problem with the tape cartridge.
	Action:	see above

5h—ILLEGAL REQUEST

The following actions apply to all Additional Sense codes in this group:

Action:
1. Terminate the current I/O and return the appropriate error.
2. Log the incident in the system log.
3. Print out all the REQUEST SENSE data bytes and check bytes 15 through 17 to identify the location of the offending bits or bytes.
4. Refer to the table of Drive Error Codes in Volume 3, The SCSI Interface, of the Ultrium Technical Reference Manual to understand why the current values were rejected.
5. This is likely to be an application fault. Send a message to the console "`Illegal SCSI request to tape drive`".

Code	Meaning	Comments
1A 00	Parameter list length error	A MODE SELECT parameter list sent to the drive contains one of the following: ■ An incomplete Mode Parameter header (must be 4 bytes) ■ An incomplete Mode Block Descriptor (must be 0 or 8 bytes) ■ An incomplete Mode page
20 00	Invalid command opcode	The drive does not recognize the opcode of the command it has received.
24 00	Invalid field in CDB	The drive has detected an invalid field in a command descriptor block.
25 00	LUN not supported	The command was addressed to a logical unit number that does not exist.
26 00	Invalid field in Parameter List	The drive detected an invalid field among the command parameters sent during the data phase.
26 01	Parameter not supported	A request for an invalid page number has been sent.
53 02	Medium removal prevented	An UNLOAD command failed to eject the tape because medium removal has been prevented.
82 83	Bad microcode detected	The data transferred to the drive during a firmware upgrade is corrupt or incompatible with the drive hardware.

6h—UNIT ATTENTION

Code	Meaning	Comments
28 00	Not ready to ready transition	A tape has been loaded successfully into the drive and is now ready to be accessed. *Action:* 1 The host should be polling, receiving a CHECK CONDITION with sense key 2h (NOT READY) and additional sense of 04 01h (LUN in process of becoming ready), and expecting this transition. 2 Send the console message: "`Tape drive in process of becoming ready`". 3 After the transition, send the console message "`Tape loaded - media may have changed`".
29 00	Power-on, reset or bus device reset occurred	The drive has powered on or received a SCSI Reset signal or a Bus Device Reset message since the initiator last accessed it. *Action:* The action of the calling application depends on the current I/O and what the operating system is expecting. 1 As a minimum, the host should re-negotiate for synchronous negotiation, and reconfigure the drive with any host-specific operating parameters (burst size, bus activity limit, fixed or variable mode, and so on). 2 The host should then report to the console that the drive has been reset. 3 The I/O can be retried if desired.
2A 01	Mode parameters changed	The Mode parameters for the drive have been changed by a host other than the one issuing the command. UNIT ATTENTION is set for all hosts following a MODE SELECT command, apart from the host that issued the command. This code will only be returned in a multi-host environment.

Code	Meaning	Comments
		Action: When operating the drive in this type of environment, the following actions should occur: 1 The calling application receiving this code should issue a MODE SENSE command requesting the drive to return all parameters. 2 The application should check those parameters over which it has configuration control, to ensure that the current configuration of the drive does not conflict with what the application expects. 3 If it finds discrepancies, the application can either reconfigure the drive to the original values, or halt and report an error. 4 If an error is reported, a console message must be displayed, and information logged to the system log.
3F 01	Microcode downloaded	The firmware in the drive has just been changed by a WRITE BUFFER command.
3F 11	Media Auxiliary Memory accessible	MAM is accessible but the cartridge is in the Hold position.
55 06	Media Auxiliary Memory full	There is insufficient space in the Host Attribute area in MAM to fit the attribute that need to be written. *Action:* Check MAM attribute 0004h (MAM Space Remaining) to identify how much space remains in MAM.
5D FF	False informational exception condition generated	A TapeAlert Mode page has been sent with the Test field set to 1 and the DExcpt field to 0, causing the drive to generate a false informational exception condition (a false device failure). *Action:* Since the function of the Test field is simply to test that an informational exception condition will produce a CHECK CONDITION and that the exception will be reported to the TapeAlert log, no action is necessary.

7h—DATA PROTECTION

Code	Meaning	Comments
27 00	Write-protect	This is set if a write operation (WRITE, WRITE FILEMARKS, or ERASE) is requested for a write-protected cartridge. *Action:* 1 Terminate the current I/O and return the appropriate error. 2 Send a message to the console indicating that the drive has been trying to write to a write-protected tape. 3 Subsequent action depends on the application.
30 00	Incompatible medium installed	A write-type operation could not be executed because it is not supported on the tape type that is loaded. *Action:* 1 Terminate the I/O and return the appropriate error. 2 Send a message to the console indicating that writing is not allowed on the type of tape that is currently loaded. 3 Prompt the user to insert a different tape type. 4 Log the incident in the system log. 5 The calling application can retry the operation.

