

# HP LTO Ultrium tape drives technical reference manual

## LTO4 FC, SCSI and SAS drives volume 1: hardware integration

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

HP LTO Ultrium 4 drives technical reference manual, volume 1: hardware integration

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# Related documents

This is one of five volumes that document HP LTO Ultrium drives. This volume provides hardware integration information for the following products:

- HP LTO Ultrium 4 full-height Fibre Channel tape drives
- HP LTO Ultrium 4 full-height SCSI tape drives
- HP LTO Ultrium 4 full-height SAS tape drives

The following documents provide additional information:

# Related documents

## Documents specific to HP LTO Ultrium drives

- *Software Integration Guide*, volume 2 of the HP LTO Ultrium Technical Reference Manual
- *Host Interface Guide*, volume 3 of the HP LTO Ultrium Technical Reference Manual
- *Specifications*, volume 4 of the HP LTO Ultrium Technical Reference Manual
- *UNIX, Linux and OpenVMS Configuration Guide*, volume 5 of the HP LTO Ultrium Technical Reference Manual

Please contact your HP supplier for copies.

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

# Documentation map

The following will help you locate information in the Technical Reference Manual. A reference like “1 HW Integration: ch. 7” means Volume 1, *Hardware Integration Guide*, of the HP LTO Ultrium Technical Reference Manual, chapter 7.

## Drives—general

	FC Drives	SCSI Drives	SAS Drives
Connectors	1 HW Integration: <i>ch. 4</i>	1 HW Integration: <i>ch. 7</i>	
Front panel LEDs	1 HW Integration: <i>ch. 3</i>	1 HW Integration: <i>ch. 6</i>	
Specifications	4 Specifications		

# Installation and configuration

	FC Drives	SCSI Drives	SAS Drives
Connectors	1 HW Integration: <i>ch. 4</i>	1 HW Integration: <i>ch. 7</i>	
Determining the configuration	2 SW Integration: <i>ch. 2</i>		
External drives	n/a	1 HW Integration: <i>ch. 5</i>	

	FC Drives	SCSI Drives	SAS Drives
In libraries	1 HW Integration: ch. 1		
In servers	n/a	1 HW Integration: ch. 4	
In tape arrays	n/a	1 HW Integration: ch. 3	n/a
Linux configuration	5 UNIX, Linux, OpenVMS Configuration		
Modes of usage	n/a	1 HW Integration: ch. 8	n/a
OpenVMS configuration	5 UNIX, Linux, OpenVMS Configuration		
Optimizing performance	n/a	1 HW Integration: ch. 8	n/a
		2 SW Integration: ch. 4	
UNIX configuration	5 UNIX, Linux, OpenVMS Configuration		

## Operation

	FC Drives	SCSI Drives	SAS Drives
External drives	n/a	1 HW Integration: ch. 5	
In libraries	1 HW Integration: ch. 1		
In servers	n/a	1 HW Integration: ch. 4	
In tape arrays	n/a	1 HW Integration: ch. 3	n/a

## Cartridges

	FC Drives	SCSI Drives	SAS Drives
Cartridge Memory (LTO-CM)	2 SW Integration: <i>ch. 5</i>		
Cartridges	1 HW Integration: <i>ch. 5</i>	1 HW Integration: <i>ch. 9</i>	
Managing the use of cartridges	2 SW Integration: <i>ch. 1</i>		
Use of cartridges	2 SW Integration: <i>ch. 3</i>		

## Interface

	FC Drives	SCSI Drives	SAS Drives
FC, SCSI and SAS host interface guide	3 Host Interface		
Commands	3 Host Interface: <i>ch. 5</i>		
Error codes	1 HW Integration: <i>ch. 6</i>	1 HW Integration: <i>ch. 10</i>	
Implementation	3 Host Interface: <i>ch. 1</i>		
Interpreting sense data	2 SW Integration: <i>ch. 3</i>		
Messages	3 Host Interface: <i>ch. 2</i>		
Mode pages —see the MODE SENSE command	3 Host Interface: <i>ch. 5</i>		

	FC Drives	SCSI Drives	SAS Drives
Pre-execution checks		3 Host Interface: ch. 4	
Responding to sense keys and ASC/Q		2 SW Integration: ch. 6	
Sense keys and ASC/Q —see REQUEST SENSE command		3 Host Interface: ch. 5	
Task management functions	n/a	3 Host Interface: ch. 3	

## Maintenance and troubleshooting

	FC Drives	SCSI Drives	SAS Drives
Cleaning		2 SW Integration: ch. 5 2 SW Integration: ch. 7	
External drives	n/a	1 HW Integration: ch. 5	
In libraries		1 HW Integration: ch. 1	
In servers	n/a	1 HW Integration: ch. 4	
In tape arrays	n/a	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

	FC Drives	SCSI Drives	SAS Drives
Error codes	1 HW Integration: ch. 6	1 HW Integration: ch. 10	
Handling errors		2 SW Integration: ch. 5	
Logs—see the LOG SENSE command		3 Host Interface: 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	

## LTO Ultrium features

	FC Drives	SCSI Drives	SAS Drives
Autoload		1 HW Integration: ch. 2	
Automation Control Interface (ACI)		1 HW Integration: ch. 2	
Cartridge Memory (LTO-CM)		1 HW Integration: ch. 2 2 SW Integration: ch. 5	
Data compression, managing		2 SW Integration: ch. 5	
OBDR and CD-ROM emulation		2 SW Integration: ch. 7	

	FC Drives	SCSI Drives	SAS Drives
Performance optimization	n/a	1 HW Integration: ch. 8	
		2 SW Integration: ch. 1	
Performance, factors affecting		2 SW Integration: ch. 4	
Software design		2 SW Integration: ch. 1	
Supporting LTO Ultrium features		2 SW Integration: ch. 5	

## General documents and standardization

See [http://www.t10.org/t10\\_main.htm](http://www.t10.org/t10_main.htm) for INCITS SCSI Primary Commands—3 (SPC-3), SCSI Streaming Commands (SSC-3) and other specifications

Copies of documents of other standards bodies can be obtained from:

*INCITS* 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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# 1 LTO Ultrium drives in libraries

## Introduction

This chapter contains information that relates to placing an HP LTO Ultrium drive in an automated device, such as an autochanger or a tape library:

- Drives for use in libraries have different front panels from drives mounted individually in servers and standalone drives. There is also a special front panel for use in autoloaders. These are described on [page 14](#).
- For notes on the requirements and other details for the installation of drives into libraries, see [page 16](#).
- For notes on the operation of drives in libraries, see [page 20](#).
- For troubleshooting information, see [page 22](#).

Chapter 2 contains information about using special features of LTO Ultrium drives in libraries:

- The “Automation and drive interface” (ACI/ADI) allows the activities of the drive to be coordinated within a library. See [page 25](#) for details.
- “Configuring autoload and library-controlled loads” on [page 27](#) allows you to configure whether automatic or ACI-controlled loads and unloads occur.
- LTO Cartridge Memory (LTO-CM) or Cartridge Memory 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.
  - For suggestions of how to make use of cartridge memory in libraries, see “Using Cartridge Memory (LTO-CM)” on [page 30](#).

## Backup software

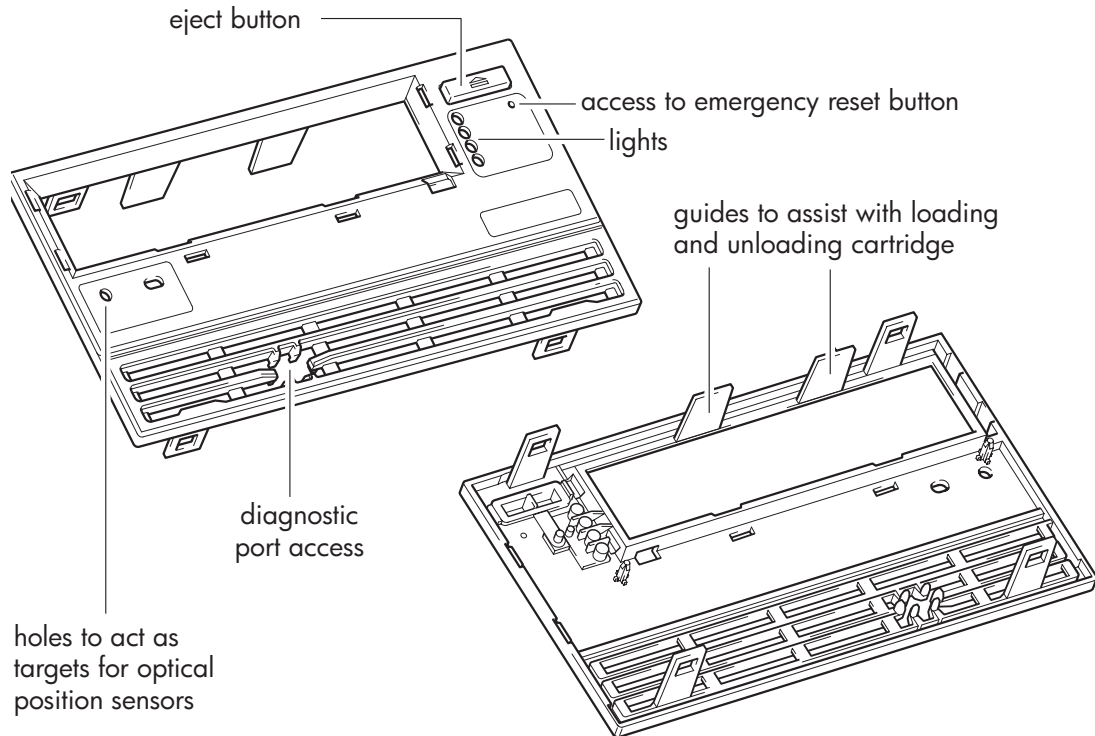
You need backup application software that supports your LTO Ultrium drive and tape library.

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 numbers, so check the following table for the appropriate reference.

### Drive Model ID String

<i>LTO 4 FC drive</i>	<code>"HP Ultrium 4-SCSI"</code>
<i>LTO 4 SCSI drive</i>	<code>"HP Ultrium 4-SCSI"</code>
<i>LTO 4 SAS drive</i>	<code>"HP Ultrium 4-SCSI"</code>

## Front panel for automation use



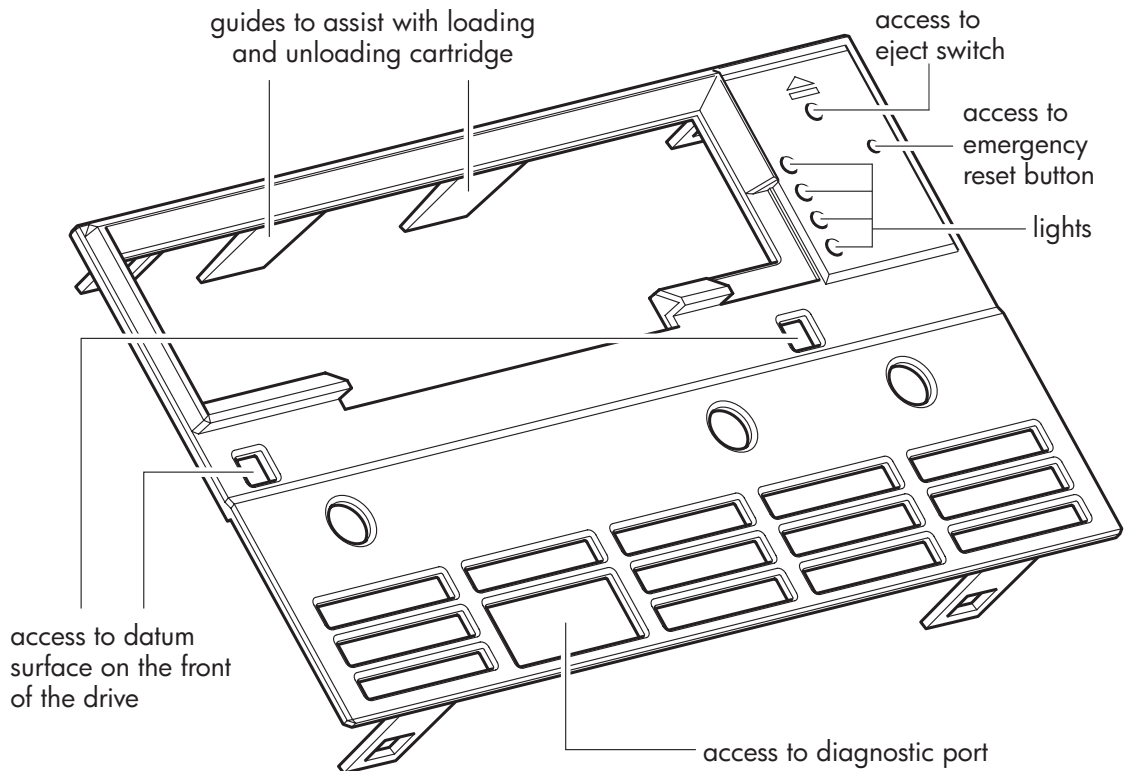
The automation front panel has the following features:

- There is an eject button for manually ejecting a cartridge. Press this for approximately ten seconds to start a “forced eject” for recovering a cartridge manually. See [page 22](#) for details.
- Indicator LEDs provide a visible indicator of the state of health of the drive. See [Chapter 6 on page 69](#) for details.
- There is no door. Instead there are two fixed guides to guide the cartridge into the drive.
- There is access to a proprietary serial HP LTO diagnostics port. To access this port via RS232 requires an HP LTO Diagnostics Interface Card. Diagnostic information from the drive such as power-on hours, tape-pulling hours, error codes, and firmware trace-logs can be accessed by connecting to the serial communications port on a computer. Please contact HP for further details on this diagnostics port.
- The indent for a label on the left just under the cartridge opening is left blank, exposing two holes. These can be used to provide a target for the optical position sensor of a library picker.
- There are additional holes around the cartridge opening to allow a throat to be fitted if necessary, to help the smooth loading of cartridges.

## Front panel for use in autoloaders

A special front panel is available for autoloader applications where the autoloader conforms to a 2U product height. The front panel fits within the drive form factor in height and width:

The autoloader front panel has the following features:



- Simple one-piece plastic design
- Pinhole access to the eject switch on the drive for manually ejecting a cartridge. Press this for approximately ten seconds to start a "forced eject" for recovering a cartridge manually. See [page 22](#) for details.
- Indicator LEDs provide a visible indicator of the state of health of the drive. See [Chapter 6](#) for details. The LEDs are viewed through holes in the autoloader front panel; no light pipes are present.
- Access to a proprietary serial HP LTO diagnostics port. To access this port via RS232 requires an HP LTO Diagnostics Interface Card. Diagnostic information from the drive such as power-on hours, tape-pulling hours, error codes, and firmware trace-logs can be accessed by connecting to the serial communications port on a computer. Please contact HP for further details.
- Clearance for picker finger access to the right-side cartridge-handling notch
- Two square holes through the panel to provide access to a datum surface on the front of the drive
- Cartridge lead-in features to improve cartridge load and unload operations

# Installing drives

## Airflow requirements

HP LTO Ultrium drives require forced airflow from front to back and, in the case of full-height drives, from back to front provided it does not exceed critical temperatures.

The required flow depends on the ambient air temperature:

- 6 cfm for ambient air temperatures fluctuating in the range 10°C–35°C.
- 8 cfm for ambient air temperatures fluctuating in the range 10°C–40°C.

## Measuring internal drive temperatures

### FC and SCSI drives

The recommended method of measuring the temperature of critical components is to read the “Max temperature since cartridge loaded” after exercising the drive by writing data at the maximum data rate for a period of at least one hour. This temperature correlates closely with the temperature of the most critical ICs.

If the airflow is adequate, the maximum temperature at the sensor should be no more than 20°C above ambient.

The maximum temperature at the sensor should be:

- <31°C above ambient for 40°C maximum temperature ambient environment
- <36°C above ambient for 35°C maximum temperature ambient environment

This equates to:

- <71°C at 40°C ambient (8 cfm airflow)
- <71°C at 35°C ambient (6 cfm airflow)

### Extracting internal temperature information

You can extract the “Max temperature since cartridge loaded” reading via the main interface or via the ACI/ADI `send_scsi` command as follows:

1. Send a SEND DIAGNOSTICS command with the following data out:

```
1D 11 00 00 08 00
93 00 00 04 00 00 20 2A
```

2. Send a RECEIVE DIAGNOSTICS command:

```
1C 01 93 00 44 00
```

3. The “Max temperature since cartridge loaded” value is ASCII encoded in bytes 22–29 of the incoming data.

Example SCSI trace:

```
SendDiagnostic      |1D 11 00 00 08 00 |00008|00|00|
Data Out           |93 00 00 04 00 00 20 2A |
ReceiveDiagResults |1C 01 93 01 00 00 |0009C|00|00|
Data In            |93 00 00 98 30 30 30 30 31 41 31 32 20 30 30 30 |
Data In            |30 31 41 31 32 20 30 30 30 30 31 41 37 34 20 30 |
```



```

Data In |30 30 30 31 39 31 37 20 0D 0A 30 30 30 30 30 30 |
Data In |30 30 20 30 30 30 30 30 30 30 30 30 20 30 30 30 |
Data In |33 32 30 30 20 30 30 30 30 30 30 35 30 30 20 0D 0A |
Data In |46 46 46 46 38 30 30 30 20 46 46 46 46 38 30 30 |
Data In |30 20 46 46 46 46 38 30 30 30 20 46 46 46 46 38 |
Data In |30 30 30 20 0D 0A 46 46 46 38 30 30 30 30 20 46 |
Data In |46 46 46 38 30 30 20 30 30 30 30 30 30 35 30 30 |
Data In |20 30 30 30 30 30 35 30 30 20 0D 0A |

```

4. Translate each character received from ASCII to hex numbers.

For the example above: 30 30 30 30 31 41 37 34 = 00001A74h

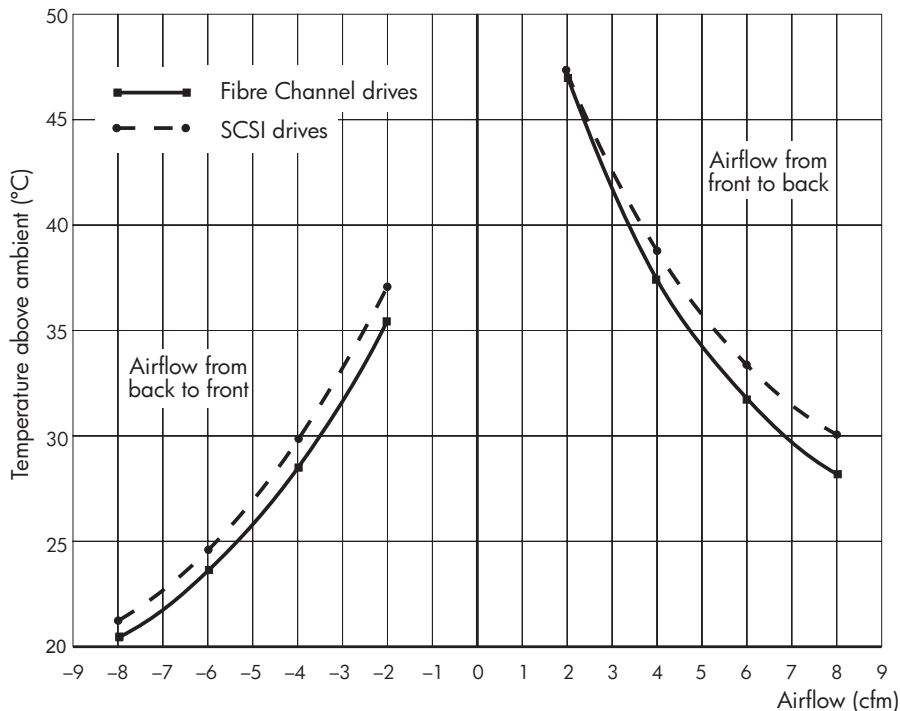
5. Convert this number to decimal = 6772

6. Divide this number by 256 to give the temperature in °C = **26.45°C**

## FC and SCSI drives

A method for approximating the air flow for LTO Ultrium drives is to use the drive's Primary Temperature Sensor (PTS).

1. Exercise the drive by writing data at the maximum data rate for a period of at least 45 minutes.
2. Find the PTS reading as in the previous section, "[Extracting internal temperature information](#)".
3. Subtract the ambient air temperature in which the drive was run from this PTS temperature.
4. Use this temperature rise above ambient to find the required air flow for the drive using the following graph. Because of variations in the temperature sensor (PTS) reading between drives, you are recommended to average readings from four different drives to obtain the best results.



**NOTE:** SAS drives should be powered from the normal rear panel connector, not through the power part of the SAS connector.

The drive is specified to operate at 5V±5% and 12V±10%. Voltage and current requirement are as follows:

Full-height drives

	FC Drives		SCSI Drives		SAS Drives	
Specification	5V	12V	5V	12V	5V	12V
Max voltage	5.25V	13.2V	5.25V	13.2V	5.25V	13.2V
Min voltage	4.75V	10.8V	4.75V	10.8V	4.75V	10.8V
Max steady-state current	4.2A	0.75A	3.4A	0.7A	TBD*A	TBDA
Max transient current	4.5A	2.5A	3.8A	2.5A	TBD*A	TBDA
Max steady-state power	21W	9W	17W	9W	TBDW	TBDW
Max transient power	22.5W	30W	21W	30W	TBDW	TBDW
Max noise/ripple	150 mVpp	150 mVpp	150 mVpp	150 mVpp	TBD mVpp	TBD mVpp

Rear panel and connectors

△ **CAUTION:** LTO Ultrium tape drives are not installable or replaceable by end-users, so the attachment or removal of FC, SCSI, SAS, power and ADI cables between the tape drive and the tape library should only be carried out by service-trained personnel authorized by the tape library supplier. The connectors are not field upgradeable.

The rear panel contains the connectors that allow the tape drive to communicate with the tape library and host computer system. The panel includes the following connectors:

On all drives:

- Power connector  
A standard 4-pin power connector used to supply the 5V and 12V power the tape drive.
- ADI connector (for automation use)  
For details of the ADI connector, see [page 80](#). For details of the use of the ADI connector in libraries see "[Automation/Drive Interface \(ADI\)](#)" on [page 26](#).
- Diagnostic Serial port connector  
The proprietary serial HP LTO diagnostic port. To access this port via RS232 requires an HP LTO Diagnostic Interface Card. Diagnostic information from the drive can be accessed by connecting to the serial communications port on a computer. Contact HP for further details on this diagnostic port and its function.

### On Fibre Channel drives:

- Fibre Channel connectors  
Two Small Form Factor Pluggable (SFP) duplex-LC fibre channel transceivers. Depending on the specific configuration, only one SFP FC transceiver may be installed. For details see [page 80](#).
- AL\_PA connector  
A 2x7-pin auxiliary connector used to set a specific Arbitrated Loop Physical Address (AL\_PA). Two pairs of pins can also be used to power remote transceiver status LEDs. For details see ["Fibre Channel addressing"](#) on page 78.

### On SCSI drives:

- SCSI connector  
A standard 68-pin high-density SCSI connector. The SCSI cables may be installed in a daisy-chain configuration linking two or more LTO Ultrium tape drives on the same SCSI bus.
- SCSI address connector  
A 12-pin auxiliary connector used to set the SCSI ID. Each device on the SCSI bus must have a unique SCSI ID set by the SCSI address connector or by the tape library.

### On SAS drives:

- A standard internal SAS connector  
An HP LTO4 SAS tape drive should be powered from the normal power connector and not through the power port of the SAS connector. The power port on the SAS connector is not connected to the tape drive.

## Fixing dimensions

The positions of fixing points are shown below.

The recommended screw length depends on the thickness of the rails or enclosure into which the drive is mounted:

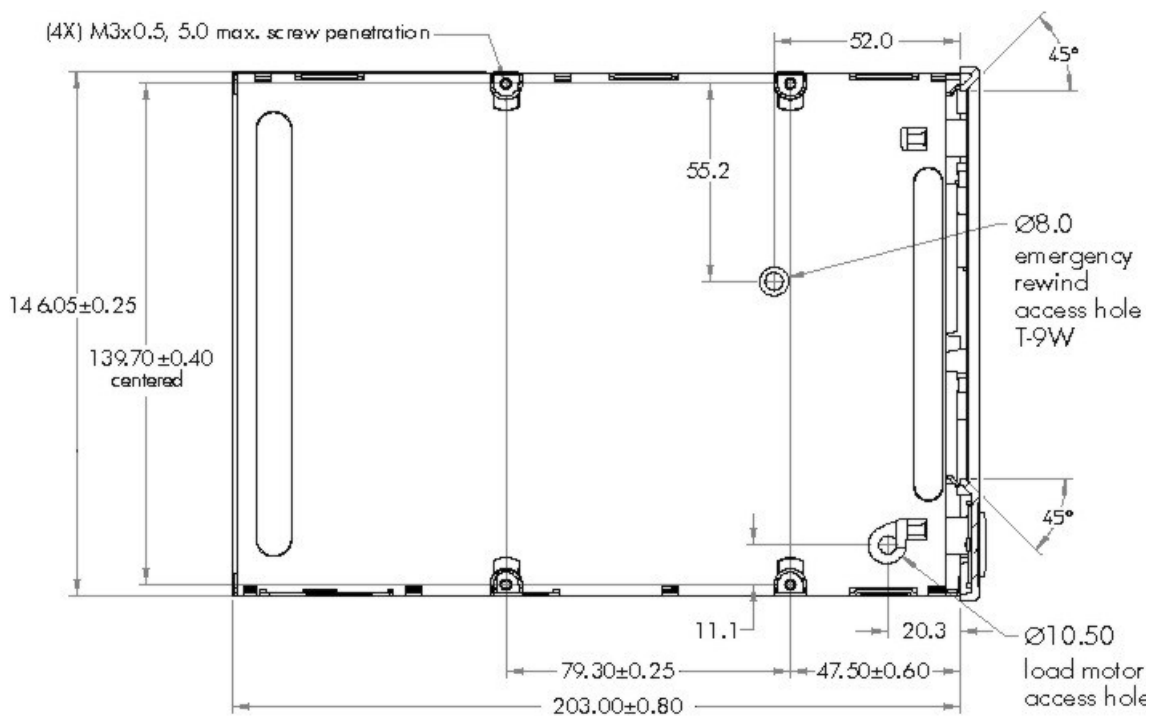
Server or Rail Thickness	Recommended Screw Length
> 1.5 mm ≤ 2.0 mm	M3 x 6.0 mm
> 1.0 mm ≤ 1.5 mm	M3 x 6.0 mm
≤ 1.0 mm	M3 x 5.0 mm

All screws should be M3 threaded. Do not use spring washers.

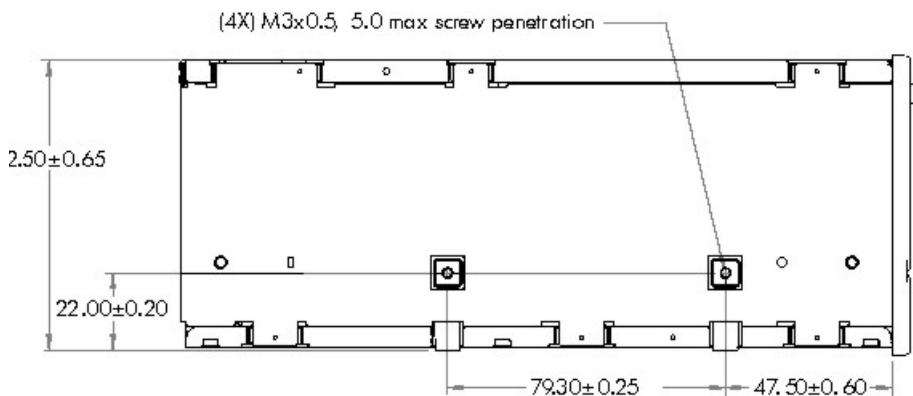
The recommended mounting torque is 6.0 ±0.5 in-lbs (60–70 N/cm).

HP recommends 0.3 mm mounting clearance around all covers for isolation mounting movement.

## Bottom panel



## Side panel



## Operating drives

Drives installed in a tape library are controlled through the tape library operator panel. Refer to the tape library documentation for details.

## Cleaning

When the drive needs cleaning, the orange 'Clean' LED on the tape drive will flash. Only insert an HP Ultrium Universal cleaning cartridge into the tape drive when the LED flashes.

The tape drive also tells the automation controller that a cleaning tape needs to be used via the ADI connector.

See "[Automation and drive interface](#)" on page 25 for details of ACI commands.

---

△ **CAUTION:** Only use LTO Ultrium Universal cleaning cartridges with HP LTO Ultrium tape drives. Do not use swabs or other means of cleaning the heads.

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### To clean the heads:

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📝 **NOTE:** HP recommends that you use the HP LTO Ultrium Universal cleaning cartridge C7978A (Orange).

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LTO Ultrium Universal cleaning cartridges can be used up to 50 times.

1. Insert a cleaning cartridge into the drive. The tape drive automatically loads the cartridge and cleans the heads.

If the cleaning cartridge ejects or returns to the ready-to-eject position immediately with the Tape Error LED on, it has expired or it is not an LTO Ultrium Universal cleaning cartridge (or is an older unsupported LTO Ultrium 1 cleaning cartridge). In this case, discard the cleaning cartridge and repeat the operation with a new one.

The cleaning cycle can take up to 3 minutes, during which the orange 'Clean' LED will be on steadily and the green 'Ready' LED will flash. When it has finished, the drive ejects the cartridge or returns the cartridge to the ready-to-eject position.

2. Remove the cleaning cartridge from the drive.

## Resetting drives

The tape drive can be reset by the automation controller via the ADI connector or by pulling the ACI\_RST\_L line low (see [page 80](#)).

There are two levels of reset via the ADI connector:

- ACI reset—resets the ACI port and all Fibre Channel, SCSI or SAS ports
- Drive reset—equivalent to a power-on reset

Either reset method will interrupt the interface between the drive and host. A reset may result in no End of Data mark being written. As a result, it is strongly recommended that a reset command is not sent unless all other recovery methods have failed. Note that certain automation commands (Load, Unload, Set Drive Configuration, Reset and Set Baud Rate) can be queued behind outstanding SCSI commands giving the impression that the drive has stopped responding over the ADI connector. (All command packages will be still be ack'ed even though the command will be queued.)

Following a 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 ADI connector configurations.

An FCP reset will not affect the ACI interface.

Note that following an upgrade of the drive firmware, the drive will be reset as if it had been powered up.

## Troubleshooting

If you experience problems when using your tape drive within an automation environment, you need to isolate the cause of the problem. For example, if you have just installed a new SCSI host bus adapter in your host system and your system will not start, the cause of the problem is likely to be the adapter.

The first step in problem-solving is establishing whether the problem lies with the cartridge, the drive, the tape library, the host computer and its connections, the operating system or backup application on the host, or operator error.

Please refer to troubleshooting information provided with the tape library, the host or the backup software if the problem seems to lie in one of these areas.

If none of the following advice helps you solve the problem, contact your tape library supplier.

## Diagnostics

HP LTO Ultrium tape drives continuously monitor and gather information such as tape-pulling hours, power-on hours, usage information on cartridges, firmware trace-logs, and error logs. These can be used to aid health checks and diagnosis in cases of failure. Data can be extracted via:

- The main host interface
- The ADI connector
- The serial diagnostics port using a proprietary serial interface application.