8h—BLANK CHECK

Code	Meaning	Comments
00 05	End of Data (EOD) detected	A READ or SPACE command terminated early because it encountered EOD. *Action:* 1 Terminate the current I/O and return the appropriate error to the calling application indicating that EOD has been encountered. 2 Send a console message saying that EOD has been encountered. 3 Recovery depends on the calling application and what was expected.

Code	Meaning	Comments
14 03	End of Data not found	A read-type operation failed because a format violation related to a missing EOD data set. The most likely cause is a tape with corrupt format (perhaps from a powerfail when the tape was being written). *Action:* 1 Terminate the current I/O and return the appropriate error. 2 Send a message to the console indicating that EOD could not be found because the tape has corrupt format. 3 Prompt the user to back up the data to another tape and discard the current one. 4 Log the incident in the system log.

Bh—ABORTED COMMAND

The following action applies to all codes in this group except 00 00h and 44 00h:

Action: 1 Terminate the current I/O and return the appropriate error.
2 Log the incident in the system log.
3 Send the console message "`SCSI command aborted - low-level failure on SCSI bus`".

Code	Meaning	Comments
3D 00	Invalid bits in IDENTIFY message	The drive has received an illegal IDENTIFY message at the start of a command.
43 00	Message error	The number of parity errors or problems on inbound or outbound messages has exceeded the limit. Note that it is likely that a Bus Release will occur if excessive parity errors are detected, since the drive will fail to complete the Status phase and Command Complete message.
45 00	Select or reselect failure	The drive has failed to reselect a host to complete an operation. CHECK CONDITION state is assumed to exist, even though it was never reported.
47 00	SCSI parity error	The drive has detected a parity error in an unexpected SCSI state. It should never do this, so this error should be treated as a firmware error.

Code	Meaning	Comments
48 00	Initiator Detected Error message received	An Initiator Detected Error message has been received, and the previous phase (the phase in which ATN was asserted) was invalid.
49 00	Invalid message error	This is set for a number of reasons related to the host and drive not recognizing each others' messages.
4A 00	Command phase error	A command could not be executed because too many parity errors occurred during the Command phase.
4B 00	Data phase error	A command could not be executed because too many parity errors occurred during the Data-In and Data-Out phases.
4E 00	Overlapped commands attempted	A host has selected the drive even though it already has a command outstanding.

Dh—VOLUME OVERFLOW

Code	Meaning	Comments
00 02	End of Tape detected	A WRITE or WRITE FILEMARKS command has encountered EOT or the physical end of tape. The EOM flag will be set.

Note

When the Sense, Additional Sense and Qualifying Sense Keys are listed, the software may look at all three keys to determine action. The drive should use that exact combination to report that particular error.

For example, a drive will report that it is not ready when there is no cartridge present by setting Sense Key = NOT READY with Additional/Qualifying Sense Keys = 04 02. No other combination of Additional/Qualifying Sense Keys may be used to report that particular condition.

Exception Handling

7

These pages cover methods of dealing with certain error conditions and exceptional circumstances. They include the following:

- A suggested Escalation Procedure to follow when exceptions occur
- How to make the most of the TapeAlert facility, see "Supporting TapeAlert" on page 63
- How to respond to the 'Clean' LED (lit on the front panel when there are an excessive number of retries or error corrections)
- The need for a pass-through mode, which can return information or commands specific to a vendor's product
- How drives recover from read and write errors
- How to use the drive's ability to read through media errors, so that as much data can be retrieved from a badly damaged tape as possible

Typical Escalation Procedure

For exception handling, there needs to be a well defined *escalation path*, through which the calling application, user, operator or System Supervisor may take increasingly drastic action to clear any product-related faults.

An escalation procedure is important to allow local recovery where possible, and to avoid the unnecessary replacement of peripheral devices.

A typical escalation procedure is as follows:

1 *Retrieve fault information.*

Specific fault information is retrieved from the following sources:

— INQUIRY data, such as firmware revisions

— REQUEST SENSE data, such as Additional Sense Codes and Drive Error Codes

— MODE SENSE data, such as data on the current configuration

— LOG SENSE data, stored in the drive's logs

2 *Inform the user.*

The system gives the user helpful advice by attempting to decode the returned information, and also allows the user access to the raw data.

3 *Allow the user to try recovery.*

For any fault, the system allows the user to use simple recovery commands such as REWIND or LOAD/UNLOAD.

4 *Allow the user to reset devices.*

If these actions fail, including repeated attempts to retry the operation, the user should be able to reset devices on the SCSI bus selectively, through the use of a BUS DEVICE RESET message. This message is specific only to the device to which it is addressed and will not disturb other devices on the SCSI bus.

5 *Allow the System Supervisor or support person to perform a controlled hard SCSI Bus Reset.*

If the BUS DEVICE RESET message fails to clear the problem, the System Supervisor or technical support person should be able to perform a controlled hard SCSI Bus Reset as follows:

— Lock other users out cleanly.

— Go to a minimal-system single-user mode.

— Close all applications.

— Execute a hard SCSI Bus Reset.

The process should *not* require a complete shutdown and reboot of the system.

Monitoring the Condition of the Drive and Media

HP Ultrium drives support TapeAlert (version 3.0), in which the drive constantly monitors the condition of the mechanism and media, and presents the results in a form that host software can readily use and users can easily understand.

You can find a general description of TapeAlert in the diagnostics section of the User's Guide.

Supporting TapeAlert

HP has refined the TapeAlert standard to include the Predictive Failure flag. If the drive sets this flag, the host should display a message that the drive is "about to fail and should be replaced". There should be no impact on ISV software is the TapeAlert standard is already fully supported.

As with DDS drives, the benefits of the TapeAlert system can only be fully realized if the host software supports full SNMP TapeAlert rather than just Basic TapeAlert. The sending of SNMP traps in response to tape drive-initiated TapeAlert flags allows network management consoles to be aware of tape drive and backup status.

Monitoring the Condition of the Drive and Media

The TapeAlert Log page consists of 64 flags that indicate potential problems with the drive, and that allow host software to suggest appropriate corrective action to the user. For example, if Flag 20 ("Clean Now") is set, the software should advise the user to clean the tape heads.

See the Chapter 4 of Volume 3, **The SCSI Interface** of the HP Ultrium Technical Reference Guide for details of the TapeAlert log page.

Flags

The following table lists the flags that could potentially be supported in tape drives. Of these, flags 3,4,5,6,20,22 and 31 and mandatory for drives that support cleaning cartridges, as do Ultrium drives.

The flags are grouped into the following sections:

- Flags 1 to 19: For tape drive write/read management
- Flags 20 to 25: For cleaning management
- Flags 26 to 39: For tape drive hardware errors
- Flags 40 to 49: For tape autoloader errors

For each flag, the message that the host software should display to the user is given, together with the cause of the flag being set. The Type column classifies the flags by seriousness into the following three groups:

I	Information	A suggestion to the user.
W	Warning	The user is advised to take action. Performance or data may be at risk otherwise.
C	Critical!	Take action immediately.

No.	Flag	Type	Recommended Host Message	Cause
Flags for Tape Drive Write/Read Management				
1	**Read warning**	W	The tape drive is having problems reading data. No data has been lost, but there has been a reduction in the capacity of the tape.	The drive is having severe trouble reading.
2	**Write warning**	W	The tape drive is having problems writing data. No data has been lost, but there has been a reduction in the capacity of the tape.	The drive is having severe trouble writing.
3	**Hard error**	W	The operation has stopped because an error has occurred while reading or writing data which the drive cannot correct.	This flag is set for **any** unrecoverable read/write/ positioning error, and is cleared internally when the tape is ejected. The flag is set as an explanation of the error in conjunction with one of the recovery action flags 4, 5, or 6.
4	**Media**	C	Your data is at risk: 1 Copy any data you require from this tape. 2 Do not use this tape again. 3 Restart the operation with a different tape.	Media performance is severely degraded or the tape can no longer be written or read. This flag is set for any unrecoverable read/write/ positioning error caused by faulty media. It is cleared internally when the media is ejected.
5	**Read failure**	C	The tape is damaged or the drive is faulty. Call the tape supplier's helpline.	The drive can no longer read data from the tape. The flag is set for any unrecoverable read error where the diagnosis is uncertain and could either be a faulty tape or faulty drive hardware. It is cleared internally when the tape is ejected.