Contact HP for a copy of the *Diagnostics Extraction Guide* on extracting and interpreting the information.

### Interpreting the LEDs on individual drives

HP LTO Ultrium tape drives have four LEDs on the front. See [Chapter 6 on page 69](#).

## Forced eject

If a cartridge fails to eject using the normal unload procedure, press and hold the Eject button for 10 seconds. This instructs the drive mechanics to perform an emergency unload. Wait for the cartridge to be ejected. This may take up to 15 minutes (the maximum rewind time).

If the cartridge is still jammed, press the emergency reset button (see [page 14](#)) or perform an emergency reset by pressing and holding the Eject button for 20 seconds. The drive will reset when you release the button. Wait for the drive to reset and get back to the loaded position. This may take up to 15 minutes. Again press and hold the Eject button for 10 seconds to perform a second forced eject and emergency unload.

# Cleaning issues

Use the following table to resolve cleaning problems:

Problem	Solution
Recurring cleaning message.	<p>Clean the drive with an LTO Universal Cleaning Cartridge as instructed in the tape library documentation. If the message reappears, replace the cleaning cartridge with a new one.</p> <p>If the message reappears when a particular data cartridge is used, verify that the data cartridge is readable by clearing the message and reading the tape again.</p> <p>If the data cartridge can be read, back up the data to another cartridge and then discard the damaged one.</p>
A brand new data cartridge is used, and the library operator panel indicates that cleaning is required.	<p>Clean the outside of the data cartridge with a barely damp, clean, lint-free cloth. Clean the drive as instructed by your tape library documentation.</p> <p>If the operator panel indicates cleaning is required within a short period of time, replace the data cartridge.</p>
The cleaning cartridge is ejected immediately after loading.	<p>Make sure that you are using an approved LTO Ultrium Universal cleaning cartridge and that the cleaning cartridge is not expired.</p>





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## 2 Using special features in libraries

### Introduction

This chapter contains information that relates to placing an HP LTO Ultrium drive in an automated device, such as an autochanger or a tape library.

- The “Automation and drive interface” described below allows the activities of the drive to be coordinated within a library.
- [“Configuring autoloader and library-controlled loads” on page 27](#) tells you how to configure whether automatic or library-controlled loads and unloads occur.
- [“Using Cartridge Memory \(LTO-CM\)” on page 30](#) describes the EEPROM embedded in every LTO Ultrium tape cartridge, part of which is available for use by applications.

Drives for inclusion in automated devices have different front panels from individual drives.

### Automation and drive interface

The interface between the tape drive and the library will support both the Automation Control Interface (ACI) and the Automation/Device Interface (ADI) standards. Typically the interface support will be an OEM selection. For convenience, the connector is referred to as the ADI Connector in this manual.

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 **NOTE:** ADI is covered by two T10 standards:

- For ADT: ANSI INCITS 406-2005
  - For ADC: ANSI INCITS 403-2005
- 

### Automation Control Interface (ACI)

The Automation Control Interface (ACI) allows the activities of the drive to be coordinated within a library. The protocol has been designed so that it can be made into a standard feature of tape drives. It provides a rich and extensible functionality to allow automation manufactures to add value in their application of it.

The interface is a serial bus with additional control lines, designed to connect the LTO Ultrium tape drive to an automation controller in a tape library. Each tape drive position has a separate automation controller. The ADI RS-422 serial port on the rear of the drive allows for ACI connection.


The ACI protocol provides the following fundamental functions:

- Coordinating the automation controller and the tape drive for Load and Unload operations
- Allowing the automation controller to retrieve information from the tape drive
- Setting tape drive configuration information

In addition, the following functions may be supported depending on the way that the tape library is configured:

- Providing upload and download of firmware images
- Providing access to the contents of the Cartridge Memory
- Providing a protocol for passing SCSI commands from the host to the tape drive
- Providing a protocol for passing SCSI commands from the host to the library (Surrogate SCSI)

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 **NOTE:** These notes refer to the “standard” automation drive variant.

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For details of using ACI commands and the ACI protocol, see Chapter 5 of the *Software Integration Guide*, volume 2 of the HP LTO Ultrium Technical Reference Manual.

## Automation/Drive Interface (ADI)

The INCITS T10 (SCSI) committee has a working group devoted to the development of a common Automation-Drive Interface (ADI). ADI consists of two standards:

- *Automation/Drive Interface—Commands (ADC)*, ANSI INCITS 406-2005, which specifies the SCSI command set used over ADI.
- *Automation/Drive Interface—Transport Protocol (ADT)*, ANSI INCITS 403-2005, which specifies a transport protocol for ADI.

The drive operates in either ACI or ADI mode. It is not possible to interleave ACI and ADI commands because they are handled very differently. The drive defaults to ACI mode after a power-on or hard reset. The Automation Controller can then instruct the tape drive to switch to ADI mode by sending a Port Login frame under the following conditions:

1. No ACI commands are outstanding. This not only means that the tape drive must have received acknowledgement for all responses to all ACI commands received, but also that all immediate response commands have also finished. For example, if an Automation Controller initiates an immediate response Load command (see section 5.3 of ACI specification), it cannot issue an ADI command until the tape drive has finished physically loading the cartridge. If an ACI command is outstanding when an ADI frame is received the drive will transmit an ACI <NAK> character in response.
2. An Encoded ADI frame received when the tape drive is in ACI Mode must not exceed the Receive Buffer size (see section 5.16 of the ACI Specification for details) and the frame must be received within the ACI Transmission Period (see section 4.6.6.3.2 of the ACI Specification). If either of these conditions is exceeded the tape drive will transmit a <NAK> character.
3. ADI frames received in ACI Mode must be Port Login frames otherwise the tape drive will revert to ACI Mode after transmitting the appropriate ADI response.
4. The ADI protocol must be enabled; see the Set Drive Configuration command (section 5.6 of the ACI Specification) for details. If the tape drive receives an ADI frame when the ADI protocol has been disabled the drive will transmit a <NAK> character.

When the tape drive is in ADI Mode it will not acknowledge or respond to any ACI command until the ADI port becomes logged out, either with an explicit Port Logout frame or an ADI Reset.

When the tape drive transitions from one mode to the other (ACI to ADI or ADI to ACI) it will not implicitly change the drive’s configuration. However, Automation/Drive Interface [ADC] SCSI mode

parameters only apply when the tape drive is in ADI Mode, so the tape drive behavior may change after transitioning between the two modes.

HP recommends that the drive is used in either exclusively ACI or ADI modes of operation. Avoid mixing operation of the two modes.

## Configuring autoloader and library-controlled loads

HP LTO Ultrium tape drives can be configured so that loads either occur automatically or under the control of the library. A SCSI MODE SELECT command can set the Autoload field to do this. The field is byte 5, bits 0–2 of the Control Mode page, 0Ah.

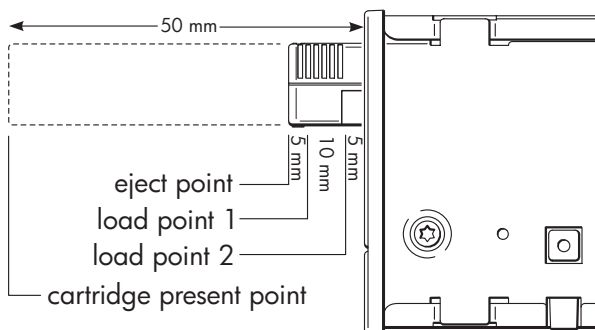
If the Autoload field = 0, Autoload is set and the drive automatically loads a cartridge when it is inserted and threads the tape so that it is ready for use.

If the Autoload field = 1 or 2, the drive pulls the cartridge into the drive but does *not* thread the tape. In this position, the LTO-Cartridge Memory can be read. The drive requires a Load command to thread the tape and make it ready for use.

## Cartridge positions during load and unload

The following diagrams show the positions of importance during load and unload.

## Full-height drives



### Eject Point

Cartridges are ejected to this point. It is 20.9 mm beyond the front panel and 26.1 mm beyond the front of the mechanism. The position tolerance is  $\pm 1$  mm. The automation controller cannot configure the location of this position.

### Load Point 1

If Autoload is set (Autoload field = 0), the drive will start to load the cartridge when it reaches this point.

If Autoload is not set (Autoload field = 1 or 2), the library must insert the cartridge into the drive to a position between Load Point 1 and Load Point 2 and preferably closer to Load Point 1. The library can then issue a Load command via the ADI connector to instruct the drive to load and thread the cartridge.

The maximum speed for inserting a cartridge into the drive is 80 mm/s.

Load Point 1 is the recommended minimum load point for commanded loads. It is 15 mm beyond the front panel with a  $-2$  mm tolerance.

### Load Point 2

The maximum distance a cartridge can be inserted for optimal loading performance, so that autoload or a Load command can load the cartridge. It is 5 mm beyond the front panel. The automation controller cannot configure the location of this position.

The maximum speed for inserting a cartridge into the drive is 80 mm/s.

There is one other point of note, the **ready-to-eject position**. If Auto-Eject is not set then when an unload command is received by the drive, the tape will be rewound and unthreaded. The drive will then wait at this point until it is commanded to eject the cartridge by the ACI Unload command.

## Load scenarios

The following scenarios describe the operation during the various types of load.

### Load scenario 1: Autoload

1. The library sends a Set Configuration command to enable Autoload. This is only necessary after a drive power-on.
2. The host sends a Move Medium command to the robotics.

3. The picker gets a cartridge from a storage slot.
4. The picker inserts the cartridge into the drive aperture.
5. The picker pushes the cartridge to at least Load Point 1.
6. The drive automatically takes the cartridge, loads it and threads it.

#### Load scenario 2: Library controlled

1. The host sends a Move Medium command to the robotics.
2. The picker gets a cartridge from a storage slot.
3. The picker inserts the cartridge to between Load Point 1 and Load Point 2.
4. The picker lets go of the cartridge.
5. The library sends a Load command to the drive.
6. The drive takes the cartridge, then loads and threads it.

#### Unload scenario 1: Autoload

1. The library sends a Set Configuration command to enable Auto-Eject. This is only necessary after a drive power-on.
2. The host sends an Unload command to the tape drive.
3. The drive rewinds, unthreads and ejects the cartridge to Eject Point.
4. The host sends a Move Medium command to the robotics.
5. The picker takes the cartridge from the tape drive and places it in its storage slot.

#### Unload scenario 2: Library controlled

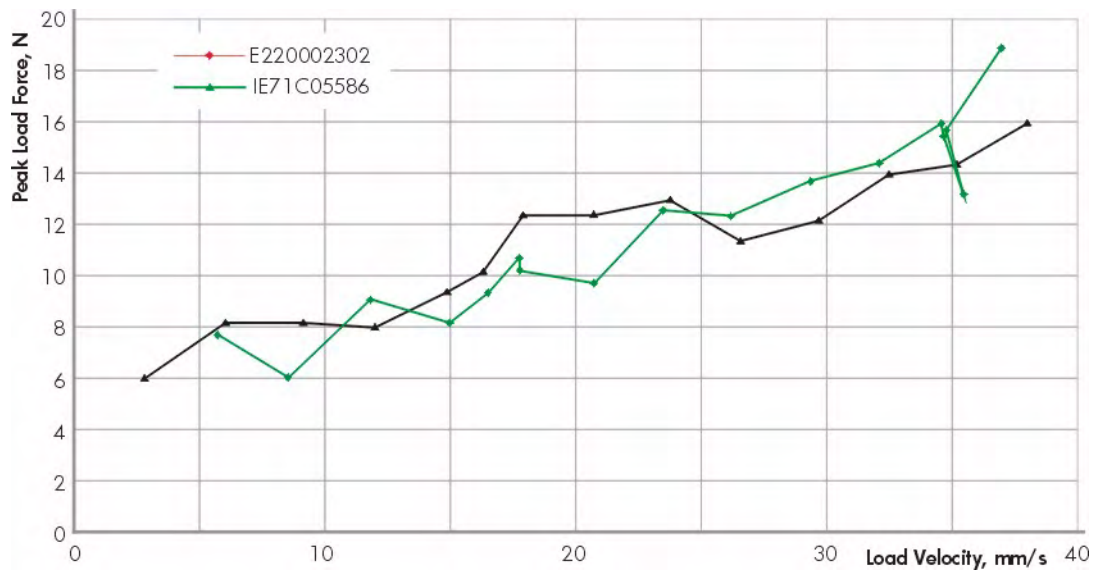
1. The host sends an Unload command to the drive.
2. The drive rewinds and unthreads the tape. It then pauses with the cartridge at ready-to-eject position.
3. The library sends an Unload command to eject the cartridge.
4. The drive ejects the tape to Eject Point.
5. The picker takes the cartridge from drive and places it in its storage slot.

## Load forces

The *unload* force is 4.45N maximum; this is the force that an external mechanism must exert to remove a fully ejected cartridge from the drive.

The *load* force varies according to the speed at which the cartridge is inserted into the drive. The peak load force occurs when the cartridge begins to accelerate the drive carrier and only lasts for a short time. The following graph plots examples of peak load force against load speed:

**Figure 1** Peak load force versus load speed



## Using Cartridge Memory (LTO-CM)

Linear Tape Open—Cartridge Memory (LTO-CM) is an EEPROM that is embedded in every LTO Ultrium tape cartridge. It is non-volatile and is contactless in that it is read by inductive coupling rather than electrical contact.

The Cartridge Memory is used to store the tape directory and diagnostic and log information. Because of the speed at which it can be read, load and unload times are reduced, information is found on the tape more quickly and fewer tape passes are needed, increasing tape reliability.

The memory is primarily designed to speed up internal operations in the drive, but it also contains free space that can be used by application software. This may be used to store “common” information (shared by all software vendors) and “vendor-unique” information (specific to the application).

Hosts can use this free space using the SCSI Write Attribute and Read Attribute commands. For information on these commands, see Chapter 4 of *Interface Guide*, Volume 3 of this HP LTO Ultrium Technical Reference Manual.

To support CM fully, software vendors should ensure that their company names are registered with ANSI T10 or the National Committee for Information Technology Standards (NCITS) as they are now known. The list of Vendor IDs is displayed at <http://www.t10.org/lists/vid-alpha.htm>, which also contains details of how to get a new name assigned.

Cartridge Memory adheres to the Media Auxiliary Memory (MAM) standard. “MAM” indicates that the access method applies to all types of media, not just LTO Ultrium.

The MAM standard provides for the storage and access of information held as a set of pre-defined and user-definable attributes that are divided into six main sections:

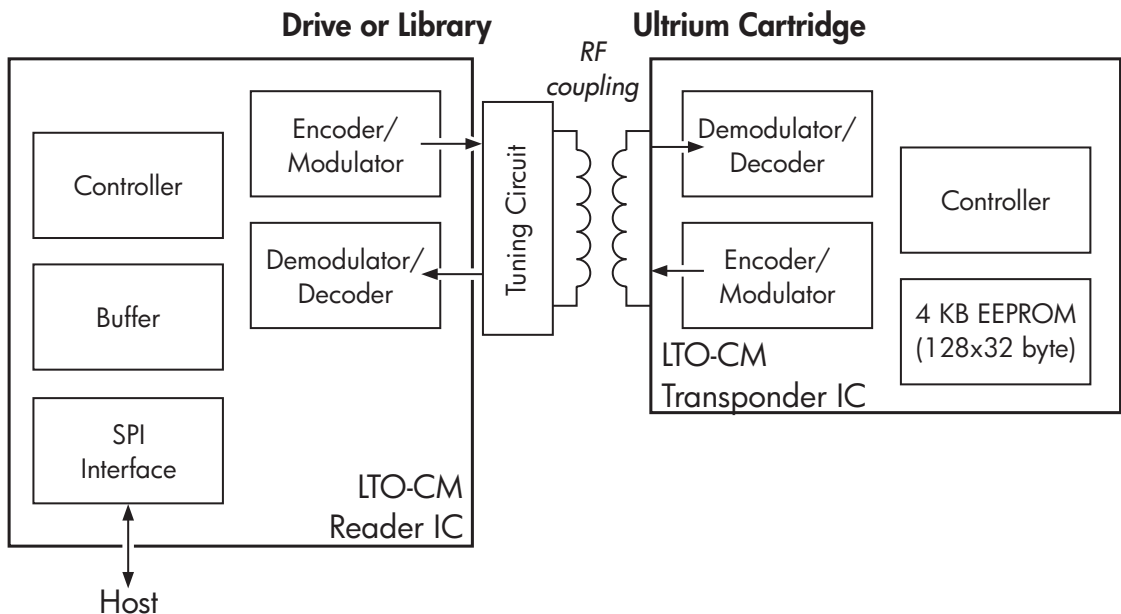
- Media Common Section—hard-coded by the media manufacturer.  
For example: manufacturer’s name, cartridge serial number, length, media type

- Drive Common Section—updated by the drive every time it accesses the media. For example: maximum and remaining tape capacity, TapeAlert flags
- Host Common Section—updated by the host's software application every time it uses the media. For example: software application vendor's name and version, media text label, date last written
- Media Vendor Unique Section—optional information written by the media vendor for their own purposes. Unique to the media vendor.
- Media Vendor Unique Section—optional information written by the media vendor for their own purposes. Unique to the media vendor.
- Host Vendor Unique Section—space reserved for use by software applications for their own purposes. Unique to the software vendor. Approximately 1 kilobyte.

For details of SCSI commands relating to Cartridge Memory or MAM, see Read Attributes (8Ch) and Write Attributes (8Dh) in the *Interface Guide*.

## Use in libraries

Cartridge memory offers possibilities for use in libraries as an adjunct to or replacement for barcodes. The following diagram shows the architecture required. HP is working to provide a standard module with this functionality via a third party.



## Current libraries — barcodes

Many libraries use sticky labels with barcodes on cartridges to identify them. These are read by a barcode reader attached to the picker arm. The application then needs to hold information as to the contents of the tape to which it can relate the bar code.

Cartridge Memory can be used as a substitute for these barcodes. No human interaction is needed to fix barcode labels, reducing errors, though cartridges may still need labels that humans can read. A cartridge can be identified by its serial number.

However, because Cartridge Memory has space that can be written by applications, it can hold details of the contents and nature of the tape. This obviates the need for this information to be held by the application. HP is working with other industry leaders, both hardware and software, on an Industry Common Implementation Guide.

## More information

- The latest version of the specification is incorporated into SCSI SPC-3.
- The access specification can be found at <http://www.t10.org/>.



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## 3 Drives in tape arrays

### Installing drives

#### Identifying the drive

The model name is on the front panel and the product and serial numbers are on a label attached to the drive.

#### Modes of usage

Tape arrays can be used in different system configurations; direct attach, network attach and attached to a Storage Area Network (SAN). For details of these see [page 83](#).

#### Attaching to Fibre Channel

When installing a SCSI drive on a fibre channel direct attach network or SAN configuration, you need a fibre channel/SCSI router. Check [www.hp.com](http://www.hp.com) for the latest ordering information. This manual does not describe how to configure your fibre channel infrastructure or SAN network to use the tape array. This is a complex area and users are advised to refer to their SAN documentation or contact their SAN system administrator or supplier for technical support.

#### Attaching to SCSI

HP LTO Ultrium SCSI drives are high performance Ultra 3 SCSI devices designed to operate on a low voltage differential SCSI bus (LVDS). They are installed in a tape array in a rack-mount system and can be connected to a SCSI connection on a server or fibre channel/SCSI router. To get optimum performance from your tape drive you need a SCSI bus that can transfer data at a rate that supports the tape drive's maximum transfer speed. We recommend an Ultra 3, 160 and 320 SCSI bus.

#### Attaching to SAS

HP LTO Ultrium SAS drives are high performance 3 GB SAS devices. When installed in a tape array in a compatible rack mount system they can be connected to a SAS connection on a server or to an expander as part of a larger SAS network. To get the optimum performance from your tape drive you need a SAS topology that can transfer data at a rate that supports the tape drive's maximum transfer speed.

#### Appropriate HP rack-mount systems

HP LTO Ultrium removable tape drives are used in conjunction with the **HP StorageWorks Tape Array 5300** system, which will hold up to two full-height drives.

The tape array is designed to be installed into any compatible 19" rack-mount systems. It must be properly installed and configured. Refer to your tape array documentation for further details.

#### Airflow requirements

As long as the tape array is fully populated, it will provide adequate airflow for HP LTO Ultrium drives.

If you have unused bays in the tape array, you must install the blanking plates provided with the tape array. This ensures that there is adequate airflow to the drives. See the documentation with the tape array for details on installing blanking plates.

You should ensure that ventilation is adequate at the front and rear of the tape array.

HP LTO Ultrium drives require forced airflow, either from front to back or from back to front.

The required flow depends on the ambient air temperature:

- 6 cfm for ambient air temperatures fluctuating in the range 10°C–35°C.
- 8 cfm for ambient air temperatures fluctuating in the range 10°C–40°C.

For details of how to test if the airflow is adequate, see [“Airflow requirements” on page 16](#).

## Setting the SCSI ID

For removable drives installed in an HP StorageWorks Tape Array 5300 rack enclosure, set the SCSI ID at the appropriate switch on the rear of the tape array. Each drive should have a unique ID. The number of address switches corresponds to the number of tape drives that can be inserted into the tape array, so the HP StorageWorks Tape Array 5300 has four SCSI ID switches to enable the installation of up to four half-height tape drives. When installing two HP LTO Ultrium full-height tape drives, use the SCSI ID switches 1 and 2 only.

## Termination

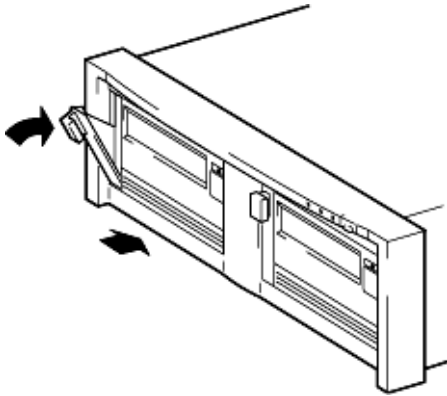
Both ends of a SCSI bus must be terminated.

Assuming that the host bus adapter is already correctly terminated, there are typically two possibilities:

- The tape drive is being connected in a direct one-to-one configuration to the host server—termination must be used.
- The tape drive is being daisy-chained with other tape devices onto the host server—only the last device must be terminated.

The terminator can be plugged directly onto either of the two SCSI connectors on the rear of the tape array. Terminators must be ordered separately.

## Inserting a drive



1. Ensure that the extractor lever on the drive is in the out position, as shown in the picture.
2. Lift the drive carefully.
3. Align the rear of the drive with the guides on the side of the HP StorageWorks Tape Array 5300.
4. Slide the drive along the guides until the connectors on the back mate with the connectors at the back of the enclosure.
5. Push the extractor lever in until it locks the drive in position.

## Connecting to a Fibre Channel router or by SCSI/SAS to a server or router

Individual SCSI tape drives are connected to their host server or fibre channel router via the high density LVD/SE SCSI connectors on the back of the tape array. They do not require any SCSI cables to plug into the tape array. However, cabling and terminators are required to connect the tape array with the SCSI host.

Individual SAS tape drives are connected to their hosts via the SAS connectors on the back of the tape array. They do not require any SAS cables to plug into the array. However, cabling is required to connect the tape array with the SAS host or expander.

### Fibre Channel connection

If you are using your SCSI tape drive on a fibre channel (FC) network, you will need a FC/SCSI router with a spare LVDS SCSI port. The router should be connected via a 68-pin, wide, LVDS-rated cable to the tape array. Refer to our web site at [www.hp.com/go/connect](http://www.hp.com/go/connect) for details of recommended FC/SCSI routers and cables. If you are attaching your tape drive to a SAN environment supplied by HP, refer to your SAN solution collateral or configuration guides for further details.

### Server SCSI connection

If you are attaching the drive to a server, you will need a properly installed and configured SCSI host bus adapter (HBA) or a built-in SCSI controller on your server with a spare LVDS SCSI port. For optimum performance your tape drive should only be connected to an Ultra 3, 160 or 320 host bus adapter or SCSI controller.

The server should be connected via a 68-pin, wide, LVDS-rated cable to the tape array. The standard, recommended configuration is a direct, one-to-one SCSI connection between the tape drive and the host server so that the drive is the only device on the SCSI bus. It is possible to daisy-chain two tape drives together within the tape array, but to preserve performance, this should only be done if the drives are on an Ultra 3, 160 or 320 SCSI bus. Do **not** daisy-chain more than two drives together, as this will degrade their individual performance with respect to transfer rate.

Do **not** attach the drive to the same SCSI bus as your disk drive or RAID controller.

## Server SAS connection

If you are attaching the drive to a server, you need a properly installed and configured SAS host bus adapter (HBA) or a built-in SAS controller on your server with a spare SAS port. For optimum performance your tape drive should only be connected to a 3 GB SAS host bus adapter or SAS controller, but the drive will also work with a 1.5 GB SAS connection.

## Replacing a drive

HP LTO Ultrium removable drives can be removed and replaced without powering down the tape array and without interrupting operations to the other drives in the array. However, note the following:

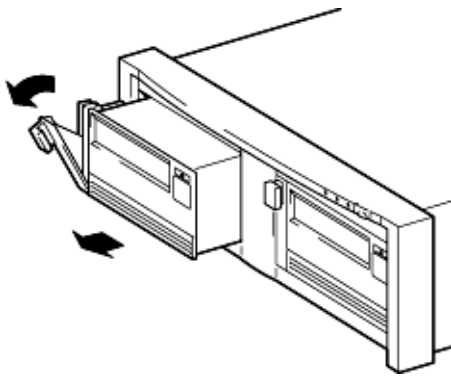
- In Berkeley mode, the tape position will remain unchanged by a device close operation.
- In AT&T mode, a device close operation will cause the tape to be repositioned just after the next tape filemark (the start of the next file).

If all drives in the tape array are powered up when the system is turned on, the host will be aware of those drives. You can remove any drive and replace it with another without disrupting the system.

If a drive is not powered up or you place a drive in an empty slot after the system has been powered up, the system will have to be reset before the host will recognize the drive.

Removable drives allow modules to be replaced while powered up as long as no data is being transmitted from the system to the module or vice versa. The SCSI IDs are controlled by the tape array, not the drives, so if you remove a drive and replace it with another the ID will not change.

## Removing a drive



1. Pull the extraction lever of the drive that you want to replace so that it is in the out position.
2. Using the extraction lever, pull the drive gently and firmly out of the tape array.

## Installing a new drive

See the instructions in [“Inserting a drive”](#) on page 35.

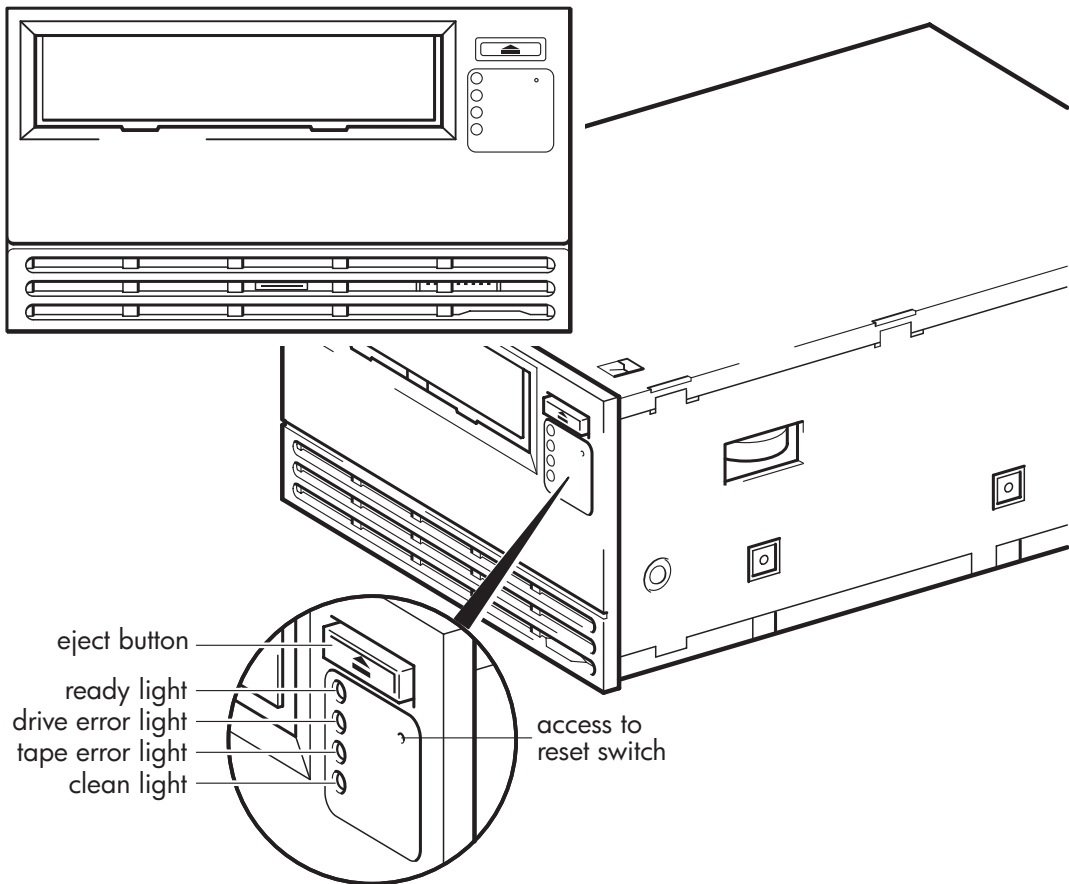
## Operating the drive

Removable drives are powered on when you switch on your tape array and computer.

The tape drive will run its hardware self-test. During the test the 'Ready' LED flashes and all the other LEDs are off. On successful completion the 'Ready' LED is on. If the self-test fails, the 'Drive Error' and 'Tape Error' LEDs flash, while the 'Ready' and 'Clean' LEDs are off. This continues until the drive is reset.

- If you have just installed the drive, check the installation for loose connections, reset the drive and repeat the self-test.
- Try the ["Troubleshooting" on page 39](#) to determine what the problem is.
- If the fault condition persists, call for assistance.

## Front panel features



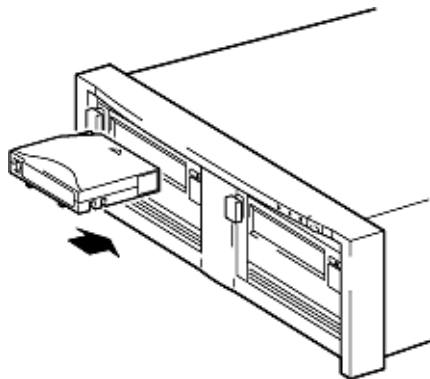
## LEDs

For details of the front panel LEDs, see [page 69](#).

## Reset switch

The emergency reset switch allows you to reset the drive without powering off the drive and computer, for example if the drive stops responding. Access to the switch is through a small hole. It can be activated by a thin object, such as the end of a straightened paper-clip.

## Loading a cartridge



Use HP LTO Ultrium cartridges with your drive.