No.	Flag	Type	Recommended Host Message	Cause
6	**Write failure**	C	The tape is from a faulty batch or the tape drive is faulty: 1 Use a good tape to test the drive. 2 If the problem persists, call the tape drive supplier's helpline.	The drive can no longer write data to the tape. The flag is set for any unrecoverable write/ positioning error where the diagnosis is uncertain and could either be a faulty tape or faulty drive hardware. It is cleared internally when the tape is ejected.
7	**Media life**	W	The tape cartridge has reached the end of its calculated useful life: 1 Copy any data you need to another tape. 2 Discard the old tape.	The media has exceeded its specified life.
8	**Not data grade** *(not relevant to Ultrium drives)*	W	The tape cartridge is not data-grade. Any data you write to the tape is at risk. Replace the cartridge with a data-grade tape.	A DDS drive has not been able to read the MRS stripes that indicate data-grade tape.
9	**Write-protect**	C	You are trying to write to a write-protected cartridge. Remove the write-protection or use another tape.	A write command was attempted to a write-protected tape.
10	**No removal**	I	You cannot eject the cartridge because the tape drive is in use. Wait until the operation is complete before ejecting the cartridge.	A manual or software unload was attempted when Prevent Medium Removal was in force.
11	**Cleaning media**	I	The tape in the drive is a cleaning cartridge.	A cleaning cartridge is loaded in the drive.
12	**Unsupported format**	I	You have tried to load a cartridge of a type that is not supported by this drive.	Attempted load of an unsupported tape format.

No.	Flag	Type	Recommended Host Message	Cause
13	**Recoverable mechanical cartridge failure**	C	The operation has failed because the tape in the drive has experienced a mechanical failure: 1 Discard the old tape. 2 Restart the operation with a different tape.	The tape has snapped or suffered some other mechanical failure in the drive, but the tape can still be ejected.
14	**Unrecoverable mechanical cartridge failure**	C	The operation has failed because the tape in the drive has experienced a mechanical failure: 1 Do not attempt to extract the tape cartidge. 2 Call the tape drive supplier's helpline.	The tape has snapped or suffered some other mechanical failure in the drive and the tape cannot be ejected.
15	**Memory chip in cartridge failure**	W	The memory in the tape cartridge has failed, which reduces performance. Do not use the cartridge for further write operations.	The LTO-CM chip has failed in cartridge.
16	**Forced eject**	C	The operation has failed because the tape cartridge was manually de-mounted while the tape drive was actively writing or reading.	A manual or forced eject occurred while the drive was writing or reading.
17	**Read-only format**	C	You have loaded a cartridge of a type that is read-only in this drive. The cartridge will appear as write-protected.	A write command has been attempted to a tape whose format is read-only in this drive.
18	**Tape directory corrupted on load**	W	The tape directory on the cartridge has been corrupted. File search performance will be degraded. The tape directory can be rebuilt by reading all the data on the cartridge.	The drive was powered down with a tape loaded, or a permanent error prevented the tape directory being updated.

No.	Flag	Type	Recommended Host Message	Cause
19	**Nearing media life**	I	The tape cartridge is nearing the end of its calculated life. It is recommended that you: 1 Use another tape cartridge for your next backup. 2 Store this tape cartridge in a safe place in case you need to restore data from it.	The tape may have exceeded its specified number of passes.
Flags for Cleaning Management				
20	**Clean now**	C	The tape drive needs cleaning: ■ If the operation has stopped, eject the tape and clean the drive. ■ If the operation has not stopped, wait for it to finish and then clean the drive. Check the tape drive user's manual for cleaning instructions.	The tape drive has detected that it needs cleaning. The flag is cleared internally when the drive is cleaned successfully.
21	**Clean periodic**	W	The tape drive is due for routine cleaning: 1 Wait for the current operation to finish. 2 Use a cleaning cartridge. Check the tape drive user's manual for cleaning instructions.	The drive is ready for a periodic cleaning.
22	**Expired cleaning media**	C	The last cleaning cartridge used in the tape drive has worn out: 1 Discard the worn-out cleaning cartridge. 2 Wait for the current operation to finish. 3 Use a new cleaning cartridge.	The cleaning tape has expired. The flag is set when the tape drive detects a cleaning cycle was attempted but was not successful. It is cleared internally when the next cleaning cycle is attempted.

No.	Flag	Type	Recommended Host Message	Cause
23	**Invalid cleaning cartridge**	C	The last cleaning cartridge used in the tape drive was an invalid type: 1 Do not use this cleaning cartridge in this drive. 2 Wait for the current operation to finish. 3 Use a valid cleaning cartridge.	An invalid cleaning tape type was used.
24	**Retension requested**	W	The tape drive has requested a retension operation.	The drive is having trouble reading or writing that will be resolved by a retension cycle.
25	**Dual-port interface error**	W	A redundant interface port on the tape drive has failed.	One of the interface ports in a dual-port configuration (in other words, Fibre Channel) has failed.
Flags for Tape Drive Hardware Errors				
26	**Cooling fan failure**	W	A tape drive cooling fan has failed.	A fan inside the drive mechanism or enclosure has failed.
27	**Power supply failure**	W	A redundant power supply has failed inside the tape drive enclosure. Check the enclosure user's manual for instructions on replacing the failed power supply.	A redundant PSU has failed inside the tape drive enclosure ot rack subsystem.
28	**Power consuption**	W	The tape drive power consumption is outside the specified range.	The tape drive power consumption is outside the specified range.
29	**Drive maintenance**	W	Preventive maintenance of the tape drive is required. Check the tape drive user's manual for preventive maintenance tasks or call the tape drive supplier's helpline.	The drive requires preventive maintenance (not cleaning).

No.	Flag	Type	Recommended Host Message	Cause
30	**Hardware A**	C	The tape drive has a hardware fault: 1 Eject the tape or magazine. 2 Reset the drive. 3 Restart the operation.	The drive has a hardware fault from which it can recover through a reset.
31	**Hardware B**	C	The tape drive has a hardware fault: 1 Turn the tape drive off and then on again. 2 Restart the operation. 3 If the problem persists, call the tape drive supplier's helpline.	The drive has a hardware fault that is not read/write related or that it can recover from through a power cycle. The flag is set when the tape drive fails its internal power-on self-tests. It is not cleared internally until the drive is powered off.
32	**Interface**	W	The tape drive has a problem with the application client interface: 1 Check the cables and cable connections. 2 Restart the operation.	The drive has identified an interface fault.
33	**Eject media**	C	The operation has failed: 1 Eject the tape or magazine. 2 Insert the tape or magazine again. 3 Restart the operation.	Error recovery action.
34	**Download fail**	W	The firmware download has failed because you have tried to use the incorrect firmware for this tape drive. Obtain the correct firmware and try again.	Firmware download failed.
35	**Drive humidity**	W	Environmental conditions inside the tape drive are outside the specified humidity range.	The drive's humidity limits have been exceeded.
36	**Drive temperature**	W	Environmental conditions inside the tape drive are outside the specified temperature range.	The drive is experiencing a cooling problem.

No.	Flag	Type	Recommended Host Message	Cause
37	**Drive voltage**	W	The voltage supply to the tape drive is outside the specified range.	Drive voltage limits have been exceeded.
38	**Predictive failure**	C	A hardware failure of the drive is predicted. Call the tape drive supplier 's helpline.	Failure of the drive's hardware is predicted.
39	**Diagnostics required**	W	The tape drive may have a hardware fault. Run extended diagnostics to verify and diagnose the problem. Check the tape drive user's manual for instructions on running extended diagnostic tests.	The drive may have a hardware fault that may be identified by extended diagnostics (using a SEND DIAGNOSTIC command).
Flags for Tape Autoloader Errors				
			Flags 40–49 are not currently used.	
50	**Lost statistics**	W	Media statistics have been lost at some time in the past.	The drive or library has been powered on with a tape loaded.
51	**Tape directory invalid at unload**	W	The tape directory on the tape cartridge just unloaded has been corrupted. File search performance will be degraded. The tape directory can be rebuilt by reading all the data.	An error has occurred preventing the tape directory being updated on unload.
52	**Tape system area write failure**	C	The tape just unloaded could not write its system area successfully: 1 Copy the data to another tape cartridge. 2 Discard the old cartridge.	Write errors occurred while writing the system area on unload.
53	**Tape system area read failure**	C	The tape system area could not be read successfully at load time. Copy the data to another tape cartridge.	Read errors occurred while reading the system area on load.