### 1. In HP StorageWorks Tape Arrays:

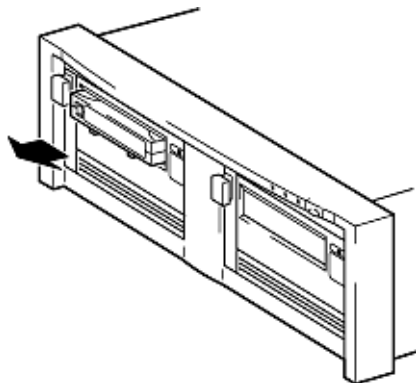
Insert the cartridge into the slot in front of the drive with the white arrow on the top facing the drive door. The toothed drive hub is on the bottom of the cartridge.

### 2. Apply gentle pressure on the rear of the cartridge until the drive takes the cartridge and loads it.

The 'Ready' LED flashes green while the drive performs its load sequence. When the cartridge is loaded, the 'Ready' LED shows steady green.

Do not try to force the cartridge if it does not load properly. The drive will eject the cartridge after about 10 seconds so you can load it again.

## Unloading a cartridge



### 1. Press the Eject button on the front panel.

During the unload sequence the 'Ready' LED flashes green. The drive completes any task it is

currently performing, rewinds the tape and ejects the cartridge. Once the tape has rewound, the eject cycle will take less than 13 seconds.

2. Remove the cartridge and store it in its plastic case in a cool, dry atmosphere.

## Cleaning the drive

- △ **CAUTION:** It is essential to use only LTO Ultrium Universal cleaning cartridges with HP LTO Ultrium tape drives as other format cleaning cartridges will not load and run. Use of HP cleaning cartridges will ensure your tape drive is fully protected.  
Do not use swabs or other means of cleaning the heads.

When the drive needs cleaning, the orange 'Clean' LED on the tape drive will flash. Only insert a cleaning cartridge into the tape drive when the LED flashes.

The drive's TapeAlert feature will send a message to your backup application when the tape heads need cleaning or a cleaning cartridge has expired.

LTO Ultrium Universal cleaning cartridges can be used up to 50 times.

### To clean the heads:

1. Insert a cleaning cartridge into the drive. The tape drive automatically loads the cartridge and cleans the heads.

If the cleaning cartridge ejects immediately, it has expired or it is not an LTO Ultrium Universal cleaning cartridge (or is an older LTO Ultrium 1 cleaning cartridge). In this case, discard the cleaning cartridge and repeat the operation with a new one.

The cleaning cycle can take up to 3 minutes, during which the orange 'Clean' LED will be on and the green 'Ready' LED will flash. When it has finished, the drive ejects the cartridge.

2. Remove the cleaning cartridge from the drive.

## Troubleshooting

### Emergency unload

If a cartridge fails to eject using the normal unload procedure, press and hold the Eject button for 10 seconds. This instructs the drive mechanics to perform an emergency unload. Wait for the cartridge to be ejected. This process may take up to 15 minutes (the maximum rewind time).

If the cartridge is still jammed, press the emergency reset button (see [page 38](#)). Wait for the drive to reset and get back to the loaded position. This process may take up to 15 minutes (the maximum rewind time). Again press and hold the Eject button for 10 seconds to perform an emergency unload.

### General guidelines

The first step in problem-solving is establishing whether the problem lies with the cartridge, the drive, the host computer and its connections, or with the way the system is being operated.

Most modern host bus adapters locate and display attached devices when the system is booting up. On Windows systems, if you swap or connect a product when your system is running, you will need

to reboot the system. IA32 systems also usually need to be rebooted. UNIX systems may have pluggable drivers, which allow drives to be attached to a running system and detected without rebooting.

If the device is not detected on boot up, there is probably a problem with the physical hardware: cables, termination, connections, power or the host bus adapter. If the device is displayed during boot up but cannot be found in the operating system, this is more likely to be a software problem.

### Problems with the host computer

Most modern host bus adapters locate and display attached devices when the system is booting up. If the device is not detected at this stage, there is probably a problem with the physical hardware: cables, termination, connections, power or the HBA itself.

If your drive is found on system boot up but cannot be found in the operating system, this is more likely to be a software problem.

#### Computer does not boot up

Possible Cause	Potential Solution
You have connected the tape drive to an existing SCSI bus that has other devices connected to it and the SCSI address of the drive is identical to the address used by another device.	Make sure that each device on the SCSI bus has a unique ID. We recommend that the tape drive is connected to a dedicated host bus adapter. Do not connect the drive to a disk RAID controller as this is not supported.
You have installed an additional host bus adapter and its resources are clashing with an existing adapter.	Remove the new host bus adapter and check the server documentation.
You have disconnected the power or cable from the computer's boot disk during the drive installation process.	Check that the cables to all devices are firmly connected.

#### Computer boots, but does not recognize the drive

Possible Cause	Potential Solution
The power or interface cable is not connected properly.	Check that the cables to the tape drive are firmly connected. Ensure that the interface cable is LVDS-compliant and that it does not have any bent pins or is damaged. Replace, if necessary.
The SCSI bus is not terminated correctly.	Check that the SCSI bus is actively terminated. (Refer also to the documentation for your SCSI controller and any other SCSI devices you may have.)
The tape drive's SCSI ID address is not unique.	Make sure that each device connected to the SCSI controller has a unique SCSI ID. Remember that 7 is normally reserved for the host bus adapter.



## Problems with the drive and cartridge

### Tape drive does not work

Possible Cause	Potential Solution
The drive is not receiving power from the tape array.	<ul style="list-style-type: none"><li>• Check the tape array is connected to a power source and switched on.</li><li>• Check the drive is properly inserted into the tape array so that it mates with the connections at the rear of the enclosure. The extraction lever should be pushed in, locking the drive in position.</li><li>• If the drive 'Ready' LED is still off, call for assistance.</li></ul>
There is a fault with the drive.	<p>If possible, and if no other drives in the tape array are in use, try resetting the drive, or turning the power switch on the tape array off and then on again. (If there is a tape cartridge loaded in the drive, try to unload it by pressing the Eject button. If this succeeds, switch the tape array off and then on again.</p> <p>If the problem persists, call for assistance.</p>

### The computer no longer recognizes the drive

Possible Cause	Potential Solution
You powered up the drive or added it to the tape array after the host system was turned on.	The host computer system only identifies which IDs are present on SCSI buses after power-on or a reset. To make the host look for devices on the bus, you need to reset the host. You should be able to do this using the SCSI management software on your computer. As a last resort, you could turn the host system off and on again.
You changed the drive's SCSI ID after the host system was turned on.	<ul style="list-style-type: none"><li>• If you have replaced a drive that was recognized by the host, the host should recognize the new drive at the same SCSI ID as its predecessor.</li><li>• If you make any changes to SCSI IDs (on the back on the tape array), you need to reset the bus for the host to recognize the changes.</li></ul>
The drive is not inserted correctly.	Check the drive is properly inserted into the tape array so that it mates with the connections at the rear of the enclosure. The extraction lever should be pushed in, locking the drive in position.

Possible Cause	Potential Solution
The SCSI bus is not terminated correctly.	<ul style="list-style-type: none"> <li>• Check the SCSI cable from the tape array is firmly connected to the SCSI connector in the computer.</li> <li>• If there are other devices in the SCSI bus, make sure that each device has a unique ID.</li> <li>• If there is more than one SCSI bus attached to your system, check that the system is looking for the drive on the correct SCSI bus.</li> <li>• Make sure that the bus is terminated correctly. If the array is the only device or the last device on the bus, it must have a terminator fitted. If some other device is last on the bus, it should have a terminator fitted and the tape array should not.</li> </ul>
There is a fault with the host system.	<ul style="list-style-type: none"> <li>• Make sure that the system is configured to recognize the correct device at each SCSI ID.</li> <li>• Ensure that the correct driver for the tape drive is installed. Look at the SCSI host adapter documentation and backup software documentation for further advice.</li> </ul>

### The application does not recognize the drive

Possible Cause	Potential Solution
The application does not support the tape drive.	Check the drive is installed properly. Refer to our World Wide Web site ( <a href="http://www.hp.com/go/connect">www.hp.com/go/connect</a> ) for details of backup applications that support HP LTO Ultrium tape drives. Load any service packs as necessary.
Some applications require drivers to be loaded.	Check the correct HBA and tape drive drivers are installed. Consult the backup application's installation notes for details.

## The cartridge will not eject

Possible Cause	Potential Solution
<p>The cartridge is jammed in the drive, or the backup application cannot eject the cartridge.</p> <p>This is most likely to be a communication problem between the drive and the system.</p>	<p>Check there is power to the drive.</p> <p>If the cartridge fails to eject using the normal unload procedure, press and hold the Eject button for 10 seconds. Wait for the cartridge to be ejected. This may take up to 15 minutes (the maximum rewind time).</p> <p>If the cartridge is still jammed, perform an emergency reset by pressing and holding the Eject button for 20 seconds. The drive will reset when you release the button. Wait for the drive to reset and get back to the loaded position. This may take up to 15 minutes. Again press and hold the Eject button for 10 seconds to perform a second forced eject.</p> <p>If the cartridge is still jammed, call for support.</p>

## The drive will not accept a cartridge or ejects it immediately

Possible Cause	Potential Solution
<p>The cartridge may have been damaged, for example dropped, the cartridge memory may be corrupted or the drive may have a fault.</p>	<ol style="list-style-type: none"><li>1. Check the drive has power (the power cable is properly connected and the ready LED is on).</li><li>2. Check you are using LTO Ultrium 2, 3 or 4 media. DLT cartridges are not compatible with LTO Ultrium drives. See <a href="#">Chapter 9 on page 87</a>.</li><li>3. Make sure that you have loaded the cartridge with the correct orientation (see <a href="#">“Front panel features” on page 37</a>.)</li><li>4. Check for damage to the media (to the cartridge case, leader pin or cartridge teeth) and discard it if it is damaged.</li><li>5. Use another cartridge that you know is good and see if it loads. If it does, the original cartridge is faulty and should be discarded.</li><li>6. Check if another drive will accept the cartridge. If it does, the original drive may be faulty. Before calling customer service, please check that the tape drive is responding and that it can be seen on the SCSI bus.</li></ol>



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## 4 Internal drives in servers

For the physical specification of the drive, see Chapter 1, “Physical Specification” in *Specifications*, Volume 4 of the HP LTO Ultrium Technical Reference Manual.

If you are installing the tape drive on a UNIX system, refer to the *UNIX Configuration Guide*, Volume 5 of the HP LTO Ultrium Technical Reference Manual.

### Installing an internal drive into a server

Full details of how to install an internal LTO Ultrium tape drive into a server drive bay is given in the Getting Started Guide.

### Identifying the model


The model name is on the front panel and the product and serial numbers are on a label on the top of the drive.

### Standards and safety

Use the drive only in equipment where the suitability of the combination has been determined by an appropriate certification organization (such as Underwriters Laboratories Inc. or the Canadian Standards Association in North America, and the British Standards Institution or Verband Deutscher Elektrotechniker in Europe). Other considerations include the following:

1. A drive must be installed in an enclosure to limit an operator's access to live parts, to provide system stability, and to give the drive the necessary grounding integrity.
2. A drive must only be supplied by a Safety-Extra-Low-Voltage (secondary) circuit in accordance with DIN VDE 0805. During incorporation of the equipment, all requirements of DIN VDE 0805 must be observed and obeyed.

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 **NOTE:** The drives are only fused to protect them from excessive currents.

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## Requirements

### Mounting requirements

Drives require one industry standard 5¼-inch, full-height bay.

HP recommends 0.3 mm mounting clearance around all covers for isolation mounting movement.

For many servers, no mounting tray or rails are required. Devices simply slide into the computer's chassis and are fixed with screws. Other servers have built-in trays or rails. Yet others require a special mounting tray or rails to fix the drive into the empty bay.

### Airflow and cooling

HP LTO Ultrium drives require forced airflow, either from front to back or from back to front, that satisfies the following conditions:

- For full-height internal drives, the airflow at 35°C ambient air operation should be at least 6 cubic feet per minute (0.17 cubic meters per minute or 10.19 cubic meters per hour) through the product. At 40°C, it should be at least 8 cfm (0.23 m<sup>3</sup>/min. or 13.60 m<sup>3</sup>/h)

These requirements and the operating temperature specification should keep the internal temperature around the media to less than 45°C and ensure reliable operation.

The airflow does not require filtering if the air contamination specifications are met. See “Climatics” in Chapter 4, “Environmental Specification” in *Specifications*, Volume 4 of the HP LTO Ultrium Technical Reference Manual.

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△ **CAUTION:** Care must be taken that empty bays in the server have the appropriate blanking plates installed so that airflow is maintained. Refer to your server documentation.

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For details of how to measure the internal drive temperature, see [“Measuring internal drive temperatures” on page 16](#).

## Power requirements

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**NOTE:** SAS drives should be powered from the normal rear panel connector, not through the power part of the SAS connector.

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The following are the PSU requirements for FC, SCSI and SAS full-height drives:

Voltage	Typical Current	Maximum Current
5 V	4.2A	4.5A
12 V	0.75A	2.5A

See also details in Chapter 2, “Electrical Requirements” in *Specifications*, Volume 4 of the HP LTO Ultrium Technical Reference Manual.

The drive is specified to operate at 5V ± 5% and 12V ± 10%.

## Full-height drives

	FC Drives		SCSI Drives		SAS Drives	
Specification	5V	12V	5V	12V	5V	12V
<b>Max voltage</b>	5.25V	13.2V	5.25V	13.2V	5.25V	13.2V
<b>Min voltage</b>	4.75V	10.8V	4.75V	10.8V	4.75V	10.8V
<b>Max steady-state current</b>	4.2A	0.75A	3.4A	0.7A	TBD*A	TBDA
<b>Max transient current</b>	4.5A	2.5A	3.8A	2.5A	TBD*A	TBDA
<b>Max steady-state power</b>	21W	9W	17W	9W	TBDW	TBDW
<b>Max transient power</b>	22.5W	30W	21W	30W	TBDW	TBDW
<b>Max noise/ripple</b>	150 mVpp	150 mVpp	150 mVpp	150 mVpp	TBD mVpp	TBD mVpp

## Server connections

You need a properly installed and configured SCSI or SAS host bus adapter (HBA) or a built-in SCSI or SAS controller on the server.

The SCSI drives are Ultra3 wide, SCAM-1 compliant SCSI devices designed to operate on a low voltage differential SCSI bus (LVDS). LVDS interfaces enable longer cable lengths compared with single ended SCSI and Ultra3 supports a maximum bus speed of 160 MB/s (as opposed to 80 MB/s with Ultra2 and 40 MB/s with single-ended SCSI). Therefore, we do not recommend installing the drive onto an Ultra2 or single-ended bus or onto a bus with other Ultra2 or single-ended devices, as this may restrict performance. Similarly, do not install the drive onto a narrow SCSI bus, as this will restrict performance.

The SAS drives have a 3 GB SAS interface, and are designed to work with most SAS devices. The 3 GB SAS interface supports a maximum bus speed of 300 MB/s, as opposed to the 150 MB/s of the 1.5 GB SAS interface. Therefore, we do not recommend installing the drive onto a 1.5 GB bus as this may restrict performance.

For optimum performance, use a dedicated host bus adapter for the tape drive.

Do not connect to a RAID controller channel; these are for disk drives only. Consult your supplier for details.

For a SCSI internal drive, you will need:

- Ultra3 (160) or Ultra4 (320) SCSI host bus adapter or server's embedded HBA
- LVDS-compliant SCSI ribbon cable with termination (normally supplied with the host bus adapter)
- A full-height 5¼-inch mounting bay
- Mounting hardware, if required
- Backup software that supports the tape drive

For a SAS internal drive, you will need:

- 3 GB SAS host bus adapter or server's embedded HBA
- SAS-compliant cable
- Mounting hardware, if required

- Backup software that supports the tape drive

### Supported bus types

SCSI Bus Type	Transfer Speed	Supported
Ultra3 (160) LVD	Up to 160 MB/s	Yes. This is the recommended configuration.
Ultra4 (320) LVD	Up to 320 MB/s	Yes. This is the recommended configuration for more than one drive per bus.
Ultra2 LVD	Up to 80 MB/s	Yes, but this will not provide optimum performance.
Single-ended, wide	Up to 40 MB/s	Yes, but this is not recommended as it will severely restrict performance. Do not connect to a narrow SCSI bus.
High Voltage Differential	Up to 40 MB/s	No. The drive will not work and you may damage the drive or controller

SAS Bus Type	Transfer Speed	Supported
1.5 Gbps	Up to 150 MB/s	Yes
3.0 Gbps	Up to 300 MB/s	Yes. This is the recommended configuration.
6.0 Gbps	Up to 600 MB/s	No

## Fixing dimensions

The positions of fixing points are shown below.

The recommended screw length depends on the thickness of the rails or enclosure into which the drive is mounted:

Server or Rail Thickness	Recommended Screw Length
> 1.5 mm ≤ 2.0 mm	M3 x 6.0 mm
> 1.0 mm ≤ 1.5 mm	M3 x 6.0 mm
≤ 1.0 mm	M3 x 5.0 mm

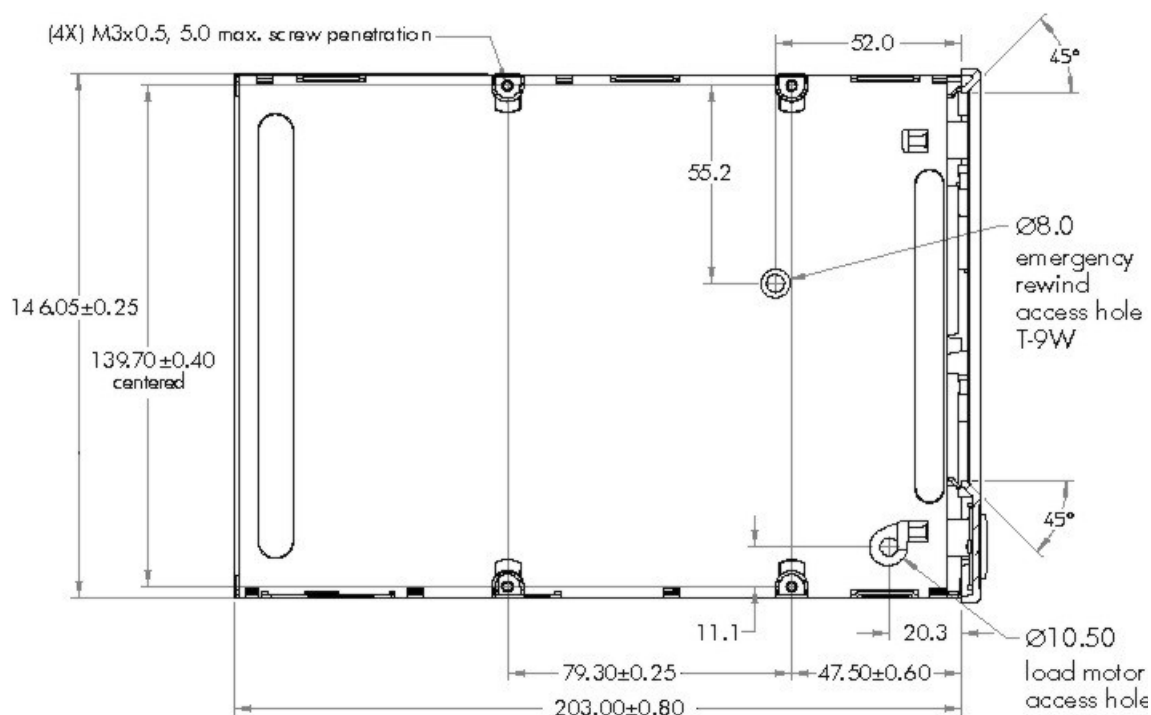
All screws should be M3 threaded. Do not use spring washers.

The recommended mounting torque is 6.0 ±0.5 in-lbs (60–70 N/cm).

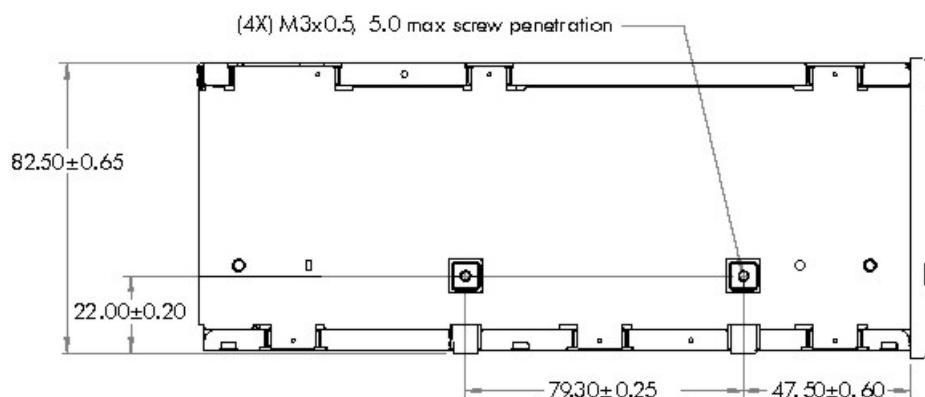
HP recommends 0.3 mm mounting clearance around all covers for isolation mounting movement.



## Bottom panel, full-height internal drives



## Side panel, full-height internal drives



## Connecting the drive

### Fibre Channel connector

For the location of the rear panel FC connector, see [page 80](#).

The fibre channel drive is equipped with a native fibre channel interface consisting of two SFP duplex-LC fibre channel transceivers. The tape drive is capable of switched fabric attach or public loop.

The rear connections of Fibre Link HP LTO Ultrium drives are as follows:

- ACI/ADI port (for libraries)
- Two SFP duplex-LC fibre connectors (only one may be loaded)
- Serial port (duplicate of the Serial Diagnostics Port on the front panel)

## SCSI connector

For the location of the rear panel SCSI connector, see [page 80](#).

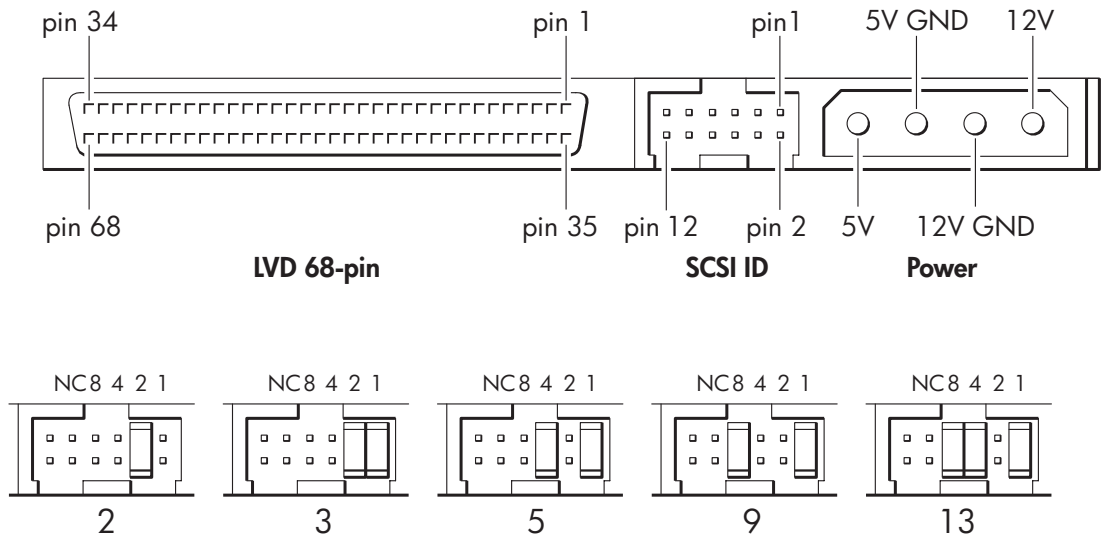
The SCSI drive uses a straddle-mounted three-part SCSI peripheral connector. This incorporates a 68-pin high density SCSI connector, a 4-pin power connector and a 12-pin auxiliary connector.

The auxiliary connector is used for setting the SCSI address. The pins are as follows:

Pin	Signal	Description
1	SEL0-	SCSI ID 0 (active low)
2	GND	Ground
3	SEL1-	SCSI ID 1 (active low)
4	GND	Ground
5	SEL2-	SCSI ID 2 (active low)
6	GND	Ground

Pin	Signal	Description
7	SEL3-	SCSI ID 3 (active low)
8	GND	Ground
9	—	
10	—	
11	—	Termination Power (5V)
12	—	Termination Power (5V)

The following diagram shows jumper settings for a few example SCSI IDs:



### To connect an internal drive:

1. Attach a spare power cable from the computer's internal power supply to the power connector.
2. Attach a spare connector on the computer or HBA's SCSI ribbon cable to the SCSI connector of the drive.
3. If the drive is the last device on the SCSI chain, make sure that the SCSI cable is terminated correctly.

## Termination

Termination must be present at two and **only** two positions on the SCSI bus—at the beginning of the SCSI bus and at the end of the SCSI bus. Termination is normally enabled by default on the HBA and most internal SCSI cables have a terminator attached. This will usually be a small, rectangular block of plastic attached to the cable end and marked 'SCSI Terminator'.

Therefore, assuming the HBA is the first device on the bus, you should check that the second terminator is placed after the last device. If the drive should be the only device on a bus, as is recommended, the terminator should be placed after the drive.

### Termination power

With HP's LTO Ultrium drives, termination power is provided and is switchable through pins 11 and 12 of the auxiliary connector. The supply is a 5V line via a fuse and diode/capacitor combination. In this way, the drive "tops up" the termination power voltage if the host supply is below 5V (due to cable length or bad host termination power).

## SAS connector

For the location of the rear panel SAS connector, see [page 77](#)

The SAS drive is equipped with a 3 Gbps SAS plug connector as per SFF8482 [5.2.3.2]. A SAS drive is hot pluggable but the connector location is not as per SFF8482.

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**NOTE:** Only power a SAS tape drive from the normal power connector, not through the power port of the SAS connector, which is not connected.

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The rear connections of an HP LTO4 SAS tape drive are as follows:

- ACI/ADI port (for libraries)
- Standard internal SAS plug connector
- Diagnostic Serial Port (contact HP for further details on this diagnostic port and its function)

## Backup software

You need backup software that supports the HP LTO Ultrium drive within your system's configuration. In a direct attach configuration, where the tape drive is attached to a standalone server, you can use backup software that is designed for a single server environment. In network and SAN configurations, you will need backup software that supports enterprise environments. As a general rule, native backup applications (such as NTBackup and tar) do not provide the required data streaming rate to get the full performance of your drive. For the latest list of backup packages that

support HP LTO Ultrium drives, please consult our World Wide Web site ([www.hp.com/go/connect](http://www.hp.com/go/connect)).

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
LTO Ultrium 1 drive	HP Ultrium 1-SCSI
LTO Ultrium 2 drive	HP Ultrium 2-SCSI
LTO Ultrium 3 drive	HP Ultrium 3-SCSI
LTO Ultrium 4 drive	HP Ultrium 4-SCSI

# Operating the drive

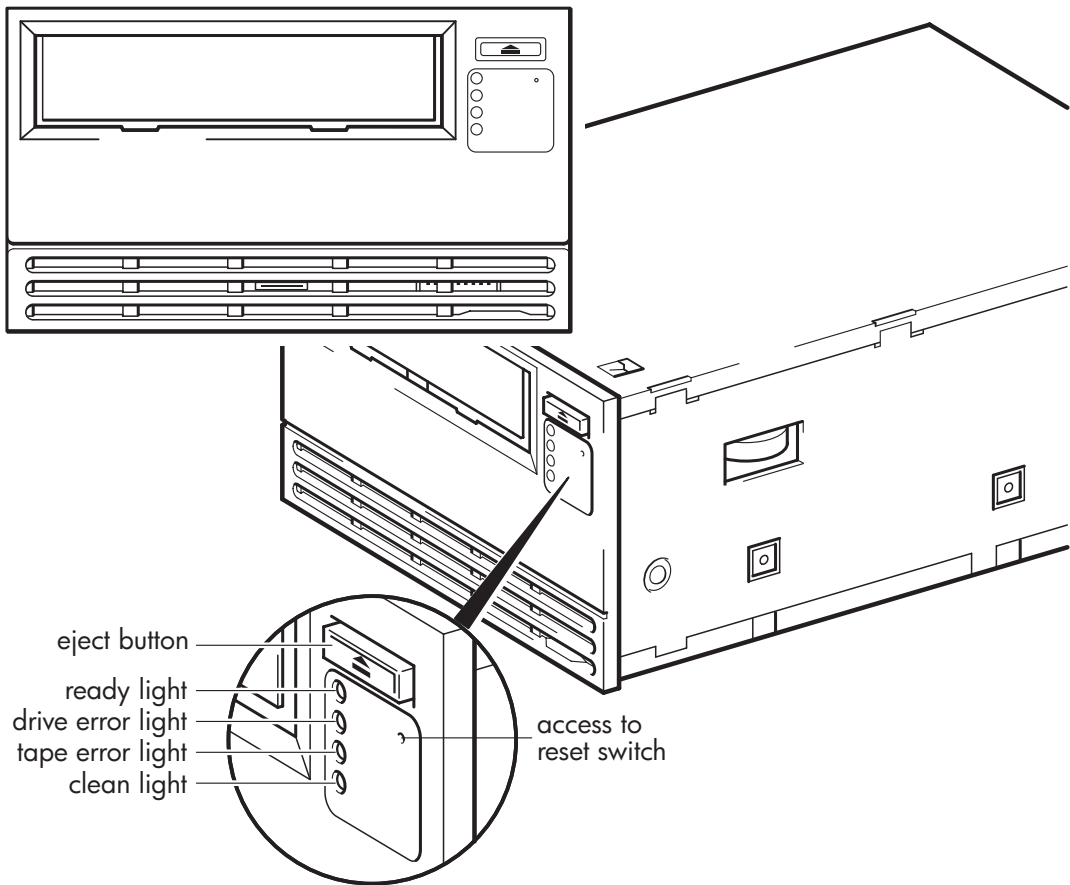
Internal drives are powered on when you switch on your computer.

The tape drive will run its hardware self-test. During the test the 'Ready' LED flashes and all the other LEDs are off. On successful completion the 'Ready' LED is on. If the self-test fails, the 'Drive Error' and 'Tape Error' LEDs flash, while the 'Ready' and 'Clean' LEDs are off. This continues until the drive is reset.

- If you have just installed the drive, check the installation for loose connections, reset the drive and repeat the self-test.
- Try the ["Troubleshooting" on page 55](#) to determine what the problem is.
- If the fault condition persists, call for assistance.

# Front panel features

**Figure 2** Full-height drive



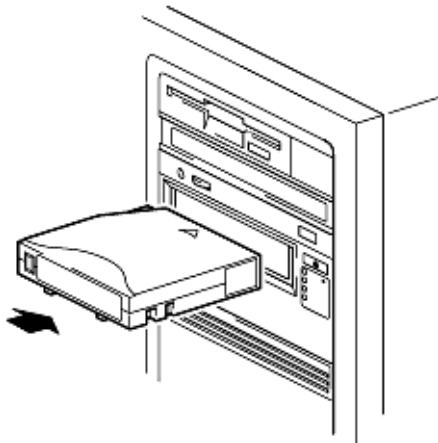
## LEDs

For details of the front panel LEDs, see [page 69](#).