No.	Flag	Type	Recommended Host Message	Cause
54	**No start of data**	C	The start of data could not be found on the tape: 1 Check that you are using the correct format tape. 2 Discard the tape or return the tape to your supplier.	The tape has been damaged, bulk erased, or is of an incorrect format.
55	**Loading failure**	C	The operation has failed because the media cannot be loaded and threaded. 1 Remove the cartridge, inspect it as specified in the product manual, and retry the operation. 2 If the problem persists, call the tape drive supplier's help line.	The drive is unable to load the cassette and thread the tape.
56	**Unrecoverable load failure**	C	The operation has failed because the tape cannot be unloaded: 1 Do not attempt to extract the tape cartridge. 2 Call the tape driver supplier's help line.	The drive is unable to unload the tape.
57	**Automation interface failure**	C	The tape drive has a problem with the automation interface: 1 Check the power to the automation system. 2 Check the cables and cable connections. 3 Call the supplier's helpline if the problem persists.	The drive has identified a fault in the automation interface.
58	**Firmware failure**	W	4 The tape drive has reset itself due to a detected firmware fault. If the problem persists, call the supplier's helpline.	There is a firmware bug.
			Flags 59–64 are not currently used.	

Note that often messages will not appear in isolation. For example, message 01h ("`The tape drive is having problems reading data.`") is likely to appear with a message suggesting remedial action, such as message 04h ("`You are advised to copy any data...`") or message 14h (`Clean Now`).

Each flag is cleared to zero in the following circumstances:

- At power-on.
- When specified corrective action has been taken, such as using a cleaning cartridge.
- When the TapeAlert Log page is read.

Note Once cleared, a flag cannot be set again until the specified clearing conditions are met. So, for example, if the cartridge in the drive is not of data grade, once flag 8 has been cleared, it cannot be set again until the cartridge has been removed.

Designing Software to Use the TapeAlert Log

When writing software to take advantage of the ability of a drive to predict problems and actions that a user should take, it is important not to exclude drives that do not support this feature. For this reason, the application should first check whether the TapeAlert Log page is supported by the drive and then use one of two methods to access the information:

- Use the MODE SELECT TapeAlert Mode page to enable "Check Condition" mode. This means that the tape drive reports CHECK CONDITION on the next SCSI command after one or more TapeAlert flags are set. When CHECK CONDITION is received, the host software should behave as follows:
  - It issues a REQUEST SENSE command. Additional sense of 5D00h indicates that the CHECK CONDITION was caused by TapeAlert. This enables the software to distinguish CHECK CONDITIONs caused by actual errors and those resulting from a TapeAlert flag being set.
  - The software then reads the TapeAlert log page to discover which flags are set (even for CHECK CONDITIONs caused by actual errors).

  Note that when CHECK CONDITION results from TapeAlert, the command that reported the CHECK CONDITION is not in error and will have

completed successfully. It follows that the software should *not* repeat the command.

- Read the TapeAlert log page using LOG SENSE at the following times:
  - Immediately after a SCSI CHECK CONDITION/REQUEST SENSE cycle.
  - At the end of each tape in cases where a backup or restore spans multiple tapes. If the tape is ejected, the host must read the TapeAlert log page before this occurs.
  - At the end of a backup or restore.

  It is also advisable to poll the TapeAlert log page every 60 seconds while the tape drive is idle.

Using "Check Condition" mode is recommended over polling because it guarantees that the software will be aware of any TapeAlert flag being set. It is theoretically possible that TapeAlert information could be missed when polling, though the higher the frequency of polling, the smaller the chance is.

Reading the TapeAlert Log

Each time the TapeAlert log page is read, the application should follow this procedure:

1. Read all 64 flags to discover which are set (there may be more than one).

   There may also be data associated with a set flag in the remainder of the flag byte, which should also be read.
2. For each flag that is set, log the associated error message.
3. Notify the user through the normal notification methods (such as broadcast, E-Mail, SNMP) by displaying the error message suggested in the table. Include the following:
   - Details to identify which drive the message refers to.
   - The software label of the tape cartridge when relevant.
   - The severity of the message (Information, Warning or Critical, with Critical the most severe). Where there are several flags set, list the messages in ascending order of severity.
4. Apply any error message filters in the software to the TapeAlert errors. If several TapeAlert flags are set, they should if possible be presented to the user as a single event. For example, the error messages could be displayed together in a single message box.

5 Optionally, automate the recommended recovery actions if there are multiple tape drives or autoloaders present.

For example, the application could perform a cleaning cycle in response to flags 20 (Clean Now) and 21 (Clean Periodic). It could perform a tape copy for flags 4 (Media performance degraded) and 7 (Media life expired), and then retire the suspect tape cartridge.

This provides an opportunity for applications to add value to the TapeAlert capability of the drives.

Note An application must *not* fail a backup job as a result of TapeAlert information. It should use the information as a preventative measure, taking action to avoid failure, or encouraging the user to take action. It should also retain the log information to help in diagnosis if a job does eventually fail.