## Reset switch

The emergency reset switch allows you to reset the drive without powering off the drive and computer, for example if the drive stops responding. Access to the switch is through a small hole. It can be activated by a thin object, such as the end of a straightened paper-clip.

## Loading a cartridge



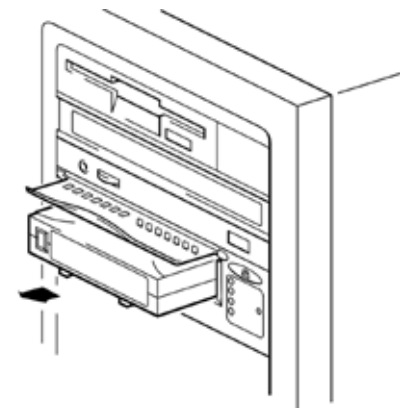
Use HP LTO Ultrium cartridges with your drive.

1. Insert the cartridge into the slot in front of the drive with the white arrow uppermost and facing the drive door.
2. Apply gentle pressure on the rear of the cartridge until the drive takes the cartridge and loads it.

The Ready LED flashes green while the drive performs its load sequence. When the cartridge is loaded, the Ready LED shows steady green.

Do not try to force the cartridge if it does not load properly. The drive will eject the cartridge after about 10 seconds so you can load it again.

## Unloading a cartridge



1. Press the Eject button on the front panel. During the unload sequence the READY LED flashes green. The drive completes any task it is currently performing, rewinds the tape and ejects the cartridge. Once the tape has rewound, the eject cycle will take less than 13 seconds.
2. Remove the cartridge and store it in its plastic case in a cool, dry atmosphere.

## Cleaning the drive

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△ **CAUTION:** It is essential to use only LTO Ultrium Universal cleaning cartridges with HP LTO Ultrium tape drives as other format cleaning cartridges will not load and run. Use of HP Universal cleaning cartridges will ensure your tape drive is fully protected. Do not use swabs or other means of cleaning the heads.

---

When the drive needs cleaning, the orange 'Clean' LED on the tape drive will flash. Only insert a cleaning cartridge into the tape drive when the LED flashes.

The drive's TapeAlert feature will send a message to your backup application when the tape heads need cleaning or a cleaning cartridge has expired.

LTO Ultrium Universal cleaning cartridges can be used up to 50 times.

**To clean the heads, proceed as follows:**

1. Insert a cleaning cartridge into the drive. The tape drive automatically loads the cartridge and cleans the heads.

If the cleaning cartridge ejects immediately, it has expired or it is not an LTO Ultrium Universal cleaning cartridge (or is an older LTO Ultrium 1 cleaning cartridge). In this case, discard the cleaning cartridge and repeat the operation with a new one.

The cleaning cycle can take up to 3 minutes, during which the orange 'Clean' LED will be on and the green 'Ready' LED will flash. When it has finished, the drive ejects the cartridge.

2. Remove the cleaning cartridge from the drive.

## Troubleshooting

### Emergency unload

If a cartridge fails to eject using the normal unload procedure, press and hold the Eject button for 10 seconds. This instructs the drive mechanics to perform an emergency unload. Wait for the cartridge to be ejected. This may take up to 15 minutes (the maximum rewind time).

If the cartridge is still jammed, press the emergency reset button (see [page 53](#)). Wait for the drive to reset and get back to the loaded position. This may take up to 15 minutes. Again press and hold the Eject button for 10 seconds to perform an emergency unload.

### General guidelines

If you experience problems when using the tape drive, you need to isolate the cause of the problem. For example, if you have just installed a new host bus adapter and your system will not start, the cause of the problem is likely to be the adapter.

When installing multiple items of hardware and software, we recommend that you install each in turn and restart the system each time. Similarly if you have already installed multiple devices and software and you experience problems, remove or uninstall each in turn to establish which one is causing the problem.

Remember that the system recognizes devices during boot-up. If you swap or connect a product when your system is running, you will need to reboot the system. Rebooting the system will reset devices and will often resolve problems. It is good practice to reboot every time you add a driver or install firmware.

### Diagnosing the problem

The first step in problem-solving is establishing whether the problem lies with the cartridge, the drive, the host computer and its connections, or with the way the system is being operated.

## Problems with the host computer

Most modern host bus adapters locate and display attached devices when the system is booting up. If the device is not detected at this stage, there is probably a problem with the physical hardware: cables, termination, connections, power or the HBA itself.

If your drive is found on system boot up but cannot be found in the operating system, this is more likely to be a software problem.

### Computer does not boot up

Possible Cause	Potential Solution
You have connected the tape drive to an existing SCSI bus that has other devices connected to it and the SCSI address of the drive is identical to the address used by another device.	Make sure that each device on the SCSI bus has a unique ID. We recommend that the tape drive is connected to a dedicated host bus adapter. Do not connect the drive to a disk RAID controller as this is not supported.
You have installed an additional host bus adapter and its resources are clashing with an existing adapter.	Remove the new host bus adapter and check the server documentation.
You have disconnected the power or data cable from the computer's boot disk during the drive installation process.	Check that the cables to all devices are firmly connected.

### Computer boots, but does not recognize the drive

Possible Cause	Potential Solution
The power or interface cable is not connected properly.	Check that the cables to the tape drive are firmly connected. Ensure that the cable is compliant and that is not damaged. Replace, if necessary.
The SCSI bus is not terminated correctly.	Remove the new host bus adapter and check the server documentation.
The tape drive's SCSI ID address is not unique.	Make sure that each device connected to the SCSI controller has a unique SCSI ID. Remember that 7 is normally reserved for the host bus adapter.



## Problems with the drive and cartridge

### Tape drive does not power up

Possible Cause	Potential Solution
The power cable is not connected properly.	<ul style="list-style-type: none"><li>• Check that the cables to the tape drive are firmly connected.</li><li>• Make sure that the power cable is firmly connected.</li><li>• Try another power connector.</li><li>• If the power supply is present and all LEDs remain off, call support</li></ul>
The self-test fails (Ready LED is off and the other LEDs are on steadily).	If there is a cartridge in the drive, remove it. Power down the drive and power it up again. If the self-test still fails, call support.

### The application does not recognize the drive

Possible Cause	Potential Solution
The application does not support the tape drive.	Check the drive is installed properly. Refer to our World Wide Web site ( <a href="http://www.hp.com/go/connect">www.hp.com/go/connect</a> ) for details of backup applications that support HP LTO Ultrium tape drives. Load any service packs as necessary.
Some applications require drivers to be loaded.	Check the correct interface and tape drive drivers are installed. Consult the backup application's installation notes for details.

### The cartridge will not eject

Possible Cause	Potential Solution
The cartridge is jammed in the drive, or the backup application cannot eject the cartridge. This is most likely to be a communication problem between the drive and the system.	<p>Check there is power to the drive.</p> <p>Press and hold the Eject button for 10 seconds. Allow the drive up to 15 minutes to eject (this is the maximum rewind time of the cartridge.)</p> <p>If the cartridge is still jammed, reset the drive (see <a href="#">page 53</a>). Allow 15 minutes for the drive to return to the loaded position. Press and hold the Eject button for 10 seconds to eject the cartridge from the reset drive.</p> <p>If the cartridge is still jammed, call for support.</p>

## The drive will not accept a cartridge

Possible Cause	Potential Solution
The cartridge is not compatible with your tape drive.	<p>Check you are using LTO Ultrium 2, 3 or 4 media. DLT cartridges are not compatible with LTO Ultrium drives.</p> <p>Check the orientation of the cartridge when loading into the drive.</p> <p><b>Note:</b> LTO Ultrium 1 cartridges are not supported in HP LTO Ultrium 4 tape drives.</p>
The cartridge has been damaged.	<p>Check the cartridge case is not cracked or split.</p> <p>Check the leader pin is not damaged. If it is, discard the cartridge.</p> <p>Check the cartridge teeth are not damaged. If they are, discard the cartridge.</p> <p>If the drive will still not accept the cartridge, try using a new or known good cartridge. If it loads, the original cartridge is faulty and should be discarded.</p> <p>If the original cartridge is accepted in another tape drive, the original tape drive may be at fault. Check the interface connection and that the tape drive is recognized by the backup application.</p>
The tape drive is faulty.	<p>Check the drive is powered on.</p> <p>If the drive still will not accept the cartridge, there may be a problem with the drive's cartridge memory. Call for support.</p>

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## 5 External standalone drives

For the physical specification of the drive, see Chapter 1, “Physical Specification” in *Specifications*, Volume 4 of the HP LTO Ultrium Technical Reference Manual.

If you are installing the tape drive on a UNIX system, refer to the *UNIX Configuration Guide*, Volume 5 of the HP LTO Ultrium Technical Reference Manual.

### Identifying the drive

The model name is on the front panel and the product and serial numbers are on a label on the bottom of the drive.

### Connecting the drive

#### SCSI connection

The rear panel connections on the external SCSI standalone drives consist of a mains power connector, two 68-pin very high density SCSI-3 connectors and a SCSI address switch. The drive should be connected to the server via a 68-pin, wide LVDS-rated cable using the SCSI-IN connection on the back of the drive. The standard, recommended configuration is a direct one-to-one SCSI connection between the tape drive and the host server so that the drive is the only device on the SCSI bus. You can daisy-chain two or more drives together, but to preserve performance you should only do this if the drives are on an Ultra320 SCSI bus. Do not daisy-chain more than two drives as this will degrade their individual performance.

#### Setting the SCSI ID

Each drive should have a unique SCSI ID. Set the ID using the SCSI address switch on the rear of the drive enclosure. Remember that a SCSI address of 7 is usually reserved for the host bus adapter.

#### Termination

Both ends of a SCSI bus must be terminated. As long as the drive is the last or only device on the SCSI bus, the drive enclosure automatically provides active termination when a cable is connected to the SCSI-IN connector. If there are other devices on the bus (which is not recommended), use the SCSI-OUT connector to connect to the next device in the chain, and make sure that the chain is terminated at the end with a multimode terminator.

If the drive is providing active termination, the green LED on the rear panel marked Act TERM will be lit (see [page 63](#)).

#### Termination power

With HP's LTO Ultrium drives, termination power is always provided; you cannot switch it off. The supply is a 5V line via a fuse and diode/capacitor combination. In this way, the drive “tops up” the termination power voltage if the host supply is below 5V (due to cable length or bad host termination power).

## SAS Connection

The rear panel connections of an external SAS standalone drive consist of a mains power connector and a Mini-SAS connector. The drive should be connected to the host server/expander with a good quality external SAS cable that is as short as possible. If you are attaching an SAS drive to a server, you will need a properly installed and configured SAS host bus adapter (HBA) or a built-in SAS controller on your server with a spare SAS port. For optimum performance your tape drive should only be connected to a 3 Gbps SAS host bus adapter or SAS controller, but the drive will also work with a 1.5 Gbps SAS bus.

## Moving drives

If there is a tape in the drive, unload it before powering down and moving the drive. When the drive is powered down, there is no physical lock on the tape reels. If you leave a tape threaded in the drive with the power off, the reels could rotate, causing a loop of tape to occur in the tape path. When the drive is next powered up, the tape could then fall off the guides and be damaged.

If for any reason you must move a drive with a tape threaded, move it slowly and carefully, making no sudden movements that could cause the reels to rotate.

## Operating the drive

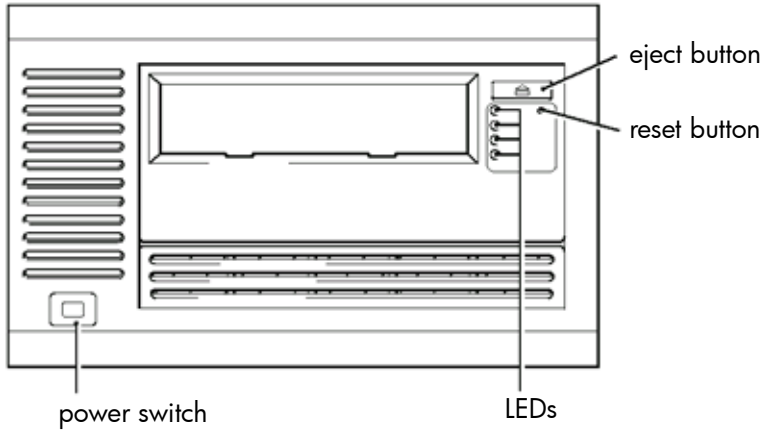
Switch on external drives using the power switch on the front panel, and then switch on the host computer.

The tape drive will run its hardware self-test, during which the 'Ready' LED flashes and all the other LEDs are off. On successful completion the 'Ready' LED is on.

If the self-test fails, the 'Drive Error' and 'Tape Error' LEDs flash, while the 'Ready' and 'Clean' LEDs are off. This continues until the drive is reset.

- If you have just installed the drive, check the installation for loose connections, reset the drive and repeat the self-test.
- Try ["Troubleshooting" on page 64](#) to determine what the problem is.
- If the fault condition persists, call for assistance.

## Front panel features



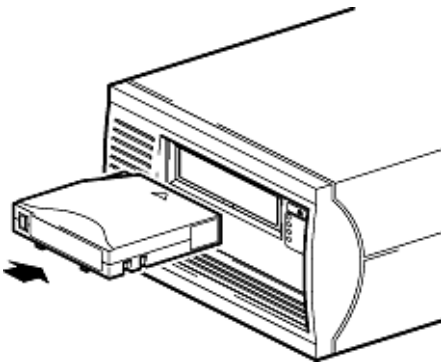
### LEDs

For details of the front panel LEDs, see [page 69](#).

### Reset switch

The emergency reset switch allows you to reset the drive without powering off the drive and computer, for example if the drive stops responding. Access to the switch is through a small hole. It can be activated by a thin object, such as the end of a straightened paper-clip.

## Loading a cartridge



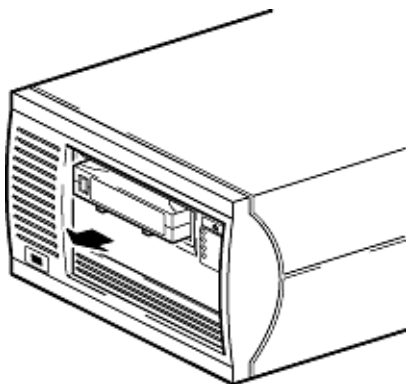
Use HP LTO Ultrium cartridges.

1. Insert the cartridge into the slot in front of the drive with the arrow uppermost and facing the drive door.
2. Apply gentle pressure on the rear of the cartridge until the drive takes the cartridge and loads it.

The Ready LED flashes green while the drive performs its load sequence. When the cartridge is loaded, the Ready LED shows steady green.

Do not try to force the cartridge if it does not load properly. The drive will eject the cartridge after about 10 seconds so you can load it again.

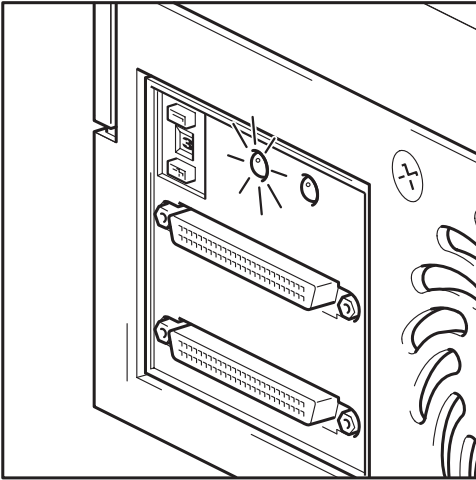
## Unloading a cartridge



1. Press the Eject button on the front panel.  
During the unload sequence the READY LED flashes green. The drive completes any task it is currently performing, winds the tape to the beginning and ejects the cartridge. Once the tape has rewound, the eject cycle will take less than 13 seconds.
2. Remove the cartridge and store it in its plastic case in a cool, dry atmosphere.

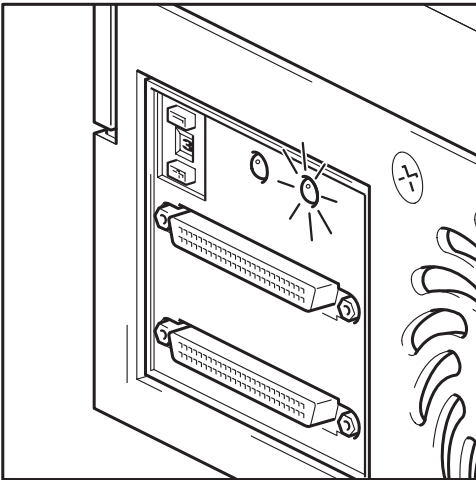
## Rear panel LEDs

The rear panel has two additional LEDs as shown below.



### **Act TERM** (termination active)

- Off** The drive enclosure is not providing active termination (there is another device or terminator attached to the SCSI-OUT connector).
- On** The drive enclosure is providing active termination on the SCSI bus.




### **Fan/PWR Fault** (fault with the fan or power supply)

- Off** No fault has been detected.
- On** A fault has been detected with the fan or power supply. Call for support.

## Cleaning the drive

When the drive needs cleaning, the orange 'Clean' LED on the front of the tape drive will flash. Only insert a cleaning cartridge into the tape drive when the LED flashes.

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 **NOTE:** The drive's TapeAlert feature will send a message to your backup application when the tape heads need cleaning or a cleaning cartridge has expired.

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- △ **CAUTION:** It is essential to use only LTO Ultrium Universal cleaning cartridges with HP LTO Ultrium tape drives as other format cleaning cartridges will not load and run. Use of HP cleaning media will ensure your tape drive is fully protected. Do not use swabs or other means of cleaning the heads.
- 

LTO Ultrium Universal cleaning cartridges can be used up to 50 times.

**To clean the heads:**

1. Insert a cleaning cartridge into the drive. The tape drive automatically loads the cartridge and cleans the heads.  
  
If the cleaning cartridge ejects immediately, it has expired or it is not an LTO Ultrium Universal cleaning cartridge (or is an older unsupported LTO Ultrium 1 cleaning cartridge). In this case, discard the cleaning cartridge and repeat the operation with a new one.  
  
The cleaning cycle can take up to 3 minutes, during which the orange 'Clean' LED will be on and the green 'Ready' LED will flash. When it has finished, the drive ejects the cartridge.
2. Remove the cleaning cartridge from the drive.

## Troubleshooting

### Emergency unload

If a cartridge fails to eject using the normal unload procedure, press and hold the Eject button for 10 seconds. This instructs the drive mechanics to perform an emergency unload. Wait for the cartridge to be ejected. This may take up to 15 minutes (the maximum rewind time).

If the cartridge is still jammed, press the emergency reset button (see [page 61](#)). Wait for the drive to reset and get back to the loaded position. This may take up to 15 minutes. Again press and hold the Eject button for 10 seconds to perform an emergency unload.

### General guidelines

If you experience problems when using the tape drive, you need to isolate the cause of the problem. For example, if you have just installed a new SCSI host bus adapter and your system will not start, the cause of the problem is likely to be the adapter.

When installing multiple items of hardware and software, we recommend that you install each in turn and restart the system each time. Similarly if you have already installed multiple devices and software and you experience problems, remove or uninstall each in turn to establish which one is causing the problem.

Remember that the system recognizes devices during boot-up. If you swap or connect a product when your system is running, you will need to reboot the system. Rebooting the system will reset devices and will often resolve problems. It is good practice to reboot every time you add a driver or install firmware.



## Problems with the host computer

Most modern SCSI host bus adapters locate and display attached devices when the system is booting up. If the device is not detected at this stage, there is probably a problem with the physical hardware: cables, termination, connections, power or the HBA itself.

If your drive is found on system boot up but cannot be found in the operating system, this is more likely to be a software problem.

### Computer does not boot up

Possible Cause	Potential Solution
You have connected the tape drive to an existing SCSI bus that has other devices connected to it and the SCSI address of the drive is identical to the address used by another device.	Make sure that each device on the SCSI bus has a unique ID. We recommend that the tape drive is connected to a dedicated host bus adapter. Do not connect the drive to a disk RAID controller as this is not supported.
You have installed an additional SCSI host bus adapter and its resources are clashing with an existing adapter.	Remove the new host bus adapter and check the server documentation.
You have disconnected the power or SCSI cable from the computer's boot disk during the drive installation process.	Check that the cables to all devices are firmly connected.

### Computer boots, but does not recognize the drive

Possible Cause	Potential Solution
The power or SCSI cable is not connected properly.	Check the cables to the tape drive are firmly connected. Ensure the SCSI cable is LVDS-compliant and that it does not have any bent pins. Replace, if necessary.
The SCSI bus is not terminated correctly.	Remove the new host bus adapter and check the server documentation.
The tape drive's SCSI ID address is not unique.	Make sure that each device connected to the SCSI controller has a unique SCSI ID. Remember that 7 is normally reserved for the host bus adapter.
The tape drive may have been switched on after the computer was booted up. The computer checks for SCSI devices only at power-on.	Switch on the tape drive, then switch the computer off and then on again.

## Problems with the drive and cartridge

### Tape drive does not power up

Possible Cause	Potential Solution
The power cable is not connected properly.	<ul style="list-style-type: none"><li>• Check the cables to the tape drive are firmly connected.</li><li>• Make sure that the power cable is firmly connected.</li><li>• The power on/off switch incorporates a green LED. If this is not on, check the power cable connection and replace the cable if necessary. You can use the power cable from your monitor or another device to check that the connection is working.</li><li>• If the power supply is present and all LEDs remain off, call support</li></ul>
The self-test fails (Ready LED is off and the other LEDs are on solidly).	If there is a cartridge in the drive, remove it. Power down the drive and power it up again. If the self-test still fails, call support.

### The application does not recognize the drive

Possible Cause	Potential Solution
The application does not support the tape drive.	Check the drive is installed properly. Refer to our World Wide Web site ( <a href="http://www.hp.com/go/connect">www.hp.com/go/connect</a> ) for details of backup applications that support HP LTO Ultrium tape drives. Load any service packs as necessary.
Some applications require drivers to be loaded.	Check the correct HBA and tape drive drivers are installed. Consult the backup application's installation notes for details.

## The cartridge will not eject



Possible Cause	Potential Solution
<p>The cartridge is jammed in the drive, or the backup application cannot eject the cartridge.</p> <p>This is most likely to be a communication problem between drive and system.</p>	<p>Check there is power to the drive.</p> <p>Press and hold the Eject button for 10 seconds. Allow the drive up to 15 minutes to eject (this is the maximum rewind time of the cartridge.)</p> <p>If the cartridge is still jammed, reset the drive (see <a href="#">page 61</a>). Allow 15 minutes for the drive to return to the loaded position. Press and hold the Eject button for 10 seconds to eject the cartridge from the reset drive.</p> <p>If the cartridge is still jammed, perform an emergency reset by pressing and holding the Eject button for 20 seconds. The drive will reset when you release the button. Wait for the drive to reset and get back to the loaded position. This may take up to 15 minutes. Again press and hold the Eject button for 10 seconds to perform a second forced eject.</p> <p>If the cartridge is still jammed, call for support.</p>

## The drive will not accept a cartridge

Possible Cause	Potential Solution
<p>The cartridge is not compatible with your tape drive.</p>	<p>Check you are using LTO Ultrium 2, 3 or 4 media. DLT cartridges are not compatible with LTO Ultrium drives.</p> <p>Check the orientation of the cartridge when loading into the drive.</p> <p><b>Note:</b> LTO Ultrium 1 cartridges are not supported in HP LTO Ultrium 4 tape drives.</p>
<p>The cartridge has been damaged.</p>	<p>Check the cartridge case is not cracked or split.</p> <p>Check the leader pin and cartridge teeth are not damaged. If they are, discard the cartridge.</p> <p>If the drive will still not accept the cartridge, try a new or known good cartridge. If it loads, the original cartridge is faulty and should be discarded.</p> <p>If the original cartridge is accepted in another tape drive, the original tape drive may be at fault. Check the SCSI connection and that the tape drive is recognized by the backup application.</p>
<p>The tape drive is faulty.</p>	<p>Check the drive is powered on.</p> <p>If the drive still will not accept the cartridge, there may be a problem with the drive's cartridge memory. Call support.</p>

### Rear panel LED patterns

The two LEDs on the rear panel can give information about problems with the following patterns:

LEDs	Cause	Action required
	The Act Term LED is off. The enclosure is not providing auto-termination.	Check that the drive's SCSI cable is connected to the SCSI-IN connector.  Check whether a terminator or other SCSI cable is plugged into the SCSI-OUT connector. If a terminator is connected, remove it. If another SCSI cable is connected, make sure that the SCSI chain is terminated at the last device.
	The Fan/PWR LED is orange. There has been an enclosure failure or the cooling fan is not working correctly.	Call support.

For more information about the rear panel LEDs, see [page 63](#).

## 6 Front panel and LEDs

There are three front panels for full-height HP LTO Ultrium 4 products:

- Default—see [page 53](#)
- Automation, for use when the drive is embedded in automation applications—see [page 14](#)
- A third front panel allowing drives to be used in 2U autoloaders where the front panel cannot exceed the drive form factor in height and width—see [page 14](#)

The drive is not designed to operate without a front panel (even in automation applications). The front panel was designed to meet Section 508 accessibility guidelines.

Full details of the default front panel are given in the Operation topic within the User's Guide.

### Usual meaning of LEDs




The four LEDs, Ready, Drive Error, Tape Error and Clean usually have the following meanings:

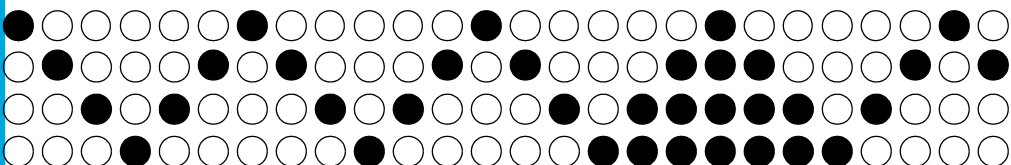
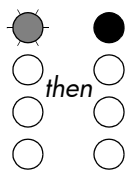
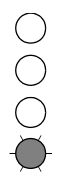
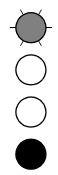
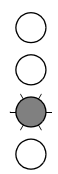
<b>Ready</b>	Top LED—green. Indicates power and activity:	
	<i>Off</i>	Power off or self-test failure
	<i>On</i>	Powered on and ready for use, but no activity
	<i>Flashing</i>	Engaged in activity, such as responding to Read, Write or Space commands or performing a self-test
	<i>Fast flash</i>	New firmware download
	Repeating pattern	A repeating pattern of short and long flashes indicates that the drive is in OBDR mode.
<b>Drive Error</b>	Second LED—orange. Indicates drive problems:	
	<i>Off</i>	No fault
	<i>Flashing</i>	Unrecoverable hardware failure. A power cycle or successful tape load will turn the LED off, but the LED will start flashing again if the same operation is performed and the hardware fault is still present
<b>Tape Error</b>	Third LED—orange. Indicates tape problems:	
	<i>Off</i>	No fault
	<i>Flashing</i>	Current tape is faulty, such as unreadable cartridge memory or unsupported type. Do not use the cartridge; replace it. The LED will go out when a tape load begins.

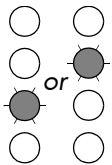
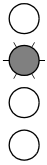
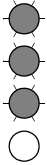
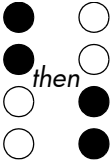
<b>Clean</b>	Bottom LED—orange. Indicates whether the drive needs cleaning.	
	<i>Off</i>	Cleaning not required
	<i>On</i>	Cleaning cartridge being used. The Ready LED flashes.
	<i>Flashing</i>	Cleaning needed. The LED continues to flash if the drive is power cycled, and will only go out after a supported cleaning tape has been used.

## Other LED patterns

There are other patterns usually involving several LEDs, which have the following meanings:

LED Sequence	Cause	Action required
	<p>All LEDs OFF.</p> <p>Drive may not have power, may be faulty or may have been power cycled or reset during a firmware upgrade.</p>	<p>Ensure the drive is switched on.</p> <p>If the green LED on the power switch is not on, check the power cable and replace it if necessary.</p> <p>If the drive has just been switched on or reset, the LED pattern should change after 1 second. If not, the drive has Firmware Image Corruption (caused by being switched off or reset during firmware upgrade). Return it to the factory for repair or reprogramming.</p> <p>If power is present and all LEDs remain off, try performing an interface operation (host or ACI). If the drive does not respond, or power-cycle the drive.</p> <p>If it still fails, call for service.</p>
	<p>Ready and Clean OFF. Drive Error and Tape Error FLASHING.</p> <p>The drive has failed to execute power-on self test (POST).</p>	<p>Power cycle or reset the drive.</p> <p>If the condition reappears, call for service.</p>
	<p>Ready ON.</p> <p>The drive is ready for operation.</p>	<p>None. This is normal.</p>

LED Sequence	Cause	Action required
	<p>Ready OFF, others ON.</p> <p>Firmware is being reprogrammed.</p>	<p>None.</p> <p>If the drive is upgrading firmware, do not reset or power cycle it.</p>
	<p>Ready FLASHES twice, then pauses ON, then FLASHES twice.</p> <p>The drive is in OBDR mode.</p>	<p>If you need to exit OBDR mode, power cycle or reset the drive.</p> <p><b>NOTE:</b> OBDR is not supported in all versions.</p>
	<p>Clean FLASHING. (Other LEDs may be flashing.)</p> <p>The drive requires cleaning.</p>	<p>Load an LTO Ultrium Universal cleaning cartridge to clean the heads.</p> <p>If the Clean LED is still flashing when you load a new or known data cartridge after cleaning, call for service.</p>
	<p>Ready FLASHING and Clean ON. (Other LEDs may be flashing.)</p> <p>Cleaning is in progress.</p>	<p>None. The cleaning cartridge will eject on completion.</p> <p>The cleaning cycle can take up to 3 minutes .</p>
	<p>Tape Error FLASHING. (Other LEDs may be flashing.)</p> <p>The drive believes the current tape or the tape just ejected is faulty.</p>	<p>Unload the tape cartridge. Make sure that it is a valid format: an LTO Ultrium data cartridge or LTO Ultrium Universal cleaning cartridge.</p> <p>Reload the cartridge. If the Tape Error LED still flashes or starts flashing during the next backup, load a new or known, good cartridge.</p> <p>If the Tape Error LED is now off, discard the 'suspect' tape cartridge. If it is still on, call for service.</p>

LED Sequence	Cause	Action required
	<p>Tape ejects immediately and Tape Error FLASHES</p> <p>The tape cartridge memory (CM) may be faulty.</p>	<p>Write-protect the cartridge by sliding the red switch on the cartridge. The tape can be loaded and the data read. Once the data is recovered, discard the cartridge.</p>
	<p>Drive Error FLASHING. (Other LEDs may be flashing.)</p> <p>The drive mechanism has detected an error.</p>	<p>Load a new cartridge. If the error persists, power cycle or reset the drive.</p> <p>If the Drive Error LED remains on, call for service.</p>
	<p>Drive Error, Tape Error and Ready FLASH.</p> <p>There is a firmware download problem.</p>	<p>Insert a cartridge to clear the LED sequence; the drive will continue using the old firmware. If the condition persists, call for service.</p>
	<p><i>Drive Error and Ready ON with Tape Error and Clean OFF. Sequence alternates repeatedly.</i></p> <p>The drive has a firmware error.</p>	<p>Power cycle or reset the drive. If the sequence reoccurs, upgrade the firmware. If the condition persists, call for service.</p>

## During firmware upgrade

△ **CAUTION:** Do not reset or power-cycle the drive until the firmware upgrade is complete, otherwise the drive will not be able to operate.

If a firmware upgrade is successful, the LEDs light in sequence during the download as shown in the table above.

If a corrupt or incompatible image is downloaded from tape, the Ready LED will remain on steadily and the Tape Error LED will flash until a tape load is started. The other LEDs will be off.



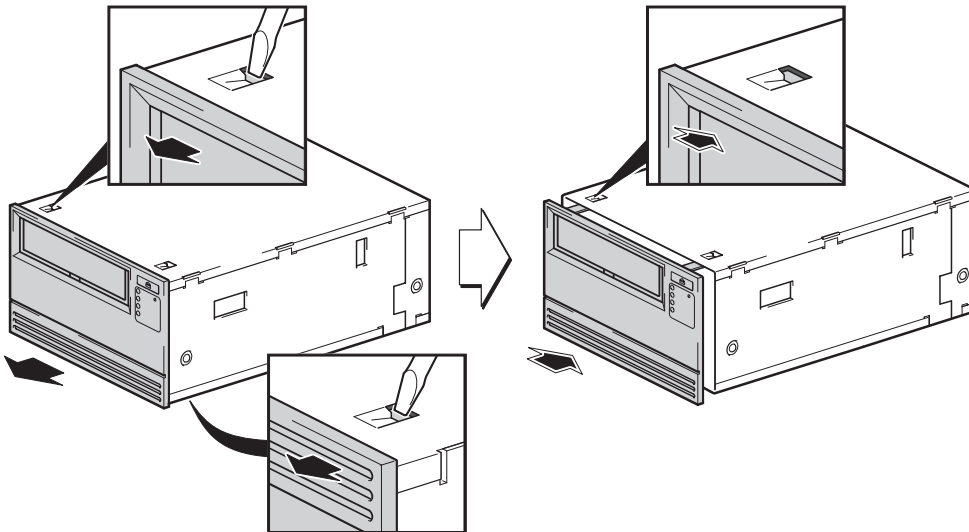
# Replacing the front panel

- △ **CAUTION:** At all times please observe ESD precautions as indicated in the installation manual supplied with the tape drive. Static electricity can damage electronic components. Touch a bare metal part of the computer, such as a back plate, before you attempt to install or remove the drive.

## Parts needed

- Replacement front panel
- Small bladed screwdriver (1.25x5 slotted or smaller)

## Replacing the front panel on an full-height LTO Ultrium drive



1. Use the screwdriver to release the tabs at the top of the chassis and underneath.
2. Pull the front panel towards you and away from the drive.

To replace the panel, line up the four tabs with the chassis and push the panel firmly into place. There will be a slight click when the lugs are located in the chassis.

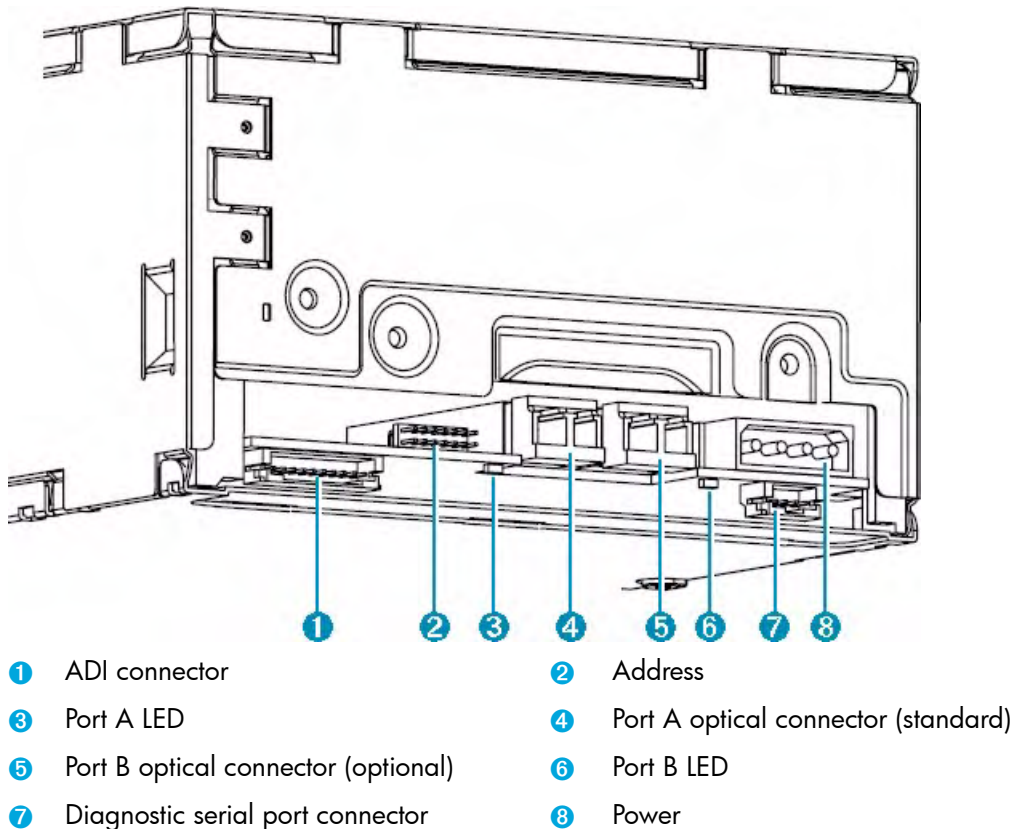


## 7 Rear panel LEDs, connectors and switches

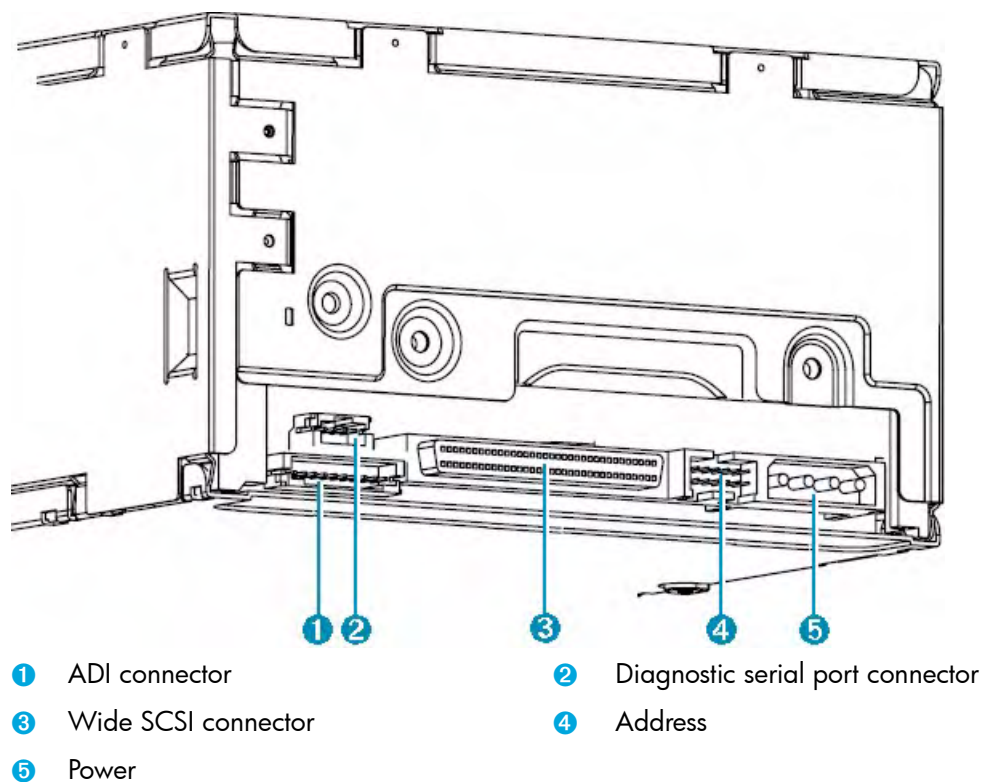
The rear panel contains the connector interface that allows the tape drive to communicate with a tape library or host computer system. The panel includes the following connectors:

- *Either:* Two SFP duplex-LC optical fibre connectors (only one might be connected)
- *Or:* A SCSI or SAS connector
- ACI/ADI connector (for libraries)
- Diagnostic serial port

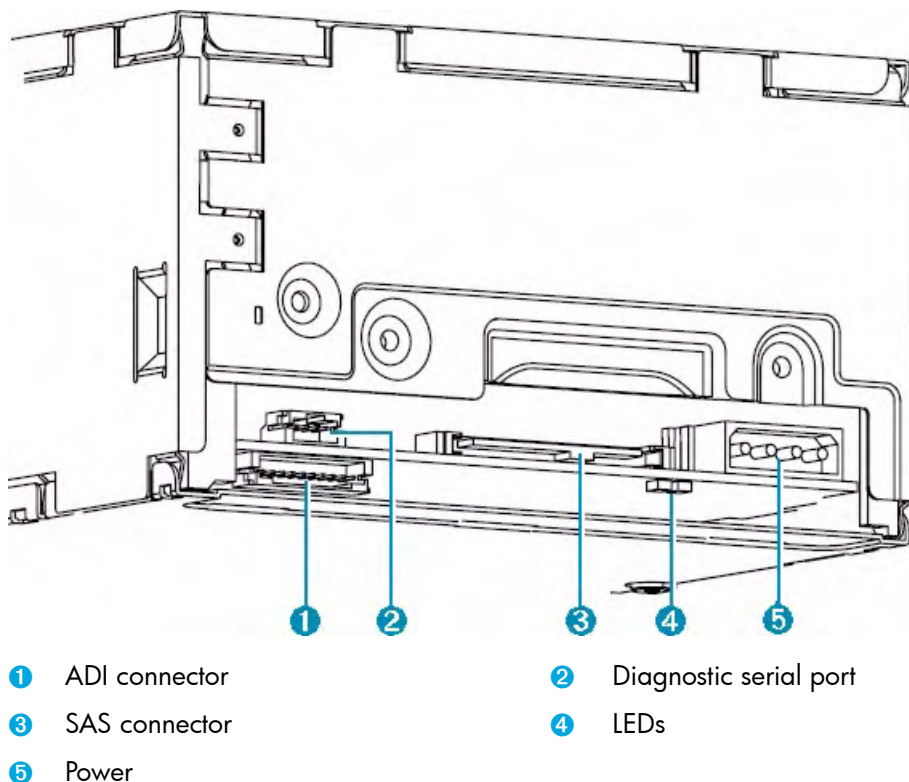
**Figure 3** Rear panel components for a Fibre Channel drive



**Figure 4** Rear panel components for a full-height SCSI drive



**Figure 5** Rear panel components for a full-height SAS drive



## LEDs *(Fibre Channel drives only)*

The rear panel has two LEDs, one each for Fibre Channel Port A and Port B.

## Power-on self-test failure

If the Fibre Channel firmware encounters a Power-On Self-Test failure, the drive will not initialize the FC ports and so will not respond over the FC interface. The two FC port LEDs will flash together at 1 cycle/second until the drive is reset or power-cycled.

## Port initialized

Once the self-test is complete, the FC Port LEDs indicate whether the respective ports have been initialized, in other words, whether successful speed negotiation and loop initialization/old port mode has occurred.

Port A LED	Port B LED	Meaning
Off	Off	Neither port is initialized
On	Off	Only port A is initialized

Port A LED	Port B LED	Meaning
Off	On	Only port B is initialized
On	On	Both ports are initialized

## Port activity

When there is SCSI activity on an FC port, the appropriate FC port LED will flash with a periodicity of 1/10 second.

## Fibre Channel addressing

The drive's hard AL\_PA can be configured in two ways:

- Jumpers connected to the address connector on the PCA
- An ACI Set Drive Configuration command or ADI Mode Select command

The value set using either of these two methods is the Loop ID, an 8-bit value which is translated by the drive into a 7-bit Arbitrated Loop Physical Address (AL\_PA) according to Table 1:

**Table 1** AL\_PA and Loop ID look-up table

AL_PA	Loop ID	AL_PA	Loop ID	AL_PA	Loop ID	AL_PA	Loop ID	AL_PA	Loop ID	AL_PA	Loop ID
00h	–	2Eh	68h	53h	52h			AAh	26h	CDh	10h
01h	7Dh	31h	67h	54h	51h	76h	3Ch	ABh	25h	CEh	Fh
02h	7Ch	32h	66h	55h	50h	79h	3Bh	ACH	24h	D1h	Eh
04h	7Bh	33h	65h	56h	4Fh	7Ah	3Ah	ADh	23h	D2h	Dh
08h	7Ah	34h	64h	59h	4Eh	7Ch	39h	A Eh	22h	D3h	Ch
0Fh	79h	35h	63h	5Ah	4Dh	80h	38h	B1h	21h	D4h	Bh
10h	78h	36h	62h	5Ch	4Ch	81h	37h	B2h	20h	D5h	Ah
17h	77h	39h	61h	63h	4Bh	82h	36h	B3h	1Fh	D6h	9h
18h	76h	3Ah	60h	65h	4Ah	84h	35h	B4h	1Eh	D9h	8h
1Bh	75h	3Ch	6Fh	66h	49h	88h	34h	B5h	1Dh	DAh	7h
1Dh	74h	43h	5Eh	67h	48h	8Fh	33h	B6h	1Ch	DCh	6h
1Eh	73h	45h	5Dh	69h	47h	90h	32h	B9h	1Bh	E0h	5h
1Fh	72h	46h	5Ch	6Ah	46h	97h	31h	BAh	1Ah	E1h	4h
23h	71h	47h	5Bh	6Bh	45h	98h	30h	BCh	19h	E2h	3h
25h	70h	49h	5Ah	6Ch	44h	9Bh	2Fh	C3h	18h	E4h	2h
26h	6Fh	4Ah	59h	6Dh	43h	9Dh	2Eh	C5h	17h	E8h	1h
27h	6Eh	4Bh	58h	6Eh	42h	9Eh	2Dh	C6h	16h	EFh	–
29h	6Dh	4Ch	57h	71h	41h	9Fh	2Ch	C7h	15h		
2Ah	6Ch	4Dh	56h	72h	40h	A3h	2Bh	C9h	14h		
2Bh	6Bh	4Eh	55h	73h	3Fh	A5h	2Ah	CAh	13h		
2Ch	6Ah	51h	54h	74h	3Eh	A6h	29h	CBh	12h		
2Dh	69h	52h	53h	75h	3Dh	A7h	28h	CCh	11h		

When setting the Loop ID via the automation interface the full 8-bit value is accessible but when setting it from the hardware jumpers only the lowermost 4 bits can be modified, the higher 4 bits being internally set to 0.

The jumper pins on the rear of the drive, seen viewing the drive from the rear in its normal 0° orientation are as follows. Pin 1 is at the bottom left; pin 14 at top right:

-----Loop-ID jumpers-----				Pins 9–14 are used for connecting to external LEDs only; do not connect jumpers		
2 <b>GND</b>	4 <b>GND</b>	6 <b>GND</b>	8 <b>GND</b>	10 <b>GND</b>	12 <b>3v3</b> (via301Ω resistor)	14 <b>3v3</b> (via301Ω resistor)
1 <b>ALPA_0</b>	3 <b>ALPA_1</b>	5 <b>ALPA_2</b>	7 <b>ALPA_3</b>	9 <b>no connect</b>	11 <b>LED_OUT1</b> (right transceiver LED)	13 <b>LED_OUT2</b> (left transceiver LED)

Table 2 shows how to set an AL\_PA via these jumpers. As an example, to set an AL\_PA of D5h, the table indicates that you need to set the Loop ID jumpers to a value of Ah, represented by jumpers in the 2nd and 4th positions from the left (as viewed from the rear of the drive), shown in the table as - | - | ----. Soft addressing is used if the jumpers are set to ---- ---- (00h).

**Table 2** Jumper settings for AL\_PAs

<b>AL_PA</b>	<b>Loop ID</b> (bits 3–0, from jumpers)	<b>Full Loop ID</b> (bits 7–4 assumed 0)	<b>Jumpers</b> (left to right as viewed from the rear)   = jumper, - = none
soft	0h	00h	---- ----
E8h	1h	01h	---- ----
E4h	2h	02h	-   -- ----
E2h	3h	03h	-- ----
E1h	4h	04h	--   - ----
E0h	5h	05h	-   - ----
DCh	6h	06h	-     - ----
DAh	7h	07h	- ----
D9h	8h	08h	---   ----
D6h	9h	09h	--   ----
D5h	Ah	0Ah	-   -   ----
D4h	Bh	0Bh	-   ----
D3h	Ch	0Ch	--     ----
D2h	Dh	0Dh	-     ----
D1h	Eh	0Eh	-       ----
CEh	Fh	0Fh	----

## Connectors

### SCSI connector

HP LTO Ultrium 4 drives are Ultra 320 wide, SCAM-1 compliant SCSI devices designed to operate on a low voltage differential (LVD) SCSI bus. They use a 68-pin SCSI Ultra 3 LVD interface to communicate with a tape library or host computer system.

The SCSI connection is a straddle-mounted three-part SCSI peripheral connector. This incorporates a 68-pin high density SCSI connector, a 4-pin power connector and a 12-pin auxiliary connector. The stub length (SCSI IC to connector) is 22 mm average.

In a library, the SCSI and power connectors interface with appropriate cables connected to the library bulkhead. The SCSI cables may be installed in a daisy-chain configuration linking two or more LTO Ultrium tape drives within the library together on the same SCSI bus.

The auxiliary connector is used for setting the SCSI address.

Each device on the SCSI bus must have a unique SCSI ID set by the library or by the auxiliary connectors.

### Fibre Channel connector

FC drives are equipped with two SFP duplex-LC short-wave 4 Gb/s fibre connectors. The drives are capable of switched fabric attach, public loop or private loop and operate at 4 Gb/s, 2 Gb/s or 1 Gb/s after auto-speed negotiation.

### SAS connector

SAS drives are equipped with a standard internal SAS connector. HP LTO Ultrium 4 drives should only be powered from the normal power connector, not from the power port of the SAS connector, because this is not connected.

### Automation Device/Interface (ADI) connector

The automation connector is a 10-pin JST PH surface-mount right-angle connector. This is mounted alongside the main interface. It can be mated with either crimped or insulation displacement connectors, as follows:

#### Crimped connectors

*Housing:* PHR-10

*Contacts:* SPH-002T-P0.5S (for AWG# 30-24 wire)

SPH-004T-P0.5S (for AWG# 32-28 wire)

See <http://www.jst-mfg.com/ProductGuideE/EPH.html> for full details.

#### Insulation displacement connectors

- 09KR-8M for AWG# 28 wire

- 09KR-6S for AWG# 26 wire

See <http://www.jst-mfg.com/ProductGuideE/EKR.html> for full details.



Connector pins

ACI operation

When used for ACI communications, the pins of the ACI connector are as follows:

Pin	ID	Function
1	ACI_RX+	RS-422 Receive (+ side of the differential RS-422 line)
2	ACI_RX-	RS-422 Receive (- side of the differential RS-422 line)
3	GND	Ground
4	ACI_TX-	RS-422 Transmit (- side of the differential RS-422 line)
5	ACI_TX+	RS-422 Transmit (+ side of the differential RS-422 line)
6	ACI_DRV_SEN_L	Drive Sense. It is tied low in the drive so that a library can sense the presence of the drive. The library should have a pull-up resistor on this line. <i>Low:</i> Drive present <i>High:</i> Drive not present (3.3 or 5 volts)
7	ACI_LIB_SEN_L	Library Sense. The drive will not appear on the bus until commanded when low. The line is pulled up to 5V in the tape drive. The automation controller should pull this pin low. <i>Low:</i> Drive is connected to an automation controller <i>High:</i> Drive is standalone (3.3 or 5 volts)
8	ACI_RST_L	Tape drive reset. The line is pulled up to 5V in the drive. The drive will perform a Drive Reset when this line is pulled low.
9	ACI_ATN_L	The drive sets this pin low to indicate to the automation controller that certain configured conditions have arisen, such as a SCSI Surrogate CDB.
10	—	No connection

Supported Baud rates

Baud Rate	Notes
9600 19200 38400 57600 115200	Default rate

For details of ACI commands, see Chapter 5 “Supporting LTO Ultrium Features” of the *Software Integration Guide*, Volume 2 of the HP LTO Ultrium Technical Reference Manual.

## ADI operation

When used for ADI communications, the pins of the ADI connector are as follows:

Pin	ID	Function
1	+Tx <sub>d</sub> -Rx <sub>d</sub>	RS-422 Receive from automation controller
2	-Tx <sub>d</sub> -Rx <sub>d</sub>	RS-422 Receive from automation controller
3	Ground	Ground
4	-Tx <sub>d</sub> -Rx <sub>a</sub>	RS-422 Transmit from tape drive
5	+Tx <sub>d</sub> -Rx <sub>a</sub>	RS-422 Transmit from tape drive
6	Sense <sub>d</sub>	Tied low in the drive so that a library can sense the presence of the drive.
7	Sense <sub>d</sub>	The drive will not appear on the bus until commanded when low.
8	Reset <sub>d</sub>	Hard reset (active low)
9	Signal <sub>aux</sub>	Reserved for future use
10	—	No connection

The ID names correlate with the descriptions in the T10 Automation/Drive Interface Transport Protocol (ADT).

### Supported Baud rates

Baud Rate	Notes
9600	Default rate
19200	
38400	
57600	
76800	
115200	
153600	

## 8 Modes of usage and optimizing performance

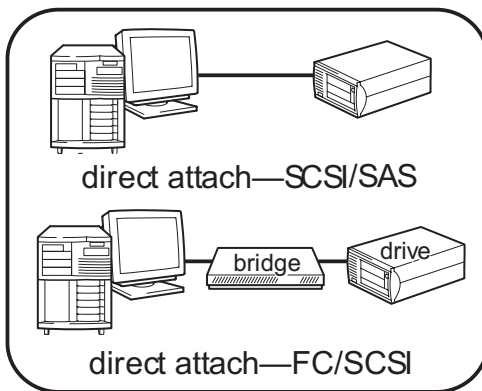
### Modes of usage

HP LTO Ultrium tape drives and arrays can be used in different system configurations (SCSI and SAS drives can be directly attached to a VHD SCSI or SAS connector respectively on a server or fibre channel router). They can be used in a standalone (direct attach) or network environments (both Local Area Network and Storage Area Network).

To connect a SCSI drive or array to fibre channel you must purchase and install a supported fibre channel/SCSI router.

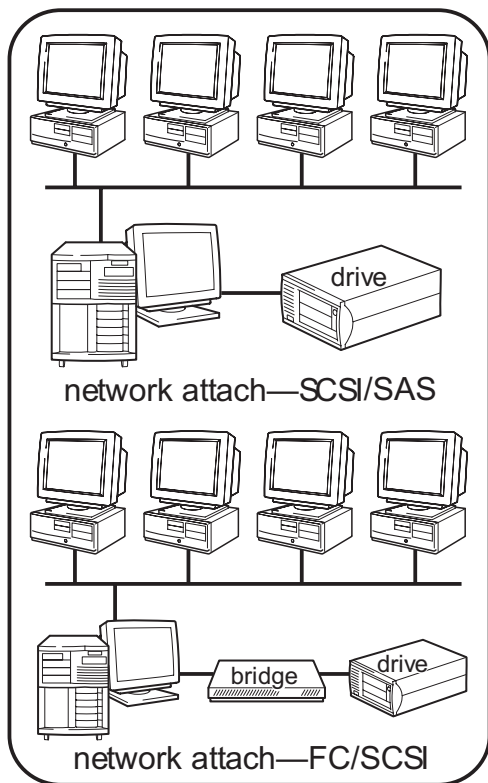
A SCSI tape drive or array should be connected to the VHD SCSI connector on the server or router. A SAS tape drive or array should be connected to the SAS connector on the server or router. Network users may need to take additional steps/to ensure that their system is configured for optimum performance. These are described in [“Optimizing performance” on page 84](#).

### Direct Attach



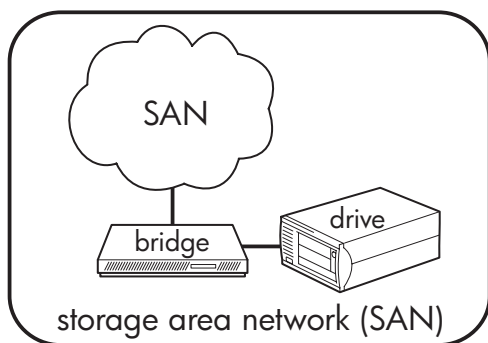
A SCSI tape array is directly attached to a single server via a SCSI link or a fibre channel/SCSI router.

## Network Attach (LAN)



A SCSI or SAS tape array is directly attached to a network storage server that can be accessed by a number of clients or workstations. As with the direct attach model, the connection is via a SCSI or SAS link or fibre channel/SCSI router to the storage server.

## Storage Area Network (SAN)



A SCSI tape array is attached to the SAN via a fibre channel/SCSI router. The array can be used to back up any device in the fibre channel fabric; in practise, the system administrator decides which devices will be able to see and access the array.

## Optimizing performance

Various factors can affect tape drive performance, particularly in a network environment or if the drive is not on a dedicated bus. If your tape drive is not performing as well as expected, consider the following points before contacting HP Support at [www.hp.com/support](http://www.hp.com/support).

## Dedicated SCSI bus

For optimum performance, we recommend that the tape drive is the only device on the SCSI bus. If it is not, ensure other devices are LVD-compliant. If they are single-ended, the bus will switch to single-ended mode with a lower transfer speed. There will also be restrictions on cable length.

## System performance

Drives can write data at 120 MB/s (native) or 240 MB/s (2:1 compression). However, to get this performance it is essential that your whole system can deliver this performance.

Typical areas where bottlenecks can occur are:

- Disk system (a single hard disk drive will not be able to deliver 240 MB/s transfer rates).
- Some file systems are able to transfer data faster than others.
- The type of data being backed up can affect backup performance (for example, file sizes and compressibility).
- Some backup software performs better than others.

To improve performance you may like to consider a RAIDed disk solution with a large number of physical hard disks.

Some enterprise class backup applications can be made to interleave data from multiple sources, such as clients or disks, to keep the tape drive working at optimum performance.

## Data transfer rate

Adaptive Tape Speed (ATS) enables the drive to “stream” data at variable tape speed, which means that it maintains a continuous data flow to tape even when the transfer speed varies. This is automatically managed by the drive to keep the drive running at best performance. When using LTO Ultrium 4 cartridges, the ATS range is 40 to 120 MB/s (native), so, if possible data transfer should remain within this range. In most cases, the backup application will provide details of the average time taken at the end of the backup.

---

 **NOTE:** For optimum performance always use Ultrium 4 1600 GB cartridges.

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## Performance checklist

The following list summarizes factors that can affect performance. They provide guideline only of areas that may need further investigation. They do not attempt to explain how to configure individual systems. For a more detailed discussion, including information about tools that allow you to test performance, refer to our white papers on [www.hp.com](http://www.hp.com). (Select the product first and look at the Information Library.)

- Is the tape drive reading and writing data at the correct speed?
- Is the source system (hard disk) transferring data at the correct speed?
- Is the backup application writing buffers at the correct speed? You may need to tune the transfer, buffer and block size settings to optimize the speed that the application writes data to the tape drive. HP LTO Ultrium drives have an internal buffer of 128 MB.

- Is the operating system tuned for performance? You may need to adjust the data transfer packet size.
- If you are using a SCSI drive or array in a SAN environment, are you are using one of the recommended fibre channel/SCSI routers?
- Are user applications, such as Exchange or database servers, optimized for backup performance?
- Are there other factors that could be affecting performance, such as interference or fibre channel infrastructure?

## 9 Cartridges

### Choosing cartridges

HP recommends HP LTO-4 Ultrium 1600 GB (2:1 compression) cartridges.

HP LTO Ultrium drives will also support other lower capacity HP and non-HP LTO Ultrium cartridges but the performance of your drive may be restricted. Data transfer rates will be slower on LTO Ultrium 3 800 GB cartridges compared to LTO Ultrium 4 1600 GB cartridges. Do **not** use HP DLTIII tape or DLTIV tape cartridges. The size and shape of LTO Ultrium media is very similar to that of DLT cartridges in order to make it easy for automation/library vendors to integrate LTO Ultrium into existing DLT libraries. Compatible media can be recognized by the LTO Ultrium logo, which is the same as the logo on the front of your drive.

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**NOTE:** HP LTO Ultrium 4 tape drives are not compatible with LTO Ultrium 1 media, which will be rejected as unsupported. The Tape Error LED will light.

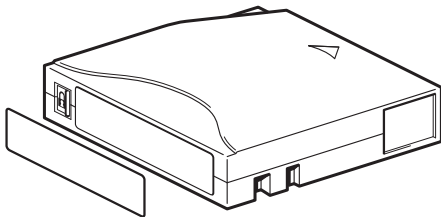
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HP recommends HP LTO Ultrium cartridges as follows:

- LTO Ultrium 1600 GB RW for multiple reading and writing
- LTO Ultrium 1600 GB WORM cartridges. WORM (Write-Once, Read-Many) cartridges guard against accidental or malicious alteration of data on the tape cartridge. You can append data to a WORM data cartridge to use the full capacity but not erase or overwrite existing data. WORM data cartridges have a distinctive, two-tone cartridge color.

To check whether your backup or archive software application supports WORM cartridges, refer to the web site: [www.hp.com/go/connect](http://www.hp.com/go/connect).

### Labeling cartridges



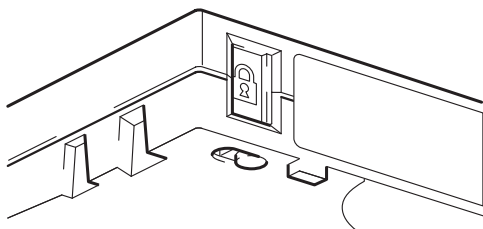
The label and write-protect switch are on the rear face of the cartridge, as illustrated.

Never use non-standard labels, and never stick anything to the cartridge other than in the label area.

### Write-protecting cartridges

If you want to protect the data on a cartridge from being altered or overwritten, you can write-protect the cartridge. Do this before you insert the cartridge. If you slide the write-protect tab after the cartridge is inserted in the drive, the change will not take effect until the cartridge is removed and reinserted, and you could damage the tape drive.

- 
- △ **CAUTION:** Write-protection will not prevent a cartridge being erased by bulk-erasure or degaussing. Do not bulk erase LTO Ultrium format cartridges. This will destroy pre-recorded servo information and render the cartridge unusable.
- 



To write-protect a cartridge, slide the write-protect tab by the label area on the rear face of the cartridge to close the hole.

Note the padlock on the tab that indicates that the cartridge is protected.

To write-enable a cartridge, slide the write-protect tab back so that the hole is open, before loading the cartridge into the drive.

## Cartridge life

Under optimum environmental conditions, HP LTO Ultrium cartridges are currently specified to 1,000,000 passes over any part of the tape. In operational terms, this can be translated to about 2000 full backup or restore operations. However, it is recommended that cartridges are used for no more than 260 full backup operations and the cartridge warranty is based on this figure. Under severe environmental conditions, particularly where the tape drive is used at low humidity or if certain areas of the tape are accessed frequently, the number of backup operations should be limited even further.