Responding to the 'Clean' LED

Note We recommend that software applications use the TapeAlert log, which should mean that potential tape or cleaning problems are flagged and corrected before the drive ever reaches the point of displaying the 'Clean' LED.

If during normal operation, the drive detects an excessive number of RAW retries, the 'Clean' LED is lit. If this happens, a user should follow this procedure:

1 Clean the heads and try the operation again.

2 If the 'Clean' LED is lit again, repeat the operation with another tape cartridge. If this clears the 'Clean' LED, it indicates that the original cartridge is at fault. Copy the data from the cartridge onto a new one and discard the old cartridge.

The 'Clean' LED is cleared by a cleaning cycle or by power-cycling.

Providing Pass-Through Mode

It is important for Drivers and Logical Device Managers to provide a *pass-through* mode that can return information or commands specific to a vendor's product. The need for this is two-fold:

- Systems must support a great variety of new devices.
- For the most part, all tape drives are similar, and Drivers and Logical Device Managers tend to provide connectivity based on the assumption that 80% of all SCSI tape drives behave identically.

A pass-through mode offers the following advantages:

- It allows the peripheral manufacturer to provide value-added diagnostics and support applications over and above those that may be shipped with a system or application.
- It allows System Supervisors and operators to take advantage of specific product features that are otherwise excluded because the driver or manager only caters for 80% of SCSI drives.
- It allows technical support people to have access to low-level device-specific information that otherwise is likely to be unavailable.

Requirements for Drivers and Logical Device Managers

Drivers and Logical Device Managers must allow the user to do the following:

1. Create either a 6-byte or 10-byte SCSI Command Descriptor Block.
2. Allocate a write buffer or file for any data associated with the SCSI command that will be sent to the drive.
   or
   Allocate a read buffer or file for any data associated with the SCSI command that will be returned by the drive.
3. Link the command and data buffers.
4. Launch the command.
5. The driver should use its standard CHECK CONDITION and REQUEST SENSE routines to report whether the command completed successfully or not. The caller must have access to the raw REQUEST SENSE data.
6. View any returned data.

Recovering from Write and Read Errors

Write Recovery

HP Ultrium drives ensure data integrity by performing *Read-After-Write* (RAW) checks while data is written to tape. The drive still maintains streaming.

Read Recovery

If all else fails, the host can attempt to *read through* the media error. See the next section, “Reading Through Media Errors”.

Reading Through Media Errors

In order to cope with exceptional situations, the drive can *read through* media errors in an attempt to recover as much data from tape as possible. Media errors in this case mean hard media errors, from which the drive’s error correction techniques are unable to recover. The media errors may be caused by poor storage or tape abuse.

The following scenario shows how the read-through facility could be used:

1. Media errors of this type can be identified in response to a READ command by a sense key of MEDIUM ERROR, and one of the following additional sense codes:

11 00h	Unrecovered read error
11 01h	Read retries exhausted
31 00h	Format command failed
09 00h	Track following error
15 02h	Positioning error detected by read of medium

2. When one of these errors occurs, the drive automatically attempts to read through several groups of data on tape (the exact number depends on the drive).

3 The host should continue to issue READ commands until no CHECK CONDITIONs are returned, or EOD is encountered. This means the drive has reached good data, and the host should concentrate on redefining the actual logical position.

4 In the extremely unlikely situation that a large number of groups are affected by damaged media, the host could still continue to issue READ commands. The drive will then read through further sets of data. The process is continuous providing that the host issues further READs. In doing this, much time is involved in recovery, and a time-out value of 7 minutes per READ is strongly recommended.

5 Once a READ completes successfully, the host should continue to issue READ commands, or issue a SPACE to filemark command. By reading the header after the filemark, the host can establish which files are unrecoverable, but more importantly, can continue to recover data beyond the damaged area of tape.

Note It is *not* recommended to use the SPACE command to move over a media error.

In addition, if a filemark is involved in the media error, the SPACE command will not complete successfully. This is because the filemark count will be inconsistent and the drive will start searching in the flawed area trying to find the missing filemark.

A filemark can only be detected on a SPACE command if the whole group containing the filemark can be read.

glossary

ANSI American National Standards Institute, which sets standards for, amongst other things, SCSI and the safety of electrical devices.