## Caring for cartridges

### Avoiding condensation

Condensation can be a problem for tape drives and cartridges. To minimize the chance of condensation, stay within the specifications for using and storing cartridges above and observe the following guidelines:

- Position the drive where the temperature is relatively stable—away from open windows, heat sources and doors.
- Avoid leaving cartridges in severe temperature conditions, for example, in a car standing in bright sunlight.
- Avoid transferring data (reading from and writing to cartridges) when the temperature is changing by more than 10°C (18°F) per hour.
- If you bring a cold tape drive or tape cartridge into a warm room, allow time for it to warm to room temperature before using it. For example, if you have moved the drive from a cold car to a warm room, allow time for the drive to reach room temperature (up to 24 hours if the temperature change is extreme).

### Conditions in use

Only use LTO Ultrium cartridges in temperatures in the tape drive's operating range from 10°C to 40°C (50°F to 104°F) and 20 to 80% relative humidity (non-condensing). If you expose cartridges



to temperatures outside the operating limits, stabilize them before you use them. To do this, leave the cartridges in the operating environment for 24 hours.

## Conditions in storage

LTO Ultrium cartridges will preserve the integrity of stored data for at least 30 years if proper storage conditions are observed.

- For short-term storage, keep cartridges at temperatures between 16°C and 32°C (61°F and 90°F) with a relative humidity between 20% and 80%.
- For long-term archival storage, keep cartridges between 5°C and 23°C (41°F and 73°F) with a relative humidity between 10% and 50%. Wet bulb temperature should not exceed 26°C (78°F).
- Always keep the cartridges in a clean environment.
- Always store cartridges in their plastic cases on their side when not in use.

## Maximizing tape life

- Do not touch the tape surface.
- Do not attempt to clean the tape path or tape guides inside the cartridge.
- Do not leave cartridges in excessively dry or humid conditions.
- Do not leave cartridges in direct sunlight or in places where magnetic fields are present (for example, under telephones, next to monitors or near transformers).
- Do not drop cartridges or handle them roughly.
- Stick labels onto the label area only.

## LTO Cartridge Memory

Linear Tape Open—Cartridge 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 inductive coupling rather than electrical contact.

The Cartridge Memory is used to store the tape directory and diagnostic and log information. Because of the speed at which it can be read, load and unload times are reduced, information is found on the tape more quickly and fewer tape passes are needed, increasing tape reliability.

The memory is primarily designed to speed up internal operations in the drive, but it also contains free space that can be used by application software. This may be used to store “common” information (shared by all software vendors) and “vendor-unique” information (specific to the application).

An access method has been defined to allow hosts to use this free space using Write Attribute and Read Attribute commands. For information on these commands, see Chapter 4 of *The SCSI Interface*, Volume 3 of this HP LTO Ultrium Technical Reference Manual.

For details of use of LTO-CM in library applications, see [“Using Cartridge Memory \(LTO-CM\)” on page 30](#).

# LTO Cartridge Memory issues

The LTO Cartridge Memory stores identification and usage information such as the number of times the cartridge has been loaded, when it was last cleaned, and error logs. In the unlikely event of the Cartridge Memory becoming damaged, you may experience difficulty with the cartridge.

Use the following table to resolve LTO Cartridge Memory problems:

Problem	Cause	Solution
A new data cartridge that is write-enabled is rejected by the drive.	LTO Cartridge Memory has failed or is damaged.	Replace the data cartridge.
A new data cartridge that is write-protected is rejected in several known good drives.	LTO Cartridge Memory has failed and the drive has found no data to recover.	Replace the data cartridge.
A cartridge that has data written to it and is write-enabled is rejected by the drive.	LTO Cartridge Memory has failed or is damaged.	The data can still be recovered. Contact the tape library supplier for more information. After data recovery, replace the cartridge.
A cartridge that has data written to it and is write-protected restores very slowly.	LTO Cartridge Memory has failed and the drive cannot use the tape directory information to recover the data.	The data can still be recovered but may take longer than normal.

## 10 Drive error codes

The following error codes may be reported in bytes 16 and 17 of the Request Sense data and also reported in ACI Get Error Info RDATA, bytes 3 and 4. See the REQUEST SENSE command in Chapter 4 of the *SCSI Interface*, Volume 3 of the HP LTO Ultrium Technical Reference Manual.

### Generic module (from 0000h)

Code	Description
0000h	Good.
0001h	Bad.
0002h	Done.
0003h	Aborted.
0004h	Invalid configuration values.
0005h	Invalid configuration name.

### Automation Control Interface (from 0400h)

Code	Description
0401h	Unsupported command opcode.
0402h	Busy—command rejected.
0403h	RAMBIST failed.
0404h	Invalid command checksums.
0405h	Invalid baud rates.
0406h	Invalid command while load/unload pending.
0407h	Time-out waiting to end immediate command.
0408h	RAM framing error.
0409h	RAM overrun error.
040Ah	Invalid command length.
040Bh	Byte buffer framing error.
040Ch	Byte buffer overrun error.
040Dh	Command active abort rejected.
040Eh	Invalid response acknowledgement.
040Fh	Transmission time-out.
0410h	Did not receive ETX.
0411h	Cancel command packet timer error.
0412h	Custom byte error.
0413h	Response acknowledgement time-out.
0414h	Cancel response acknowledgement timer error.

Code	Description
0415h	Unexpected byte received.
0416h	Zero length command.
0417h	Invalid command reserved field.
0418h	RAMBIST did not complete.
0419h	Ignored a byte received while transmitting response.
041Ah	Invalid CDB data length.
041Bh	Firmware image too big.
041Ch	The ACI response is longer than the available buffer.
041Dh	Did not receive acknowledgement to program flash.
041Eh	Attempt to create a polling object instance without a polling function.
041Fh	Attempted to create more polling object instances than the maximum allowed.
0420h	Attempted to access a polling object instance that does not exist.
0421h	ACI command length is greater than the available buffer.
0422h	ACI has run out of CRAM.
0423h	ACI has received a firmware image larger than expected.
0424h	ACI command parameter contains an invalid value.
0425h	ACI <code>acMalloc()</code> failed, insufficient memory available to process command.
0426h	ACI Control queue is full.
0427h	ACI Response queue is full.
0428h	ACI Control queue is empty.
0429h	ACI Response queue is empty.
042Ah	ACI Response packet was NAKed.
042Bh	ACI attempted to execute an unsupported PPL command.
042Ch	ACI has detected a command with a parameter out of range.
042Dh	ACI attempted to execute a PPL command before the previous command completed.
042Eh	ACI received more raw data than expected; see the Write Buffer PPL command.
042Fh	Internal status indicating a <b>slow</b> ACI command rather than a fast one.
0430h	Internal status indicating an operation has initiated a DMA transfer.
0431h	Internal status indicating that a firmware image has been downloaded so the firmware should have been upgraded.
0432h	Internal status indicating that a firmware image download has been aborted.
0433h	Surrogate SCSI command terminated due to a SCSI reset/abort for the LUN.
0434h	ACI has not been allocated the amount of DRAM it requires.
0435h	ACI has not been allocated the amount of CRAM it requires.
0436h	ACI surrogate SCSI command packet contained an invalid Exchange ID.
0437h	A command contained an invalid exchange ID.

Code	Description
0438h	The ACI Surrogate SCSI queue is full.
0439h	The ACI Surrogate SCSI queue is empty.
043Ah	A request for an invalid entry in Surrogate SCSI queue has been made.
043Bh	The ACI has received an <code>acSurrogateNotifyOp</code> with an unknown SCSI CDB type.
043Ch	The SCSI Data Length parameter has changed unexpectedly.
043Dh	Internal status indicating a PPL Command is being executed.
043Eh	ACI too busy for fast command. Used in tracepoints to identify cause of <code>AC_BUSY_CMD_REJECTED</code> error.
043Fh	ACI too busy for immediate command. Used in tracepoints to identify cause of <code>AC_BUSY_CMD_REJECTED</code> error.
0440h	ACI too busy for slow command. Used in tracepoints to identify cause of <code>AC_BUSY_CMD_REJECTED</code> error.
0441h	ACI too busy for SCSI command. Used in tracepoints to identify cause of <code>AC_BUSY_CMD_REJECTED</code> error.
0442h	ACI too busy because of overlapped commands. Used in tracepoints to identify cause of <code>AC_BUSY_CMD_REJECTED</code> error.
0443h	ACI too busy because of comms resync. Used in tracepoints to identify cause of <code>AC_BUSY_CMD_REJECTED</code> error.
0444h	ACI too busy because upgrading. Used in tracepoints to identify cause of <code>AC_BUSY_CMD_REJECTED</code> error.
0445h	ACI too busy because out of memory. Used in tracepoints to identify cause of <code>AC_BUSY_CMD_REJECTED</code> error.
0446h	ACI is resynchronizing comms with library after persistent comms failure.
0447h	SCSI opcode is not supported in this firmware release.
0448h	Internal status indicating an ACI reset is required.
0449h	Internal status indicating a full drive reset is required.
044Ah	Command contains an invalid Memory ID.
044Bh	All Command Control Blocks have been allocated.
044Ch	The returned or referenced Command Control Block is invalid.
044Dh	Response Time-out — command aborted and response sent.
044Eh	Response Time-out — response sent but command allowed to continue.
044Fh	Response Time-out — ACI failed to send response within the Response Period.
0450h	ACI too busy because the CCB queue is full. Used in tracepoints to identify the cause of <code>AC_BUSY_CMD_REJECTED</code> error.
0451h	ACI command contains the sequence number of the previous command. The command is ignored.
0452h	Internal status indicating a <b>slow</b> ACI command being executed before Drive Ready event.

Code	Description
0453h	Failed to transmit ACK/NAK within the Packet Acknowledgement period.
0454h	Internal status indicating a <b>direct</b> ACI command rather than a fast or slow one.
0455h	ACI too busy for a direct command. Used in tracepoints to identify cause of <code>AC_BUSY_CMD_REJECTED</code> error.
0456h	Cannot perform operation because the SCSI burst size is zero or unknown.
0457h	Command not supported because the primary interface has not been enabled.
0458h	Unable to get a new task object.
0459h	An ADI frame has been received while one or more ACI commands are outstanding.
045Ah	An SOF was received in ACI Mode which was not a valid frame.
045Bh	The SSC device has not requested the amount of data supplied with the ACI SCSI command.
045Ch	The specified automation port is not supported.
045Dh	A function will send a response when it has finished.
0480h	ACI self-test failure — the ACI should not be executing a direct Command while performing the self-test.
0481h	ACI self-test failure — the ACI should not be executing a slow Command while performing the self-test.
0482h	ACI self-test failure — if the ACI is idle, the Control queue should be empty.
0483h	ACI self-test failure — if the ACI is idle, the Response queue should be empty.
0484h	ACI self-test failure — if the ACI is idle, the Surrogate SCSI queue should be empty.
0485h	ACI self-test failure — if the ACI is idle, only the self-test command should be allocated in the small Data Region.
0486h	ACI self-test failure — if the ACI is idle, no memory from the Large Data Region should be allocated.
0487h	ACI self-test failure — if the ACI is idle, no CRAM memory should be allocated.
0488h	ACI self-test failure — if the ACI is idle, only one CCB should be allocated.

## Buffer manager (from 0800h)

Code	Description
0800h	The buffer manager failed to initialize correctly.
0801h	No Buffer Allocation description exists for the supplied Module ID.
0802h	The request queue has overflowed.
0803h	The priority request queue has overflowed.
0804h	Dataset index error: <code>BMMDatasetIdxToAddr()</code> has been passed an invalid <code>Idx</code> .
0805h	Dataset information table index error: <code>BMMDatasetIdxToDSITAddr()</code> has been passed an invalid <code>Idx</code> .

Code	Description
0806h	ACN index error: <code>BMMDataSetIdxToACNandLPOsAddr()</code> has been passed an invalid <code>Idx</code> .
0807h	Wrap index error: <code>BMMDataSetIdxToWrapAddr()</code> has been passed an invalid dataset <code>Idx</code> .
0808h	The Notification queue has overflowed. See <code>BMMXferComplete()</code> .
0809h	The notification was not SDL signal for DSIT read. See <code>BMMXferComplete()</code> .

## Diagnostic control (from 1800h)

Code	Description
1800h	No errors.
1801h	Invalid command.
1802h	Invalid parameters.
1803h	Drive not ready.
1804h	Command failed.
1805h	Command aborted.
1806h	Too few parameters.
1807h	Too many parameters.
1808h	Command denied.
1809h	Opcode not supported in diagnostic CDB command.
180Ah	Page code not supported in diagnostic CDB command.
180Bh	Buffer ID not supported in READ/WRITE BUFFER command.
180Ch	Parity error on serial receive.
180Dh	Framing error on serial receive.
180Eh	Overflow error on serial receive.
180Fh	Excessive input length, exceeding 220 characters.
1810h	Power-on self-test not executed.
1820h	Error detected during the Register Walking 1 test.
1821h	Built-in self-test failure.
1822h	No test available for the parameters provided.
1823h	Error detected during the Memory test.
1830h	Power-on self-test failed the processor internal SRAM data bus test.
1831h	Power-on self-test failed the processor internal SRAM address bus test.
1840h	Power-on self-test failed the DRAM MPU Port test.
1841h	Power-on self-test failed the DRAM Data Bus test.
1842h	Power-on self-test failed the DRAM Addr Bus test.
1843h	Power-on self-test failed the Formatter ASIC Register test.

Code	Description
1844h	Power-on self-test failed the Formatter ASIC built-in self-test).
1845h	Power-on self-test failed the firmware image checksum.
1846h	Power-on self-test failed the CRAM Data Bus test.
1847h	Power-on self-test failed the CRAM Address Bus test.
1848h	Power-on self-test failed the SCSI ASIC Register test.
1849h	Power-on self-test failed the SCSI ASIC Buffer Data Bus test.
184Ah	Power-on self-test failed the SCSI ASIC Buffer Address Bus test.
184Bh	Internal status instructing DI to exit Data Collection mode.
184Ch	Internal status instructing DI to execute the command as a Slow command.
184Dh	Diagnostic Control has rejected a command because it is already executing a command.
184Eh	Attempted to release Diagnostic Results memory that has not been allocated.
184Fh	Unable to perform a Diagnostic command as the Diagnostic Results memory is already reserved.
1850h	Diagnostic Results data has overflow the memory allocated for results.
1851h	DI has received an unsupported SCSI opcode in <code>diExecScsiDiagOp</code> .
1852h	DI attempted to set an illegal baud rate.
1853h	Set Config attempted to set a read-only configuration.
1854h	Indicates DI needs to send response in the Port buffer before completing the command.
1855h	Power-on self-test failed the external SRAM Data Bus test.
1856h	Power-on self-test failed the external SRAM Address Bus test.
1857h	Internal status indicating that a Log command specifies an FLM log.
1858h	Returned by some log extraction functions to indicate there is more data to extract.
1859h	Comms error (such as framing or overrun) detected on the Serial Test port.
185Ah	The Serial Test port has timed-out while receiving data.
185Bh	A device server has requested an operation not supported by <code>diPortIF</code> .
185Ch	Unable to get a new task object.
185Dh	SCSI command cannot be executed in limited operation mode.
185Eh	Internal status instructing DI to send status before starting the protocol test.
185Fh	Memory access denied to a READ/WRITE BUFFER command.
1860h	Memory access denied to a READ/WRITE MEMORY command.
1861h	Power-on self-test failed; unrecoverable ECC error detected.
1862h	A field is invalid in a diagnostic CDB command.
1863h	POST failed. The image checksum is invalid.
1864h	POST failed. The checksum is incomplete.



## Drive control (from 1C00h)

Code	Description
1C00h	Bad cartridge type. Attempted to load a cartridge of a type that drive control cannot handle.
1C01h	Attempted to unload a cartridge when Prevent Medium Removal is on.
1C02h	There is no firmware image available for upgrade.
1C03h	Firmware image is incomplete.
1C04h	Firmware image has checksum or other errors.
1C05h	Firmware image is not compatible with the drive configuration.
1C06h	Firmware image is too big to upgrade from.
1C07h	Internal error in the Drive Control firmware upgrade code.
1C08h	A firmware upgrade cartridge was in the drive when it powered on.
1C09h	A load without threading has been requested for a cartridge with unusable Cartridge Memory.
1C0Ah	Tried to load a writable cartridge with an unusable Cartridge Memory.
1C0Bh	The write-protect tab setting was changed during a load.
1C0Ch	A non-HP cleaning cartridge has been inserted in the drive.
1C0Dh	Cannot determine the manufacturer of the cleaning cartridge.
1C0Eh	No DRAM space reserved to hold the firmware image.
1C0Fh	A cleaning cartridge was in the drive when it powered on.
1C10h	Drive Control did an eject during the power-on sequence.
1C11h	A firmware upgrade cartridge has been loaded when a data cartridge was expected.
1C12h	A firmware upgrade cartridge was expected but some other type of cartridge has been inserted.
1C13h	Failure due to drive temperature being out of acceptable range.
1C14h	Cleaning cartridge initialized by a non-HP drive.
1C15h	Trying to convert a non-data cartridge into a firmware upgrade cartridge.
1C16h	Operation failed because cartridge is not present or not ready.
1C17h	Cleaning cartridge loaded when a data cartridge was expected.
1C18h	Expected a cleaning cartridge but got something else on load.
1C19h	Cartridge Memory is unusable and failed to read the FID.
1C1Ah	Firmware upgrade image information is unavailable.
1C1Bh	Could not find firmware information in the new image.
1C1Ch	A tape load has failed.
1C1Dh	The EOD Validity field is not Good.
1C1Eh	Firmware image is not compatible with drive sub-personality configuration.

Code	Description
1C1Fh	A TMR timer fired but the ID does not match what was expected.
1C20h	Firmware image has incorrect signature.
1C21h	The firmware upgrade image is too old.

## Drive monitor (from 2000h)

Code	Description
2000h	No error. Synonymous with GOOD status.
2001h	Invalid parameter. The value of a parameter received with a Drive Monitor operation falls outside its valid range.

## External interfaces (from 2400h)

Code	Description
2400h	Command holder full.
2401h	Bad command handle.
2402h	Empty command handle.
2403h	No tape loaded.
2404h	Already loaded.
2405h	In diagnostic mode.
2406h	Not in diagnostic mode.
2407h	Tried to write to write-protected cartridge.
2408h	Aborted an active command.
2409h	Aborted a command before it became active.
240Ah	Tried to abort a command that was not queued.
240Bh	Invalid state requested of the EII State Manager.
240Ch	EII tried to process a firmware upgrade type that is not supported.
240Dh	EII state manager could not handle an abort request.
240Eh	Tried to abort a command that was already being aborted.
240Fh	Tried to get a command for the wrong module.
2410h	Command specified in <code>eiNotifyOp</code> would not have been top of queue.
2411h	Attempt to delete a queued EII command.
2412h	Multiple attempts to delete an executing EII command.
2413h	Attempt to queue a queued EII command.
2414h	Attempt to queue an executing EII command.
2415h	Attempt to remove a command from empty EII command queue.
2416h	Attempt to execute a command still on the EII command queue.
2417h	Attempt to execute an EII command when another is executing.

Code	Description
2418h	Attempt to stop executing an EII command that was not executing.
2419h	The module putting a command on the EII command queue is not the module that allocated it.

## Front panel interface (from 2800h)

Code	Description
2801h	Failure due to use of forced eject.

## Host interface (from 2C01h)

Code	Description
2C01h	Unknown opcode.
2C02h	Reserved field set.
2C03h	Unknown mode page.
2C04h	Firmware bug.
2C05h	Parameter list length error.
2C06h	Already prevented.
2C07h	Not prevented.
2C08h	Too many hosts.
2C09h	32-bit overflow.
2C0Ah	Invalid space code.
2C0Bh	Bad inquiry page.
2C0Ch	Not the reserver.
2C0Dh	Not reserved.
2C0Eh	Third-party bad.
2C0Fh	Third-party host.
2C10h	Reserved.
2C11h	Read Buffer ID.
2C12h	Read Buffer mode.
2C13h	Write Buffer ID.
2C14h	Write Buffer mode.
2C15h	Main Buffer mode.
2C16h	Write Buffer header.
2C17h	No EVPD.
2C18h	Drive not ready.
2C19h	Density medium no tape.
2C1Ah	ARM firmware error code 0, used by the embedded ARM firmware.

Code	Description
2C1Bh	ARM POST fail.
2C1Ch	TX fail.
2C1Dh	Inf host interface ARM POST — SDRAM test failed.
2C1Eh	Inf host interface ARM POST — SDRAM BIST time-out.
2C1Fh	ARM POST — SDRAM memory access.
2C20h	Inf host interface ARM POST — Atmel memory test.
2C21h	Inf host interface ARM POST — no Olga connected.
2C22h	Inf host interface ARM POST — FC diagnostic CC1.
2C23h	Inf host interface ARM POST — FC diagnostic counters.
2C24h	Inf host interface ARM POST — FC diagnostic FIFO test.
2C25h	Inf host interface ARM POST — FC diagnostic interface.
2C26h	Inf host interface ARM POST — FC diagnostic register check.
2C27h	SPI host interface report parity error status.
2C28h	SPI host interface ARM POST — register diagnostics failed.
2C29h	SPI host interface ARM POST — PDC BIST time-out.
2C2Ah	SPI host interface ARM POST — PDC RAM BIST error.
2C2Bh	SPI host interface ARM POST — BC BIST time-out.
2C2Ch	SPI host interface ARM POST — BC RAM BIST error.
2C2Dh	SPI buffer channel 1 CRC error.
2C2Eh	SPI buffer channel 1 FIFO parity error.
2C2Fh	SPI sync offset error.
2C30h	SPI illegal write error.
2C31h	SPI illegal command error.
2C32h	SPI FIFO overflow or underflow error.
2C33h	SPI IDE message received.
2C34h	SPI BDR message received.
2C35h	SPI abort task message received.
2C36h	SPI parity error message received.
2C37h	SPI host interface ARM POST record manager diagnostics failed.
2C38h	SPI host interface ARM POST host port diagnostics failed.
2C39h	Buffer manager Titov host port control premature DREQ.
2C3Ah	Buffer manager Titov host port control parity error.
2C3Bh	Buffer manager Titov host port control CRC error.
2C3Ch	Buffer manager Titov host port control FIFO overflow.
2C3Dh	Buffer manager Titov host port control DMA overrun.
2C3Eh	Buffer manager Titov host port control outstanding error.

Code	Description
2C3Fh	Buffer manager Titov host port control sync data error.
2C40h	Buffer manager check buffer CRCs mismatch.
2C41h	Buffer manager check CRC passed.
2C50h	Illegal SCSI command. The hardware or firmware does not recognize the CDB.
2C51h	The SCSI Macro command was aborted because the drive was selected first.
2C52h	ATN was pulled by the initiator.
2C53h	Initiator did not respond to reselect within the reselect time-out period.
2C54h	The internal port interface task queue was empty.
2C55h	Too many port interface tasks. There is no room left in the internal port interface task queue.
2C56h	Parity error on the SCSI bus.
2C57h	Parity error in the mini-buffer.
2C58h	Attempted to use an invalid value internally.
2C59h	The SCSI FIFO was not empty when attempting to write to it.
2C5Ah	Not connected. Attempted to issue SCSI macro target command while not in target mode.
2C5Bh	Wrong host. Attempted to communicate with Host X while connected to Host Y.
2C5Ch	Wrong bus state. Attempted SCSI macro command while in the incorrect bus phase.
2C5Dh	No information on host. This host has not communicated with us previously.
2C5Eh	Invalid speed. The saved SCSI bus speed for this host is corrupt.
2C5Fh	Invalid SCSI ID, outside the range 0-15.
2C60h	The group code in CDB is not supported.
2C61h	The host attempted to issue an overlapped command.
2C62h	Not enough buffer space. The internal requestor asked for more space than was available in the mini-buffer.
2C63h	The mini-buffer is non-functional.
2C64h	Buffer in use. The internal requestor was denied access to the mini-buffer.
2C65h	Status interrupted; the SCSI status phase failed.
2C66h	Received an IDE (Initiator Detected Error) message.
2C67h	Received an MPE (Message Parity Error) message.
2C68h	Received a BDR (Bus Device Reset) message.
2C69h	Received an Abort message.
2C6Ah	Failed the Media Information check.
2C6Bh	There is no tape in the drive.
2C6Ch	Loading a tape.
2C6Dh	Media changed. A tape is present in the drive but not loaded.

Code	Description
2C6Eh	Cleaning the tape heads.
2C6Fh	Received a PON or SCSI reset.
2C70h	A mode change (LVD/SE) occurred on the SCSI bus.
2C71h	Gross error detected by the SCSI Macro.
2C72h	Illegal length record (ILI) — too long.
2C73h	Illegal length record (ILI) — too short.
2C74h	CRC error on read.
2C75h	The requested burst size was larger than the drive supports.
2C76h	There was an invalid field in the mode parameter list for this MODE SELECT command.
2C77h	Unloading the tape.
2C78h	A parameter supplied by the internal requestor was out of range.
2C79h	The allocation length exceeded the permitted length.
2C7Ah	Invalid (unsupported) page code.
2C7Bh	Invalid (unsupported) page code in parameter list.
2C7Ch	BOT encountered on space.
2C7Dh	EOT encountered on space.
2C7Eh	Blank Check, EOD was encountered. Returned by <code>hiPerformPreExeChecks</code> if a space or read is attempted on a virgin tape.
2C7Fh	Position lost. A temporary code for returning status after a write-behind error.
2C80h	PCR error in the Log Select command.
2C81h	The supplied Page Code is not a resettable page.
2C82h	The supplied Page Code is not a writable page.
2C83h	The reserved bit in the Log Page header has been set.
2C84h	The Log Select Page Length is incorrect.
2C85h	There is an error with the Log Parameter Header.
2C86h	Log Select Parameter list length error.
2C87h	The Log Sense Page Code is invalid.
2C88h	The Log Sense PC Code is in error.
2C89h	Log Select: error in the parameter header.
2C8Ah	Restart the Logical Pipeline after a format error.
2C8Eh	The Buffer Manager has been interrupted with an error.
2C8Fh	Check the cables. The Host Interface has exhausted all of the retries for a data phase.
2C90h	Log Select parameter list length error.
2C91h	<code>hiPopulateSenseBuffer()</code> could not find any free sense data buffers.

Code	Description
2C92h	The failure prediction threshold has been exceeded. This error code is sent when a check condition is generated for a CDB as a result of the Test flag being set in the Information Exceptions Mode page.
2C93h	Reset after GE. Triggers the power-on self-test UA 2900 after LTO 1 SCSI ASIC GE has been detected.
2C94h	Return GOOD status. Used to force GOOD status to be returned.
2C95h	There is a firmware bug in the handling of an inquiry page.
2C96h	There is a firmware bug in the execution of the Prevent/Allow Medium Removal command.
2C97h	There is a firmware bug in the parsing of a Mode page.
2C98h	An attempt was made to write data or filemarks inside EW-EOM.
2C99h	Firmware incorrectly programmed the SCSI macro.
2C9Ah	An unsupported LUN was specified in the SCSI Identify message.
2C9Bh	Aborting a previous command.
2C9Ch	Aborting and no disconnect. A command was rejected that could not be queued while an abort was in progress.
2C9Dh	The host interface has exhausted all of the retries for a command phase.
2C9Eh	Parameter not supported. A request for an invalid page code has been sent.
2C9Fh	Buffer offset good. This is used internally by the Read Write Buffer code and should never be reported to the host.
2CA0h	Operation in progress. Reported when an Immediate command is executing and a subsequent command is received.
2CA1h	Illegal length record (ILI) — too long, and there is an EOR in FIFO. This occurs when a record is long by less than the FIFO length.
2CA2h	Illegal length record (ILI) — too short with bad CRC.
2CA3h	Illegal length record (ILI) — too long with bad CRC.
2CA4h	LUN not configured. The drive is the process of becoming ready.
2CA5h	ILI long has been detected but a read error was encountered during the residue flush.
2CA6h	An init command is required; a tape has been loaded but not threaded.
2CA7h	ILI long has been detected but flushing the residue timed out.
2CA8h	LTO 1 drives only: The CD-ROM El Torito identifier is corrupt.
2CA9h	The LTO 1 Formatter ASIC is not supported any more.
2CAAh	The LTO 1 SCSI ASIC is an invalid revision.
2CABh	MAM attribute header truncated. The specified parameter list length has caused an attribute header to be truncated.
2CACh	Reserved field set in a MAM attribute header.
2CADh	MAM attribute IDs were not ascending order.

Code	Description
2CAEh	The MAM attribute header specified an unsupported attribute value.
2CAFh	A MAM attribute ID is unsupported.
2CB0h	A MAM attribute ID is in an incorrect format.
2CB1h	The MAM attribute header specifies an incorrect length for this attribute.
2CB2h	The host attribute area in MAM is full.
2CB3h	A Write Attribute command attempted to delete a non-existent attribute.
2CB4h	An invalid MAM service action was requested.
2CB5h	A Read attribute command failed because the Host Attribute area was not valid.
2CB6h	There is an invalid field in the MAM attribute data.
2CB7h	Failure prediction threshold exceeded. A Tape Alert flag has been set and the next SCSI command needs to be check conditioned.
2CB8h	GWIF idle error, cause unknown. This will never be returned to the host.
2CB9h	GWIF idle, read error. This will never be returned to the host.
2CBAh	GWIF idle, write error. This will never be returned to the host.
2CBBh	MAM is accessible but the cartridge is in the load "hold" position. Unit Attention is generated.
2CBCCh	MAM is accessible but the cartridge is in the load "hold" position. Not Ready is generated.
2CBDh	Internal port interface task queue error — invalid task.
2CBEh	Unable to write due to bad Cartridge Memory.
2CBFh	Selway ignored ATN on REQUEST SENSE.
2CC0h	Invalid number of wraps requested for LEOT.
2CC1h	Invalid LEOT request compared to current position.
2CC2h	MAM not accessible for some indeterminate reason.
2CC3h	SCSI sequencer was asked to reconnect during invalid nexus.
2CC4h	SCSI sequencer received a <code>hiRetryDataBurst</code> which failed.
2CC5h	INQUIRY data too long.
2CC6h	REQUEST SENSE data too long.
2CC7h	Invalid LUN for storing INQUIRY data in the mini-buffer.
2CC8h	No free slot to store REQUEST SENSE data.
2CC9h	Surrogate SCSI not configurable.
2CCAh	Surrogate SCSI LUN not a valid LUN.
2CCBh	Surrogate SCSI command arrived.
2CCCCh	Incompatible tape type.
2CCDh	The supplied exchange is invalid.
2CCEh	Invalid value for Dev Cfg SDCA.
2CCFh	Bad length for WRITE BUFFER command.



Code	Description
2CD0h	Echo buffer has been overwritten by another host.
2CD1h	Never reported to host — used to signify a special entry in the Fault Log.
2CD2h	Never reported to host—port interface gave good status.
2CD3h	Port interface detected a bus error.
2CD4h	Port interface detected an unknown internal opcode.
2CD5h	Port interface detected a bad context ID.
2CD6h	Port interface detected bad parameters for an internal operation.
2CD7h	Port interface has encountered a FM/EOD. Should not be reported.
2CD8h	Port interface SCSI reselection timeout.
2CD9h	Port interface internal operation failed due to a PIF/MIF buffer parity error.
2CDAh	Command outstanding. Should not be reported.
2CDBh	No command outstanding. Should not be reported.
2CDCCh	Not in automode status. Should not be reported.
2CDDh	ARM POST failure.
2CDEh	Port interface detected Bad Data Length—FC_DPL mismatch to CDB allocation length.
2CDFh	Selected while reselecting. Never reported to the host.
2CE0h	Bad state—firmware defect.
2CE1h	Bad configuration—firmware defect.
2CE2h	The Host Interface ASIC has not responded to a mail-box operation within 10 ms.
2CE3h	Got an internal firmware reboot.
2CE4h	SCSI Bus Reset signal asserted by host.
2CE5h	Bus Device Reset message sent by host.
2CE6h	Transceivers changed to SE.
2CE7h	Transceivers changed to LVD.
2CE8h	Got a power-on reset.
2CE9h	Checksum failure when copying bootloader code into Lucan dual-port RAM.
2CEAh	Amunsden has been reset before receiving the <code>hiPowerOneEvent</code> from Iona.
2CEBh	LF stall on reads.
2CECh	Tape is threaded but the drive shows it as unloaded.
2CEDh	The ARM FW has determined that this is not a DR tape.
2CEEh	There has been a change in the support Logical Unit inventory.
2CEFh	An invalid Port ID has been logged in.
2CF0h	An invalid LUN opcode has been passed to <code>hiConfigureSurrogateLun()</code> .
2CF1h	Fixed mode request was too large.
2CF2h	Decompression size mismatch while expanding and programming the Lucan FPGA code.

Code	Description
2CF3h	Host interface has more to do.
2CFDh	SCSI command failed because another host has changed the log pages.
2CFEh	SCSI command failed because new firmware has been downloaded.
2CFFh	SCSI command failed because another host has changed the mode pages.
2D00h	Hebrides is reporting a failure due to a read-ahead error.
2D01h	Hebrides is reporting a failure due to a write-behind error.
2D04h	Drive requested single shot read/write while streaming.
2D05h	Search for a handle for a given context ID failed.
2D06h	The dispatcher has completed the handling of the extended reset rewind.
2D07h	Firmware upgrade or unknown cartridge loaded but not threaded.
2D08h	Cleaning tape loaded but not threaded.
2D09h	Drive control has set <code>drDriveStatus</code> to <code>DR_FW_UPGRADE</code> .
2D0Ah	Immediate LOAD/UNLOAD in progress.
2D0Bh	Reported when an Immediate command is executing and a subsequent command is received.
2D0Ch	I_T nexus loss occurred.
2D0Dh	The maximum number of surrogate logical units have been defined.
2D0Eh	The supplied surrogate inquiry page is incorrect.
2D0Fh	The surrogate logical unit inquiry area is full.
2D10h	The surrogate logical unit inquiry area has been corrupted.
2D11h	The operation has been denied as the SCSI port is currently enabled.
2D12h	ACI has attempted a surrogate SCSI status operation without first setting up any sense data.
2D13h	This is no nexus live for this surrogate logical unit.
2D14h	An invalid SCSI status value has been supplied.
2D15h	Can not process this command, for some reason send it to lib.
2D16h	The <code>hiConfigureSurrogateLunOp</code> has resulted in a LUN being deleted.
2D17h	Unsupported Sub pagecode.
2D18h	First burst.
2D19h	ACK NAK timeout.
2D1Ah	NAK received.
2D1Bh	Initiator response timeout.
2D1Ch	Data offset error.
2D1Dh	Information Unit too short.
2D1Eh	Too much write data.
2D1Fh	Chan1 detected a CRC error and a subsequent check of the buffer found the CRC good.

Code	Description
2D20h	Chan1 detected a CRC error and a subsequent check of the buffer found the CRC bad.
2D21h	Test function in progress.

## Logical formatter (from 3000h)

Code	Description
3000h	No error. Synonymous with GOOD status.
3001h	Operation of the Logical Formatter has been aborted.
3002h	Busy. A Logical Formatter process has received a operation request while in a transient state.
3003h	Invalid parameter. The value of a parameter received with a logical formatter operation request falls outside its valid range.
3004h	Unsupported operation. A Logical Formatter process received an operation request while in a mode that does not support that operation.
3010h	Power-on or reset failure. An error condition occurred during execution of the logical formatter power-on self-test or reset algorithm.
3011h	Unexpected interrupt. A Logical Formatter process received a signal from the hardware at an unexpected time.
3012h	A Logical Formatter process has received a <code>DiscardComplete</code> signal from the hardware at an unexpected time.
301Fh	The Codeword Packer contains data bits that cannot be self-flushed.
3020h	Data path not empty. The Hardware Functional Blocks that form the Logical Formatter data path contain data.
3021h	Filemark encountered.
3022h	Recoverable format error. The Logical Formatter has encountered a recoverable format error while unformatting the data stream.
3023h	Unrecoverable format error. The Logical Formatter has encountered an unrecoverable format error while unformatting the data stream.
3024h	End marker not required. The Logical Formatter has not inserted an end marker in the current dataset because the dataset is empty.
3025h	One or more Hardware Functional Blocks in the Logical Formatter are paused.
3026h	The Logical Formatter has a filemark pending, meaning that it is logically before the filemark but physically after it.
3027h	Restart the Logical Formatter hardware.
3028h	The Logical Formatter has provided a dataset with an access point beyond the target position.
3029h	The Logical Formatter has encountered a CRC error while unformatting the data stream.
302Ah	The Logical Formatter's C1LFI Hardware Functional Block has failed to prime.

Code	Description
302Bh	The Logical Formatter has encountered a zero-length record error.
302Ch	The Logical Formatter has encountered a reserved codeword error.
302Dh	The Logical Formatter has encountered a filemark in record error.
302Eh	The Logical Formatter has encountered a decompression error.
302Fh	The Logical Formatter has encountered EOD.
3030h	The Logical Formatter failed to write a filemark — aborted.
3031h	The Logical Formatter failed to write a filemark — data path not empty.
3032h	The Logical Formatter failed to write a filemark — unsupported operation.
3033h	The Logical Formatter has received a non-user data set.
3040h	Logical Media not able to supply any more datasets.
3301h	Operation of the Logical Formatter's Hardware Abstraction Layer has been aborted.
3302h	Invalid parameter passed to a function in the Logical Formatter's Hardware Abstraction Layer.
3303h	A function in the Logical Formatter's Hardware Abstraction Layer has detected an illegal combination of variable values.
3304h	A function in the Logical Formatter's Hardware Abstraction Layer has received a request while in a mode that does not support that request.
3305h	The Logical Formatter's hardware has failed to signal (issue an interrupt for) an event expected by the firmware.
3306h	During a buffer transfer that ended with a final burst of ten bytes or less, the Logical Formatter's hardware failed to signal the transfer completion.
3307h	During a buffer transfer of ten bytes or less, the Logical Formatter's hardware failed to signal the transfer completion.
3308h	During a buffer transfer that ended with a final burst of ten bytes or less within the first 1k DRAM page, the Logical Formatter's hardware failed to signal the transfer completion.
3309h	A parity error was detected transferring data between Iona/Lucan and Amundsen.
330Ah	Wanted to start a timer for a potential missing <code>NextDAEmpty</code> interrupt but the pipeline was not empty.
330Bh	LF's C1LFI block detected a parity error while reading a byte out of its FIFO.
330Ch	Logical Formatter detected a correctable SDRAM corruption during Restore.
330Dh	Logical Formatter detected an uncorrectable SDRAM corruption during Restore.
330Eh	Logical Formatter SDRAM corruption.
3310h	Logical Formatter pipeline stalled.
3311h	Logical Formatter compressor reset.
3312h	Logical Formatter stall timer ID confusion.
3320h	Logical Formatter packer overrun.

<b>Code</b>	<b>Description</b>
3321h	Logical Formatter non-empty packed segment.
3322h	Logical Formatter packer missed EOR.
3323h	Logical Formatter unpacker overrun.
3324h	Logical Formatter packer aligned EOR.
3325h	Logical Formatter packer data in packer.
3326h	Logical Formatter compressor at record boundary.
3327h	Logical Formatter record boundary status.
3330h	Logical Formatter unexpected current register value.
3331h	Logical Formatter unexpected next register value.
3340h	Logical Formatter compressor not hung when expected.
3350h	Bad encryption key index detected.
3351h	Encrypt decompression error detected.
3352h	Encrypt record CRC error detected.
3353h	Encrypt Crypt error detected.
3354h	Encrypt UnpackerLite error detected.
3355h	Crypt GCM tag error detected.
3356h	Crypt EoR alignment error.
3357h	Crypt EoR before tag error detected.
3358h	Crypt If_data_valid error detected.
3359h	Crypt EoR found error detected.
3360h	Encryption boundary detected.
3361h	Encryption key mismatch detected.
3362h	Encryption AAD mismatch detected.
3363h	Encryption UAD mismatch detected.
3364h	Unencryption boundary detected.
3365h	Encryption key signature mismatch detected while in RAW read mode.
3366h	RAW read attempted on encrypted data.
3367h	Externally encrypted data detected.
3368h	Non-externally encrypted data detected.
3370h	Encryption known answer test has failed.
3371h	Decryption known answer test has failed.
3372h	Random number generator known answer test has failed.
3373h	Random number generator continuous test has failed.
3374h	RSA signature known answer test has failed.
33FFh	A non-specific error has occurred in the Logical Formatter.

## Logical media (from 3400h)

Code	Description
3400h	Cache overflow. A dataset has been received when the cache is already full.
3401h	A dataset has been located in the cache where it should not be.
3402h	A tag dataset has been located in the cache where it should not be.
3403h	Attempted to unlock a dataset which is not locked.
3404h	Cache empty. Expected at least one dataset in the cache.
3405h	The dataset index appears in the cache more than once.
3406h	The dataset index is too large to be valid.
3407h	The cache entry does not contain valid datasets.
3408h	End-Of-Data has been encountered.
3409h	The number of tag datasets in the cache exceeds the limit.
340Ah	A dataset is positioned in the cache incorrectly.
340Bh	One or more dataset indices are missing from the cache.
340Ch	Not a recognized Virtual Mode.
340Dh	The operation is not supported when more than one dataset locked.
340Eh	The tape is unformatted or contains no user datasets.
340Fh	One or more cache pointers are invalid.
3410h	No datasets in the cache to fulfil the request
3411h	Operation is not supported while there are operations outstanding.
3412h	Operation is not supported while datasets are locked.
3413h	The target dataset has not been located.
3414h	The target dataset has been located.
3415h	The cache has not be initialized.
3416h	Received an operation which is not supported in the current mode.
3417h	LF has attempted to rewrite a read-only dataset.
3418h	A test has taken too long to complete.
3419h	Too many pending LP cache operations.
341Ah	Too many pending PP cache operations.
341Bh	Received an inappropriate response.
341Ch	Linked-list 'next' pointer is invalid.
341Dh	CRAM transfer started but not finished.
341Eh	Allocated insufficient CRAM.
341Fh	Dataset is available in LM but the drive is not positioned to append.
3420h	Datasets in LM, Flush WITH_EOD required before the current operation.
3421h	LM flushed but EOD is required before the current operation.
3422h	The specified dataset type is not supported by the operation.

Code	Description
3423h	The specified CRAM dataset type is not supported.
3424h	LF has attempted an operation away from EOD that can only be performed at EOD.
3425h	Search dataset available dataset number does not match the DSIT contents.
3426h	LF has requested a dataset while LM is changing to backup mode.
37FFh	Undefined error.

## Logical pipeline control (from 3800h)

Error	Description
3800h	No error. Synonymous with GOOD status.
3801h	Aborted operation.
3802h	Busy. An operation request was received while in a transient state.
3803h	The value of a parameter received with a Logical Pipeline Control operation request falls outside its valid range.
3804h	Received an operation request while in a mode that does not allow that operation.
3805h	Operation aborted because of a write-behind error.
3806h	Logical Pipeline Control has detected an unexpected File Mark during a Space operation.
3BFFh	A non-specific error has occurred in Logical Pipeline Control.

## Mechanism control (from 3C00h)

Error	Description
3C00h	No error.
3C01h	Aborted command error.
3C02h	Unsupported command error.
3C03h	Bad parameter error.
3D01h	Undefined data object error.
3E01h	Wait for signal.
3E02h	Object create failed.
3E03h	Object execute failed.
3E04h	Cartridge memory LPOS values suspect.
3E05h	Notify client list full.
3E06h	Position notify list full.
3E07h	Notify exists parameter different.
3E08h	Notify event create failed.
3E09h	Notify key map failed.

Error	Description
3E0Ah	Notify index too large.
3E0Bh	Too many MC command objects.
3E0Ch	Cleaning cartridge expired.
3E0Dh	Cannot determine, or do not recognize, the cartridge format.
3FFEh	C++ pure virtual function called.
3FFFh	Undefined error.

## Non-volatile data manager (from 4000h)

Error	Description
4002h	Invalid parameter.
4003h	Data length exceeds table length.
4004h	Not a valid EEPROM.
4005h	Checksum error. A write to EEPROM failed because the EEPROM is invalid.
4006h	Checksum read did not match the checksum written.
4007h	An unsupported data type was requested from the Non-Volatile Data Manager.
4008h	An unsupported data type was requested to be set in Non-Volatile Data Manager
4011h	PCA EEPROM missing.
4012h	PCA EEPROM void.
4013h	PCA EEPROM corrupt.
4014h	PCA table invalid.
4015h	A failure occurred while trying to update the Read ERT log in the PCA EEPROM.
4016h	A failure occurred while trying to update the Write ERT log in the PCA EEPROM.
4017h	A failure occurred while trying to update the Write Fault Counters log in the PCA EEPROM.
4018h	A failure occurred while trying to update the Tapes Used logs in the PCA EEPROM.
4019h	nv_PCA_TABLE1 invalid.
401Ah	nv_PCA_TABLE2 invalid.
4021h	Head EEPROM absent.
4022h	Head EEPROM void.
4023h	Head EEPROM corrupt.
4024h	Head table invalid.
4025h	Head table 1 invalid.
4026h	Head table 2 invalid.
4027h	Head table 3 invalid.
4028h	Head table 4 invalid.
4031h	Mechanism EEPROM absent.



Error	Description
4032h	Mechanism EEPROM void.
4033h	Mechanism EEPROM corrupt.
4034h	Mechanism table invalid.
4035h	A failure occurred while trying to update the Drive Fault logs in the PCA EEPROM.
4036h	An Algorithm error occurred while trying to update the Drive Fault Logs in the EEPROM.
4037h	Mechanism table 3 invalid.
4038h	Mechanism table 4 invalid.
4039h	The Servo Fault could not be logged because of EEPROM access failure.
403Ah	<code>nv_MECH_TABLE2</code> invalid.
403Bh	<code>nv_MECH_TABLE1</code> invalid.
4041h	CM EEPROM absent.
4042h	CM EEPROM void.
4043h	The CM could not be written before an unload causing probable corruption in the CM.
4044h	An invalid protected page table was found.
4045h	A CRC error was discovered over the unprotected page table.
4046h	CM initialized. This is not really an error, it indicates a fresh cartridge.
4047h	CM invalid CRC.
4048h	An invalid CRC over the Cartridge Manufacturers Information page was found.
4049h	An invalid CRC over the Media Manufacturers Information page was found.
404Ah	An invalid CRC over the Initialization Data page was found.
404Bh	An initialization table was request to be created for a CM with a valid initialization table in it.
404Ch	A failure occurred while trying to add a page descriptor to the unprotected page table.
404Dh	An unprotected page table entry was attempted with an invalid page ID.
404Eh	An invalid CRC over the Drive Manufacturers Support page was found.
4050h	An access to the tape directory was requested before it was read from the CM.
4051h	A CRC error was detected in the tape directory while being read.
4052h	Data for an illegal wrap section was requested from the tape directory.
4053h	The Buffer Manager does not have enough CRAM to hold the CM.
4054h	The write-protect operation was aborted because of a bogus initialization data address in CRAM.
4055h	A consistency error was detected in the Tape Directory while being read.
4056h	No more entries can be added to the Suspended Appends page.
4060h	An access to a non-existent EOD page was attempted.

Error	Description
4061h	An invalid CRC over the EOD page was found.
4062h	An access to a non-existent Initialization page was attempted.
4070h	An access to a non-existent Tape Write Pass page was attempted.
4080h	An access to a non-existent Tape Alert page was attempted.
4090h	There is no usage data available in the Cartridge Memory.
4091h	Usage pages are out of order and cannot be accessed.
4092h	The last updated usage page has a CRC error. The data is invalid.
40A0h	There is no mechanism sub-page data available in the Cartridge Memory.
40A1h	The last updated mechanism sub-page has a CRC error. The data is invalid.
40A2h	There has been a failure executing self-test. This failure is logged in the Fault Log.
40A3h	Cartridge Memory TapeAlert CRC error.
40A4h	Cartridge Memory EOD page CRC error.
40A5h	Cartridge Memory suspend append CRC error.
40A6h	Cartridge Memory Media Manufacturer CRC error.
40A7h	Cartridge Memory mechanism CRC error.
40A8h	Cartridge Memory application specific CRC error.
40A9h	Unknown cartridge type in Cartridge Memory.
40AAh	A Cartridge Memory flush operation (CRAM to CM) was aborted, probably because of a time-out condition.
40ABh	PCA persistent reservation table invalid.
40ACh	A specific request to check the consistency between the FID and CM pages shows that an inconsistency exists.
40ADh	Unable to read a word from either the head or PCA EEPROM.
40AEh	A call to <code>nvInvalidateTuningRevNo</code> was made with an incorrect parameter.
40AFh	General information about NVDS.
40B0h	An invalid CRC over the Fatal Error page was found.
40B1h	Not enough information was available to form a correct Unique Cartridge Identity.
40B2h	<code>nvSetPersonalityByte</code> was asked to change the personality but this variant of code has a fixed personality.
40B3h	<code>nvSetPersonalityByte</code> was asked to change the personality but the key provided did not allow this.
40B4h	<code>nvSetPersonalityByte</code> was asked to change the personality but cannot change zero to non-zero or non-zero to zero.
40B5h	A protected page table entry was attempted with an invalid page ID.
40B6h	The Cartridge Content data page has a CRC error. The data is invalid.
40B7h	An access to a non-existent Cartridge Content data page was attempted.

Error	Description
40B8h	The requested field to be accessed does not exist in his version of the page.
40B9h	This product's EEPROM configuration does not support the persistent storage for the Host Access table.
40BAh	The persistent storage area for the Host Access table has never been written to and is therefore not initialized.
40BBh	The persistent storage area for the device ID has never been written to and is therefore not initialized.
40BCh	The persistent storage area for the device ID only supports storage for 2 LUNs—more has been requested.
40BDh	A request to access an area of CM which is out of bounds has occurred. The access was disallowed.
40BEh	Not enough information was available to form a correct Alternative Unique Cartridge Identity.
40BFh	nvCMGetMechRelatedKAD() was asked to retrieve the KAD in the mechanism-related pages but not KAD has been stored.
40C0h	The KAD length in the mechanism-related page which was asked to be stored or retrieved was too large.
40C1h	The mechanism-related page has not been created (or the tape not loaded) so storage or retrieval of the KAD data is not allowed.

## Operating system (from 4400h)

Error	Description
4400h	'vGiveSem' failed to signal a semaphore.

## Physical formatter (from 4C00h)

Error	Description
4C00h	C1 has finished before C2 is ready for the dataset.
4C01h	The physical formatter has been sent an invalid configuration name.
4C02h	The physical formatter has been sent an invalid configuration value.
4C03h	C2 hardware is busy. The physical formatter C2 hardware is currently processing a dataset.
4C04h	The physical formatter C2 control DS0 register go bit is set.
4C05h	The physical formatter C2 control DS1 register go bit is set.
4C06h	The physical formatter C1 control register go bit is set.
4C07h	The physical formatter CCQ Reader control register go bit is set.
4C08h	The physical formatter Read Chain Controller control register go bit is set.
4C09h	The physical formatter has been asked for the error rate log for a channel which does not exist.

Error	Description
4C0Ah	The physical formatter has been asked for the error rate logs for a channel which does not exist.
4C0Bh	The physical formatter could not set the callback timer to enable the Hyperion read gate.
4C0Ch	The physical formatter Read Chain Controller DS0 is stuck.
4C0Dh	The physical formatter Read Chain Controller DS1 is stuck.
4C0Eh	Physical formatter WP update.
4C0Fh	Format other than LTO1 or LTO2.
4C10h	SDRAM error has been detected.
4C11h	The number of CCPs presented has fallen below the warning threshold.
4C12h	A CCP has been overwritten.
4C13h	A C2 error has been reported.
4C14h	General physical formatter information.
4C15h	Unexpected format complete signal arrived.
4C16h	Check CCQ Write Rewrite log: param 1 = CCQSetsWritten, param2 = CCQSetRewrites, param 3 = pfStatus.

## Physical pipeline control (from 5000h)

Error	Description
5000h	EOD not found.
5001h	Black tape.
5002h	EOD encountered.
5003h	Undefined error.
5004h	The start LPOS of the dataset is before the LPOS of the previous dataset.
5005h	The start LPOS is more than 1 metre after the previous dataset.
5008h	Invalid configuration has been requested.
5009h	Abort reject continue not used.
501Eh	Search in progress.
501Fh	Mechanism command time-out; the control command never responded.
5020h	Command not allowed in this variant.
5080h	Invalid tape type.
5081h	The Error Rate Test has been aborted.
5083h	PF reported a write error (excessive RWWs).
5084h	PF reported a read error (C2).
5086h	PF reported a streamfail.
5087h	The error-rate test reached the C1 threshold.

Error	Description
5088h	Unknown notification. An unexpected mechanism control.
5089h	Data miscompare.
508Ah	The drive has gone 4 metres since last dataset was reported.
508Bh	The speed requested for ERT s out of valid range.
508Ch	The notify for 4m give-up point is missing.
508Dh	EOT was reached before requested datasets were written.
508Eh	Start position requested for ERT s out of valid range.
508Fh	Cannot find the expected dataset number.
5090h	Blank check. Could not read anything off the tape in the last 4 metres.
5091h	Too many datasets returned while flushing.
5092h	Could not find the target during a space operation.
5093h	Could not find the target ACN during a search operation.
5094h	Write Pass on write has been corrupted.
5095h	ERT read more datasets than expected.
5096h	Logical Media has supplied an invalid dataset index.
5097h	Dataset written before BOW.
5098h	EOT reached during reading.
5099h	Warning: Dataset flags non-zero.
509Ah	EOD has been read, but is not the one in the Cartridge Memory.
509Bh	The dataset that has been read should not be on this wrap.
509Ch	The SPACE command is to a logical position that is beyond EOD.
509Dh	The current cartridge cannot be written to — Write ERT is not allowed.
509Eh	The dataset that was reported as C2 uncorrectable is considered good.
509Fh	The DSIT contains an invalid UCI.
50A0h	The drive has determined that the WORM data may have been tampered with.
50A1h	The logical media has given a illegal dataset index for an append.
50A2h	A search operation appears to have found the target too early.
50A3h	An LTO4 dataset was encountered whose encryption algorithm ID was not 01h.
50A4h	The value of TapeWritePassValue CurrentWrap and SDL sheet has been set.
50A5h	Shows the value that the Max ATS has been set.

## Physical side error recovery (from 5400h)

Error	Description
5400h	Not an error—just requests a trace log bank switch.

## Read/write control (from 5800h)

Error	Description
5800h	Success.
5801h	Null point.
5802h	Invalid parameter.
5803h	No hardware.
5804h	SPI transfer error.
5805h	Prometheus set error.
5806h	Hyperion set error.
5807h	Daughter set error.
5808h	Calibration did not complete.
5809h	Servo bias status false.
5810h	Wrong number of parameters.
5820h	Could not set Prometheus 0 to default values.
5821h	Could not set Prometheus 1 to default values.
5822h	Could not set Prometheus 2 to default values.
5823h	Could not set Prometheus 3 to default values.
5824h	A valid Mod level was not received from the PCA EEPROM.
5830h	Could not set Hyperion 0 to default values.
5831h	Could not set Hyperion 1 to default values.
5840h	Could not initialize the Diagnostic Data <code>rwInitDiagnosticData</code> .
5841h	Did not get either <code>INTODRIVE</code> or <code>INTOCARTRIDGE</code> .
5850h	Delilah failed to autocalibrate.
5851h	Gideon failed to autocalibrate: param1 = GideonRegisters, param2 = RegisterValue, param3 = nothing.
5852h	Gideon HyperTransport PLL failed to come out of reset: param1 = GideonRegisters, param2 = RegisterValue, param3 = nothing.
5853h	HyperTransport sync failure: param1 = bus, param2 = count, param3 = type.
5854h	HyperTransport parity failure: param1 = bus, param2 = count, param3 = type.
5855h	HyperTransport unexpected parity state at power-on: param1 = HT Parity Error, param2 = HT Parity Error count 0, param3 = HT Parity Error count 1.
5856h	A valid Blo Dac Gideon Register setting could not be determined in the manual calibration mode.
5857h	The Mech Interface firmware returned a failure to RWC firmware when requested to set an ATS clock frequency for Gideon calibration.
5858h	The Random Bit Sequence generator failed to collect the required samples in the allowed time.

Error	Description
5859h	A valid Blo Dac Gideon register setting could not be determined in the manual calibration mode, retrying the Gideon offset calibration.
5860h	Expected a compatible data tape but got something else.
5861h	An invalid control word was found while parsing the Cal table to program a ASIC. Param 1 = control word, Param 2 = an integer value unique to each ASIC.
5870h	Could not write to Amundsen's WEQ Control register.
5871h	Illegal WEQ setup requested.
5880h	The EEPROM calibration table area contains at least one invalid entry.
5881h	The Per Drive Cal table in the EEPROM contains one invalid entry.
5882h	The Per Drive Cal table in the EEPROM contains a revision number that is less than the revision number found in the base Cal table.
5890h	rw_c_estimate_boost.
5891h	rw_c_adjust_boost.
5892h	rw_c_boost_datasets.
58F0h	Setup Servo.
58F1h	SMUX.
58F2h	BEN.
58FFh	Undefined error.

## System architecture (from 6400h)

Error	Description
6401h	Formatter ASIC revision check failed. The ASIC is not a LTO 1 Formatter ASIC.
6402h	The processor idle time is less than 30%.

## Tight integ (from 6800h)

Error	Description
6801h	The Cmicro error handler function has been called ( <code>cm_ErrorHandler</code> ).
6802h	An implicit signal consumption has occurred.
6803h	No free SDL timer storage (in <code>SDLTimerFreeList</code> ) to set new timer — increase <code>MAX_SDL_TIMERS</code> in <code>TightInteg/cmTmr.c</code> .

## Trace logger (from 6C00h)

Error	Description
6C00h	TraceLogger initialization failed. BMM returned no good.

## Mechanical interface (from 7400h)

Error	Description
7400h	No error.
7401h	Aborted command.
7402h	Unsupported command.
7403h	Wrong number of parameters.
7404h	Invalid parameter.
7405h	This command is already in progress.
7406h	This command is not allowed now.
7407h	Command processing error.
7408h	A DSP event has occurred (most likely an off-track event unless the default was changed).
7409h	The command is obsolete.
740Ah	Incomplete initialization of the mechanism.
740Bh	There was a timing fault in the servo interrupt.
740Ch	The mechanism type ( <code>SENSORREV</code> ) specified in the mechanism EEPROM is either obsolete or unsupported.
740Dh	Obsolete command 300C.
740Eh	Obsolete command 300D.
740Fh	Invalid task. The current task for the servo system is of an unknown type. This is most likely caused by a firmware bug.
7410h	A Load command is not allowed at this time.
7411h	An Unload command is not allowed at this time.
7412h	A shuttle tape command cannot be executed at this time.
7413h	A Set Cartridge Type command cannot be executed at this time.
7414h	A Set Mechanism Type command cannot be executed at this time.
7415h	A Set Tension command cannot be executed at this time.
7416h	A Set Speed command cannot be executed at this time.
7417h	An Adjust Speed command cannot be executed at this time.
7418h	A Set Position command cannot be executed at this time.
7419h	The Cancel Set Position command cannot be executed at this time. Most likely because there is no previous set position command active.
741Ah	A Set Position and Speed command cannot be executed at this time.
741Bh	A Servo Calibration command cannot be executed at this time.
741Ch	An End of Tape Servo Calibration command cannot be executed at this time.
741Dh	A Servo Initialization command cannot be executed at this time.
741Eh	A Load Cartridge command cannot be executed at this time.



Error	Description
741Fh	A Grab Leader Pin command cannot be executed at this time.
7420h	A Load and Grab leader pin command cannot be executed at this time.
7421h	An Ungrab Leader Pin command cannot be executed at this time.
7422h	An Unload cartridge command cannot be executed at this time.
7423h	A Thread command cannot be executed at this time.
7424h	An Unthread command cannot be executed at this time.
7425h	A Recover Tape command cannot be executed at this time.
7426h	A Head Clean command cannot be executed at this time.
7427h	A Power-on Calibration command cannot be executed at this time.
7428h	A Set Notify command cannot be executed at this time.
7429h	A Wait Until Event command cannot be executed at this time, probably because the tape is not moving.
742Ah	A Set Head Position command cannot be executed at this time, probably because a servo calibration is in progress.
742Bh	A Set Tracking Offset command cannot be executed at this time, probably because a servo calibration is in progress.
742Ch	A DSP command to learn the VI offset is not allowed now because the tape is moving or another task is in progress.
742Dh	The Set Gen command is not allowed now. The format cannot be changed at this time.
742Eh	A Forced Eject command is not allowed at this time. Most likely another operation is in progress.
742Fh	Debug ERROR code.
7430h	Sensors are in a state that indicate that the sensors or Callisto is not working correctly.
7431h	Sensors are in a state that indicate that the sensors or Callisto is not working correctly on a load.
7432h	Sensors are in a state that indicate that the sensors or Callisto is not working correctly on a grab.
7433h	Sensors are in a state that indicate that the sensors or Callisto is not working correctly on an ungrab.
7434h	Sensors are in a state that indicate that the sensors or Callisto is not working correctly on an unload.
7435h	The RD sensor has stopped toggling, probably because the loader mechanism is blocked or the motor is not working.
7436h	It is unsafe to load the cartridge. A runaway condition of the FRM has been detected, probably because the tape is broken
7437h	Unexpected LP on a grab. One (and only one) of the LP sensors has been asserted at the beginning of the grab.