BOM Beginning Of Media. The first point on the tape that can be accessed by the drive.

buffered mode A mode of data transfer in write operations that facilitates tape streaming. It is selected by setting the Buffered Mode Field to *1* or *2* in the SCSI MODE SELECT Parameter List header.

compression A procedure in which data is transformed by the removal of redundant information in order to reduce the number of bits required to represent the data.

compression ratio A measure of how much compression has occurred, defined as the ratio of the amount of uncompressed data to the amount of compressed data into which it is transformed. The LTO-DC algorithm can typically achieve a compression ratio of between 2:1 and 4:1 depending on the nature of the data.

decompression A procedure in which the original data is generated from compressed data.

ECMA European Computer Manufacturers Association. The European equivalent of ANSI.

EOD End Of Data. An area that signifies the end of the valid data. If new data is written over a larger quantity of old data, it is possible for data to exist after EOD, but because it is after EOD, this old data is no longer valid.

EOM End Of Media format. The last usable point on the tape.

EW-EOM Early Warning End Of Media. A physical mark or a device-computed position on the tape that tells the drive that it is approaching EOM.

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 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.

FRU Field Replaceable Unit, an assembly or group of components that is replaced in its entirety by Service Engineers when it contains a fault.

hard error An uncorrectable data error.

host The host computer system acting as controller for the drive.

load The process in which the drive takes in an inserted cartridge and goes online.

LUN Logical Unit Number, by which different devices at a particular SCSI ID can be addressed individually. The drive has a fixed LUN of 0.

LVD Low-Voltage Differential. *See* SCSI.

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 that would cause tape motion. The host can, however, load a tape, if one is inserted, and can execute any diagnostic tests that do not require tape motion.

online The drive is online when a tape is loaded. The host has access to all command operations, including those that access the tape, set configurations and run diagnostic tests.

RAW *see* read-after-write

read-after-write RAW improves data integrity by reading data immediately after it is written and writing the data again if an error is found.

SCSI Small Computer System Interface—a standard command specification and command set that enables computers and peripherals to communicate with each other. HP's Ultrium drives adhere to the SCSI specifications (see Chapter 1, "Interface Implementation" in Volume 3, The SCSI Interface, of the HP Ultrium Technical Reference Manual) and support all features required by those standard.

Single-Ended and Low Voltage Differential SCSI

These terms define how the signals are transmitted along the cable.

With *single-ended* (SE) SCSI, each signal travels over a single wire and each signal's value is determined by comparing the signal to a paired ground wire. Signal quality tends to decrease over longer cable lengths or at increased signal speed.

With *low voltage differential* (LVD) signaling, signals travel along two wires and the difference in voltage between the wire pairs determines the signal value. This enables faster data rates and longer cabling with less susceptibility to noise than SE signaling and reduced power consumption.

Narrow and Wide, Fast, Ultra and Ultra2 SCSI

Narrow SCSI devices can transfer data one byte at-a-time (and are sometimes called "8-bit SCSI" devices). They can conform to either the SCSI-2 or SCSI-3 protocols. They have a 50-pin connection to the SCSI bus.

Wide SCSI devices can transfer two bytes of data simultaneously ("16-bit SCSI"). They usually have a single, 68-pin connection to the SCSI bus. (This physical arrangement is part of the SCSI-3 specification.) They may support either SCSI-2 or SCSI-3 protocols. Wide and narrow devices can simultaneously be connected to the same bus without problem, provided certain rules are followed.

Fast SCSI can transfer data at up to 20 MB/s wide, using a cable of up to 6 meters total length.

Ultra SCSI can transfer data at up to 40 MB/s wide, but the cable length cannot exceed 3 meters (it is also known as "Fast20").

Ultra2 SCSI can transfer data at up to 80 MB/s wide, using a cable of up to 25 meters total length for a single device, or up to 12 meters for two or more devices (it is also known as "Fast40").

Ultra3 or *Ultra160* can transfer data at up to 160 MB/s wide. Cable lengths are as for Ultra2.

Ultra4 or *Ultra320* will transfer at up to 320 MB/s.

Ultra SCSI supports both SE and LVD interfaces. In normal situations, slower devices can coexist with faster devices, and narrow devices can be used on the same SCSI bus as wide devices using a suitable adapter.

HP's Generation 1 Ultrium drives are Ultra2, wide SCSI-3 compatible devices. They can be used with both LVD and SE host bus adapters.

Generation 2 Ultrium drives are Ultra160, wide SCSI-3 compatible.

single-ended *see* SCSI

TapeAlert A set of 64 flags is held in the TapeAlert log that indicate faults or predicted faults with the drive or the media. By reading this log, host software can inform the user of existing or impending conditions, and can, for example, advise the user to change the tape.

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