Error	Description
7438h	Unexpected LP at the start of a grab. One (and only one) of the LP sensors has been asserted at the beginning of the grab. This is logged but not a failure.
7439h	The write protect sensor does not match the expected state.
743Ah	The Cartridge Present sensor does not match the expected state.
7440h	Callisto Bus test error.
744Fh	In transit after initialization—no cartridge present.
7450h	In transit after initialization.
7451h	Ungrab after initialization.
7452h	Unknown after initialization.
7453h	Timed out waiting to send a command to get DSP head-cleaning information.
7454h	Timed out waiting for DSP response with head-cleaning information.
7455h	Timed out waiting to set up DSP for a head-cleaning command.
7456h	Timed out waiting for DSP response to head-cleaning setup.
7457h	Timed out waiting for DSP to complete the head-cleaning command.
7458h	Head-cleaning engagement time-out.
7459h	Head-cleaning parking time-out.
745Ah	Head-cleaning cycling time-out.
745Bh	The state of the sensor read at initialization are illegal. The results make no sense.
745Ch	Timed out waiting to restore DSP after a head-cleaning command.
745Dh	Timed out waiting for DSP during post-head-cleaning restoration.
745Fh	Unable to send DSP compensator coefficients.
7460h	DSP download error.
7461h	Invalid DSP opcode error.
7462h	Unable to send a DSP command.
7463h	Unable to send a DSP seek command.
7464h	DSP failed to complete a seek command.
7465h	Send long-term DSP command time-out.
7466h	Send short-term DSP command time-out.
7467h	DSP long-term command protocol error.
7468h	DSP short-term command protocol error.
7469h	Too many parameters on DSP Long-term command.
746Ah	Too many parameters on DSP Short-term command.
746Bh	Too many results on DSP Long-term command.
746Ch	Too many results on DSP Short-term command.
746Dh	Long-term DSP command already in progress.
746Eh	Short-term DSP command already in progress.

Error	Description
746Fh	Long-term DSP command completed but not in progress.
7470h	Short-term DSP command completed but not in progress.
7471h	Unable to send a DSP Learn VI offset command.
7472h	DSP failed to complete a Learn VI offset.
7473h	Unable to send a DSP Calibrate VI command.
7474h	DSP failed to complete a Calibrate VI command.
7475h	Too many data points requested.
7476h	No scope data available from DSP.
7477h	DSP failed to complete the command during the initialization process.
7478h	Unable to send DSP tuning parameters.
7479h	DSP failed to boot properly.
747Ah	Time-out on sending the Clear DSP Fault log.
747Bh	Time-out on completing the Clear DSP Fault log.
747Ch	Unable to send DSP Head Clean command.
747Dh	An abort command was requested while one is already in progress.
747Eh	An abort command has timed-out while waiting for the tape to stop.
747Fh	An Adjust Speed command was requested while one is already in progress.
7480h	General load failure.
7481h	EP sensor did not transition on a load, probably because no cartridge was present.
7482h	CD sensor did not transition on a load.
7483h	CG sensor did not transition on a grab.
7484h	LP did not transition on a grab.
7485h	Too many retries to recover on a load or unload.
7486h	Cartridge not free to rotate when Cartridge Down.
7487h	The RD sensor stopped toggling while EP during a load.
7488h	The RD sensor stopped toggling while IT during a load.
7489h	The RD sensor stopped toggling while CD during a load.
748Ah	The RD sensor stopped toggling while CD during a grab.
748Bh	The RD sensor stopped toggling while LP during a grab.
748Ch	Invoked tension ramp retry.
748Dh	FRM runaway. Too much rotation was detected in the cartridge before it was threaded.
748Eh	A grab was requested but the cartridge was not loaded.
748Fh	Sensors indicate that the grabber unexpectedly moved into a grab position during a load operation.
7490h	While parking the LP, the LM voltage was increased from 0.25V to 0.5V.

Error	Description
7491h	While parking the LP, the LM voltage was increased from 0.5V to 0.75V.
7492h	While parking the LP, the LM voltage was increased from 0.75V to 1.0V.
7493h	While threading, the LM voltage was increased from 0.25V to 0.5V.
7494h	While threading, the LM voltage was increased from 0.5V to 0.75V.
7495h	While threading, the LM voltage was increased from 0.75V to 1.0V.
749Ah	Load command failed and no CM was detected, therefore it is likely there is no cartridge present.
74A0h	General unload failure.
74A1h	EP sensor did not transition while unloading.
74A2h	CD sensor did not transition while unloading.
74A3h	CG sensor did not transition while ungrabbing.
74A4h	LP sensor did not transition while ungrabbing.
74A6h	RD sensor stopped toggling while CG during ungrab.
74A7h	RD sensor stopped toggling while LP during ungrab.
74A8h	RD sensor stopped toggling while CD during ungrab.
74A9h	RD sensor stopped toggling while CD during unload.
74AAh	RD sensor stopped toggling while IT during unload.
74ACh	Too much rotation of the cartridge was detected while the tape was not threaded.
74ADh	The load, unload, grab or ungrab operation timed out.
74C0h	Time-out while deslacking the cartridge.
74C1h	Emergency stop error.
74C2h	Already past target position.
74C3h	Set speed time-out error.
74C4h	Time-out waiting for an LPOS.
74C5h	Reels not synchronized.
74C6h	Safety limit stop reached.
74C7h	LPOS calculation with invalid LPO.
74C8h	Missed target position.
74C9h	Previous tape motion command in progress.
74CBh	Unthreading time-out error.
74CCh	Remove slack process timed-out.
74CDh	Leader may have disconnected.
74CEh	Time-out waiting for radii estimate.
74CFh	Radii estimation process failed.
74D0h	Recover tape time-out error.
74D1h	Invalid cartridge type.

Error	Description
74D2h	Cal reel driver offset time-out.
74D3h	Time-out waiting for the specified event.
74D4h	Front-reel motor hall sensor fault.
74D5h	Back-reel motor hall sensor fault.
74D6h	The deslacking process timed out and did not complete, probably because the back reel motor failed to rotate.
74D7h	Threading time out while waiting for half moon to pass the first roller.
74D8h	Timed out waiting for tape to reach position for speed-up during a thread.
74D9h	Time out while waiting for tape to reach the position to stop threading.
74DAh	An unthread command was issued and aborted a tape motion operation that was already in progress.
74DBh	The cartridge type has not been specified either from LTO-CM or through a serial port command.
74DCh	The tape speed reported by the DSP is significantly different from the tape speed indicated by the hall sensors.
74DDh	Specified value of tension is either too high or too low.
74DEh	The panic stop process timed out and did not complete properly.
74DFh	Timed-out waiting for the proper tape tension to be established.
74E0h	Head selection time-out.
74E1h	Unable to position the head.
74E2h	Speed too low for enabling the heads.
74E3h	Speed too low for the head servo.
74E4h	Speed too low for sensor calibration.
74E5h	A DSP seek command was attempted while the tape speed was zero.
74E6h	DSP sensor calibration command was attempted while the tape speed was zero.
7500h	First write fault.
7501h	Write fault: it has been too long since a valid LPOS was read, so writing is not allowed.
7502h	Write fault: DSP tracking recovery operations are in progress so writing is not allowed.
7503h	Write fault: tape motion start-up operations are incomplete so writing is not allowed.
7504h	Write fault: DSP is not tracking properly on the tape, writing is not allowed.
7505h	Write fault: the current tape speed is too low so writing is not allowed.
7508h	Write fault: ATS clock frequency clipped, or DSP in idle mode.
7509h	Write fault: DSP calibrating.
750Ah	Write fault: DSP VI track follow.
750Bh	Write fault: DSP tape off-track.

Error	Description
750Ch	Write fault: DSP demod channel out.
750Dh	Write fault: DSP seek.
750Eh	Write fault: DSP uPVI.
750Fh	Write fault: write unsafe.
7510h	Unknown write fault.
7511h	Multiple write faults.
7512h	Last write fault.
7600h	Set Speed command invalid parameter.
7601h	Adjust Speed command invalid parameter.
7602h	Set Position command invalid parameter.
7603h	Set Head Position command invalid parameter.
7604h	Set Head Table command invalid parameter.
7605h	DSP Statistics command invalid parameter.
7606h	Get Servo Fault command invalid parameter.
7607h	Set Tracking Offset command invalid parameter.
7608h	Set Notify command invalid parameter.
7609h	Clear Notify command null handle.
760Ah	ATS Diagnostics command invalid parameter.
760Bh	Hall Calibrate command invalid parameter.
760Ch	Radius Calibrate command invalid parameter.
760Dh	Wait Until Event command invalid parameter.
760Eh	Convert LPOS command invalid parameter.
760Fh	Shuttle command invalid parameter.
7610h	Get DSP fault log invalid parameter.
7611h	Set General Command Invalid parameter.
7612h	Set TestMode command parameter is out of range or is invalid.
7613h	EEPROM servo table command parameter is out of range or is invalid.
7620h	Set speed operation timed out during a recover tape command.
7621h	Timed out waiting for the pin sensors to indicate almost parked.
7622h	Timed out waiting for the pin sensors to indicate fully parked.
7623h	An unthread timed out waiting for the full leader pin seating tension to be established.
7624h	Cycling the pull-in tension did not achieve pin-park.
7625h	Rethreading and then unthreading again did not get the leader pin parked.
7626h	Timed out during the rethread/re-unthread recovery while waiting for almost parked.
7627h	All recovery algorithms have been exhausted and still unable to park leader pin.

Error	Description
7628h	Rethread recovery operation timed out waiting for the tape to come to a stop.
7629h	Rethreading timed out while waiting for the tape to reach the required position.
762Ah	Deslacking process did not complete, probably because the back reel motor failed to rotate.
762Bh	The leader pin was parked as indicated by both LP sensors but then came unparked.
762Ch	The tape has been recovered and leader pin parked but the original operation failed and was abandoned.
762Dh	Rethreading timed out while waiting for the tape to reach the required position.
762Eh	Rethread recovery operation timed out waiting for the tape to come to a stop.
762Fh	A special unthreading recovery operation was needed to un-jam the leader block.
7630h	An iteration of the special unthreading recovery operation did not succeed.
7631h	The stop tape operation took longer than expected.
7632h	An attempt was made to stop the tape while still too far away from the specified position.
7633h	An abort command was issued and stopped the tape motion operation that was already in progress.
7634h	The tape thickness is too great to be handled properly by the servo system.
7635h	An ATS speed change operation (AdjustSpeed) timed out waiting for tape to reach target speed.
7636h	An ATS speed change operation (AdjustSpeed) was attempted while the tape was not moving.
7637h	While trying to park the pin, LP2 was seen, but LP1 was not seen after rotating the grabber CCW.
7638h	Threading timed out while waiting for the half moon to seat onto the back reel.
7639h	Tape motion apparently stopped while waiting for head positioning to complete.
763Ah	Unthread timed out during the initial rewind of tape back into the cartridge.
763Bh	Timed out during an operation to set tape position and speed.
763Ch	Timed out during an operation to set the tape position.
763Dh	Timed out during a RecoverTape operation.
763Eh	The front reel did not rotate during the tape slack removal process.
763Fh	Timed out waiting for back reel to reach position where leader block is fully seated.
7640h	Timed out waiting for back reel to rotate to the threading reversal point.
7641h	Timed out waiting for back reel to rotate to the reverse threaded position.
7642h	Timed out waiting for tension to be established during the reverse threading process.

Error	Description
7643h	Timed out waiting for the reverse threading target position.
7644h	Timed out waiting for leader block to detach during an unthread.
7645h	Timed out waiting for tension to be established during the reverse unthreading process.
7646h	Timed out waiting for speed to be established during the reverse unthreading process.
7647h	A fatal reel fault occurred during the time when the tape was being stopped.
7648h	Back reel stalled and was not rotating when determining thread direction.
7649h	An operation that determines thread direction timed out.
764Ah	Warning: Tape speed error integrator value is very large.
764Bh	Timed out waiting for back reel to rotate to the unthreading reversal point.
764Ch	Timed out waiting for tape to reach unthreading reversal slow down point.
764Dh	Timed out waiting for tape to reach unthreading turn around point.
764Eh	Front reel turning CCW but should be CW after going through critical point during recover tape process.
764Fh	Tape motion unexpectedly stopped during recover tape process of rewinding based on radius estimate.
7650h	Unable to detach leader block during recover tape operation when reverse threaded.
7651h	Unable to detach leader block during recover tape operation when forward threaded.
7652h	Unable to identify cartridge type during recover-tape operation.
7653h	The tape thickness reported by the Cartridge Memory is too large or too small.
7654h	The tape thickness reported by the CM is invalid and cannot be used.
7655h	The full pack radius reported by the CM appears to be invalid and will not be used.
7656h	The tape length reported by the CM appears to be invalid and will not be used.
7657h	The empty reel inertia reported by the CM appears to be invalid and will not be used.
7658h	The empty reel radius reported by the CM appears to be invalid and will not be used.
7659h	The front reel is not rotating properly. It is possible that some tape was spilled out from the back reel.
765Ah	Recovery process was unable to determine the best direction in which to move the tape.
765Bh	Front reel did not reverse direction after passing through the critical region for threading reversal.
765Ch	Back reel did not stop as expected during a tape recovery process.



Error	Description
765Dh	Warning: Leader block demate process resorted to pushing the back reel clockwise.
765Eh	Rethreading position time-out during the leader block demate retry process.
765Fh	Leader block demate retry process was unsuccessful.
7660h	It was necessary to tug the tape to detach the leader block.
7661h	Timed out waiting for the required number of layers to overwrap the leader block.
7662h	Timed out waiting for the tape to unwrap from the leader block during a reverse thread.
7663h	Timed out waiting for a return to the original lock-in position during a reverse thread.
7664h	DSP tuning parameters were reloaded into the DSP before a VI-sensor calibration command. This is a recovery algorithm.
7665h	A special test mode has been enabled that will generate specific faults.
7666h	The special test mode has now been disabled. Normal operation will resume.
7667h	The front reel is not running in the reverse direction after the tension ramp after passing through the critical region during a thread.
7668h	The front reel did not reverse direction after passing through the critical region during an unthread, step 1.
7669h	The front reel did not reverse direction after passing through the critical region during an unthread, step 2.
766Ah	Timed out waiting for speed to reduce while approaching the critical region during a thread.
766Bh	Recovery process is using a secondary head set to perform a sensor calibration operation.
766Ch	Recovery process is using a secondary head set to perform an azimuth calibration operation.
766Dh	Servo calibration cannot be done now because it is too close to BOT.
766Eh	Timed out waiting for half moon to approach head during a thread.
766Fh	Timed out waiting for half moon to approach head during an unthread.
7670h	Timed out waiting for half moon to pass head during a thread.
7671h	Timed out waiting for half moon to pass head during an unthread.
7672h	Timed out waiting for half moon to enter guide during an unthread.
7673h	Servo timing reference mismatch during timing reference calibration.
7674h	Set position and speed operation missed the target objectives by too much, probably due to DSP retries.
7675h	Timed out waiting for the grabber to rotate enough to deactivate the tape lifter and lower the tape onto the head

Error	Description
7676h	Cartridge Memory read after threading; mechanism parameters cannot be updated at this time.
7677h	Mechanism sensors not in the expected state after a load command.
7678h	Mechanism sensors not in the expected state after an unload command.
7679h	Mechanism sensors not in the expected state after a grab command.
767Ah	Mechanism sensors not in the expected state after an ungrab command.
767Bh	Deslacking process did not complete, probably due to the back reel motor failing to rotate.
767Ch	FRM tension ramp process did not complete, probably due to excessive tape slippage in the cartridge.
767Dh	FRM rotation was unexpectedly detected while ungrabbing the cartridge leader pin.
767Eh	The calculated LPOS media manufacturers string checksum does not match what was read from the tape.
767Fh	The LP sensor was asserted before loading, possibly because of a stuck or faulty sensor.
7680h	The DSP was commanded to re-lock onto servo code. (This is a recovery algorithm.)
7681h	A retry was necessary on a DSP seek command. (This is a recovery algorithm.)
7682h	A retry was necessary on a DSP VI-sensor cal command. (This is a recovery algorithm.)
7683h	A retry was necessary on a DSP azimuth cal command. (This is a recovery algorithm.)
7684h	A retry was necessary on a DSP command to learn the VI-offset. (This is a recovery algorithm.)
7685h	Unable to thread. An ungrab/regrab/rethread recovery process will now be attempted.
7686h	The thread operation is being retried because the pin detect sensor indicates parked when not parked.
7687h	The threading recovery could not get the tape stopped in a reasonable time period.
7688h	Timed out waiting for a regrab to complete before threading.
7689h	Timed out trying to read the media manufacturer's information.
768Ah	A faulty LP sensor has made it necessary to detect pin parking via FRM stall.
768Bh	Attempt to park failed. An LP sensor was most likely asserted when it should not have been.
768Ch	A VI cal was necessary to recover a DSP seek command failure. (This is a recovery algorithm.)
768Dh	The FRM driver required a reset and was restarted. This is not a fault.

Error	Description
768Eh	The BRM Driver required a reset and was restarted. This is not a fault.
768Fh	The reel motor flex continuity check failed, the line is stuck high
7690h	The reel motor flex continuity check failed, the line is stuck low
7691h	Unable to read the media manufacturers information from the LPOS bit stream.
7692h	A full eject was invoked as part of a load fault recovery.
7693h	Gently nudged grabber in order to help park leader pin. Information only, not a fault.
7694h	Leader pin may have come ungrabbed. Regrabbing pin.
7695h	A cartridge load as part of init failed.
7696h	A special recovery to try to free a stuck LP sensor is in progress.
7697h	The recovery effort to try to free a stuck LP sensor failed.
7698h	The BRM over rotated during leader block demate in recover tape. Info only.
7699h	The front reel motor DAC offset is too large or too small.
769Ah	The back reel motor DAC offset is too large or too small.
769Bh	A forced eject command was invoked. This is not a fault.
769Ch	The LPOS lock-up process 1 produced a value that does not pass the basic sanity check.
769Dh	The LPOS lock-up process 2 produced a value that does not pass the basic sanity check.
769Eh	The removing slack operation timed out while trying to determine the best direction for recovery.
769Fh	The radii estimation process in recover tape yielded a negative result.
76A0h	Unable to send a <code>DspSetGen</code> command.
76A1h	Failed to complete a <code>SetGen</code> command.
76A2h	Empty Dsp interrupt.
76A3h	Time-out during <code>ReadDspFaultLog</code> .
76A4h	Time-out during <code>ClearDspFaultLog</code> .
76A5h	Unable to send a <code>DspWriteDataMem</code> command.
76A6h	Dsp failed to complete a <code>WriteDataMem</code> command.
76A7h	Unable to send DSP sample rate parameters.
76A8h	A threading fault has occurred.
76A9h	An unthreading fault has occurred.
76AAh	Unable to send CSP PCA diagnostic command.
76ABh	DSP failed to complete PCA diagnostic command.
76ACh	Unable to initiate tape motion. The tape is stuck.
76ADh	Unable to initiate tape motion even after using the tape lifter. The tape is stuck.
76AEh	Unable to initiate tape motion even after relaxing hard pull. The tape is stuck.

Error	Description
76AFh	The tape speed error integrator value is very large. The tape is stuck and not moving.
76E8h	The reel motor flex connection is suspect; the dataset field in the fault log indicates which lines are in error.
76E9h	Tape tilt calibration failed. Drive write inhibited.
76EAh	EEPROM values unavailable. Default DSP servo compensator values are being used.
76EBh	The drive has cooled and the cooling fan has been turned off.
76ECh	The drive is getting too hot and the cooling fan has been turned on.
76EDh	The drive has cooled; resuming normal tape speeds.
76EEh	The drive is getting too hot; tape speed is now being reduced to a minimum.
76EFh	ASIC temperatures are too high. Operations must stop and the cartridge must be ejected.
76F0h	The address into the main DRAM buffer must be on an even byte boundary.
76F1h	The address into the main DRAM buffer is outside the range allowed for the servo system to use.
76F2h	The specified mode is not valid.
76F3h	The specified scope channel bit width is not supported.
76F4h	The specified scope trigger position is too large compared to the specified number of data packets in the trace.
76F5h	The length of the buffer must be larger than zero and an even number.
76F6h	The specified source number is not valid.
76F7h	The specified scope buffer format parameter is not valid.
76F8h	A reel driver calibration factor is out of range.
76F9h	A reel driver calibration factor for static torque loss is out of range.
76FAh	A reel driver calibration factor for dynamic torque loss is out of range.
76FBh	The temperature is above the maximum limit.
76FCh	The temperature is below the minimum limit.
76FDh	EEPROM values are unavailable. The default servo tuning values are being used instead.
76FEh	Previous fault conditions have made it unsafe to thread this cartridge.
76FFh	The tape temperature is too high. Operations must stop and the cartridge must be ejected.
7700h	The base number for constructing DSP error codes. This is not an actual error.
7701h	DSP fault: TMS320 was just reset due either to hardware pin assertion or receipt of the Reset command.
7702h	DSP fault: the DSP checksum failed after a hardware/software reset.
7703h	DSP fault: unsupported command opcode.

Error	Description
7704h	DSP fault: illegal command sequence.
7705h	DSP fault: the Alert bit was set during a seek or CalibrateVI command.
7706h	DSP fault: the DSP was asked to do a tape seek when the microprocessor said this was not a safe operation to do.
7707h	DSP fault: a seek or VI calibration command was issued but the mechanism has not learned the VI offset yet.
7708h	DSP fault: the stroke measured by the VI sensor hardware was not large enough.
7709h	DSP fault: excessive actuator power amp offset.
770Ah	DSP fault: main memory microprocessor time-out.
770Bh	DSP fault: the tracking PLL in the servo front end did not lock up at power up. Info only.
770Ch–770Fh	DSP fault: spare.
7710h	DSP fault: unable to find a top servo band.
7711h	DSP fault: unable to lock to track 0 on a top servo band.
7712h	DSP fault: unable to verify band ID on a top servo band.
7713h–771Fh	DSP faults: spare.
7720h	DSP fault: the track-following loop could not stay at the desired set point.
7721h–772Fh	DSP faults: spare.
7730h	DSP fault: could not stay locked to the tape servo code.
7731h–773Fh	DSP faults: spare.
7740h	DSP fault: no tape servo data during seek acceleration phase.
7741h	DSP fault: acceleration time-out fault.
7742h	DSP fault: spare.
7743h	DSP fault: no tape servo data during the seek deceleration phase.
7744h–7745h	DSP faults: spare.
7746h	DSP fault: seek failure during VI gross settle.
7747h	DSP fault: seek failure during tape gross settle.
7748h–774Ah	DSP faults: spare.
774Bh	DSP fault: no tape servo data during seek fine settle phase.
774Ch	DSP fault: too few samples to generate an azimuth correction.
774Dh	DSP fault: too few samples to generate a valid timing reference.
774Eh–774Fh	DSP faults: spare.
77nn (nn=50h–FEh)	DSP fault Code nn.
77FF	Denotes the end of DSP error codes. This is not an actual error.

## Exception handler (from 7800h)

Error	Description
7800h	Unrecognized exception.

## SPI interface (from 7C01h)

Error	Description
7C01h	Buffer overflow.
7C02h	Time-out error.
7C10h	EEPROM Write did not complete (still in progress).
7C11h	Flash write error. Flash write did not complete.

## Cartridge Memory (from 8000h)

Error	Description
8000h	Address out of limits.
8001h	SPI writing problems.
8002h	Wrong number of bits returned.
8003h	Nack error.
8004h	Unrecognized data received.
8005h	SPI reading problems.
8006h	Parity error.
8007h	Collision error.
8008h	Overflow error.
8009h	Underflow error.
800Ah	Overflow error on sending.
800Bh	Number of bits on data receive error.
800Ch	Impossible address situation.
800Dh	Invalid configuration name.
800Eh	Invalid configuration value.
800Fh	CRC error.
8010h	The serial number check failed.
8011h	Error bit set.
8012h	Type of transponder not recognized.
8013h	RF channel already opened.
8014h	RF channel already closed.
8015h	EOT polled to.

## Fault log manager section (from 8400h)

Error	Description
8400h	Log not yet implemented.
8401h	No more entries to extract.
8402h	Uninitialized non-volatile log, or the log requested is a volatile log only.
8403h	An <code>SPiXferRequest</code> failed.
8404h	Some fault entries were not placed in the log due to flushing occurring.
8405h	The size of operation of an entry is different to what the logging system expects.
8406h	A tape has been loaded and the fault log entry shows the load count and cartridge serial number.
8407h	The requested operation cannot be performed at this time as a flush to non-volatile log is currently in progress.
8481h	A request to read a snapshot log failed because the requested log number does not exist.
8482h	Snapshotting is not allowed now as one or more preconditions have not been passed.
8483h	A request to stop reading a log found the log was not being read in the first place.
8484h	An attempt was made to insert too many CDBs for snapshotting.
8485h	The end of the snapshot command set has been reached.
8486h	An attempt was made to access the log snapshot command set while it is being updated.
8487h	A snapshot command requested more SCSI data (out) than was available.
8488h	The SCSI infrastructure requested a snapshot PortIF operation with an invalid/obsolete TaskPtr.
8489h	The specified snapshot log is unavailable because it is being filled or created.
848Ah	The specified snapshot log is unavailable because it is being read.
848Bh	The specified snapshot log is unavailable because its status is unexpected.
848Ch	The command set cannot be changed while it is being read.
848Dh	The data structure that contains status has an illegal value.
848Eh	The specified snapshot LogSize is too small.

## Infrastructure section (from 8800h)

Error	Description
8800h	Inf OnEvent: EventSet – the event list is full, so the event has not been set.
8801h	Inf OnEvent: the event has not been found in the list.
8802h	Inf OnEvent: EventGetIdx – the index is out of bounds.
8803h	Inf ARM exception vector taken: undefined instruction.
8804h	Inf ARM exception vector taken: software interrupt.

Error	Description
8805h	Inf ARM exception vector taken: prefetch abort.
8806h	Inf ARM exception vector taken: data abort.
8807h	Inf ECC event: recoverable ECC error detected.
8808h	Inf ECC event: unrecoverable ECC error detected.
8809h	Inf Boot failure: firmware image failed to boot.

## Critical section (from 8C00h)

Error	Description
8C00h	End section not begun. CRSEndCritIntSect was ended without CRSBegIntSect.
8C01h	Begin section ints off. CRSBegCritIntSect found ints already off.

## SCSI module (from 9400h)

Error	Description
9401h	Power-on reset Unit Attention.
9402h	Firmware reboot after upgrade Unit Attention.
9403h	SCSI bus reset Unit Attention.
9404h	BDR reset Unit Attention.
9405h	Soft reset Unit Attention.
9406h	Transceivers changed to SE Unit Attention.
9407h	Transceivers changed to LVD Unit Attention.
9408h	Nexus lost Unit Attention.
9409h	Media changed Unit Attention.
940Ah	Mode parameters changed Unit Attention.
940Bh	Log values changed Unit Attention.
940Ch	Unsupported task management function.
940Dh	LUN has too many task objects.
940Eh	Unsupported LUN.
940Fh	Invalid field in CDB.
9410h	Unsupported opcode.
9412h	Unsupported command handler request.
9413h	Unavailable opcode.
9414h	Not a fast ACI command.
9415h	Response pending.
9416h	Aborted.
9417h	Reserved.



Error	Description
9418h	Invalid group code.
9419h	Truncated mode page.
941Ah	Invalid field mode data.
941Bh	BOT encountered on space to record.
941Ch	BOT encountered on to space to filemark.
941Dh	Firmware bug.
941Eh	Echo buffer overwritten.
941Fh	REPORT DENSITY media not present.
9420h	Overlapped command.
9421h	Erase operation in progress.
9422h	Locate operation in progress.
9423h	Rewind operation in progress.
9424h	Write inhibit tape drive.
9425h	Device ID changed Unit Attention.
9426h	Truncated Log data.
9427h	Non-clearable Log page.
9428h	Invalid field Log data.
9429h	Forward task to library. Not a reportable error code.
942Ah	Invalid surrogate SCSI LUN.
942Bh	Invalid surrogate SCSI inquiry page.
942Ch	Too many surrogate SCSI LUNs.
942Dh	Inquiry cache corrupted.
942Eh	Inquiry cache full.
942Fh	Invalid Exchange ID.
9430h	No sense data provided.
9431h	Invalid SCSI status.
9432h	Reported LUNs data has changed Unit Attention.
9433h	Parameter not supported in CDB.
9434h	Load operation in progress.
9435h	Unload operation in progress.
9436h	Early Warning EOM encountered.
9437h	Invalid field in Write buffer descriptor.
9438h	Prediction threshold exceeded false failure.
9439h	Prediction threshold exceeded failure.
943Ah	Echo buffer invalid.
943Bh	LUN not configured.

Error	Description
943Ch	Invalid field in PR Out data.
943Dh	PR Out parameter list length error in CDB.
943Eh	PR Out truncated data.
943Fh	Reservations released Unit Attention.
9440h	Registrations preempted Unit Attention.
9441h	Reservations preempted Unit Attention.
9442h	Invalid release persistent reservation.
9443h	WORM overwrite attempted.
9444h	WORM cannot erase.
9445h	Drive cleaning in progress.
9446h	Loading media.
9448h	Unloading media.
9449h	Firmware upgrade in progress.
944Ah	Cartridge is write-protected.
944Bh	Writing inhibited, caused by bad Cartridge Memory.
944Ch	Unknown cartridge loaded but not threaded.
944Dh	Tape is loaded but not threaded, initialize command is required.
944Eh	MAM is accessible but the cartridge is in load 'hold' position — not ready.
944Fh	The tape is threaded but the drive shows it as unloaded.
9450h	No media loaded.
9451h	An invalid Port ID has been logged in.
9452h	The RMC logical unit has been taken offline by the ADC RMC Logical Unit Mode page.
9453h	Write inhibit — the media is the wrong generation.
9454h	Tape position is past BOM.
9455h	No default WWN. Used by the WWN module.
9456h	No current WWN. Used by the WWN module.
9457h	WWN not changed.
9458h	No default value for the WWN. Used by the WWN module.
9459h	Library check condition surrogate SCSI command. Used in surrogate SCSI to cause the <code>siSetScsiStatus</code> to set task SCSI status to 2.
945Ah	Insufficient registration resources. Used in Fibre Channel when the maximum number of WWN has been reached.
945Bh	Write inhibit caused by suspect integrity.
945Ch	Busy command during LU Reset. This command should receive BUSY during the resetting of the LU.
945Dh	Operation complete.

Error	Description
945Eh	The maximum number of bridge LUNs has been reached.
945Fh	Unit Attention condition has been detected for this initiation to the SMC LUN.
9460h	The remote SMC device server is in the Not Ready state.
9461h	The Bridging Mode Sense cache has become corrupt due to a firmware defect.
9462h	The Bridging Mode Sense cache is full, caching operation failed.
9463h	Unable to forward command to the automation device because the ADT port is logged out.
9464h	Used to instruct the Bridge Device server to resend a SCSI command to the remote SMC LUN.
9465h	Cleaning cartridge is seated but not threaded.
9466h	Firmware upgrade cartridge is seated but not threaded.
9467h	Invalid value in supplied drive serial number.
9468h	<code>siCheckWWN</code> has detected that the supplied WWN is already assigned.
9469h	Tagged overlapped command.
946Ah	Returned GOOD status.
946Bh	Lock SMC cache failed. Internal return status indicating the SMC cache was not locked.
946Ch	SMC cache locked. Reported is <code>siSmcLockCache()</code> is called when the cache is not unlocked.
946Dh	Bridge ready but operation in progress. The Bridging Manager is busy. It already has an open exchange with the remote SMC device server.
946Eh	Bridge not ready and operation in progress. The Bridging Manager is busy. It already has an open exchange with the remote SMC device server.
946Fh	Invalid Vendor ID.
9470h	Invalid Product ID.
9471h	Medium removal prevented.
9472h	Forward task to drive. Not a reportable error code.
9473h	Logout in bad state. The Bridging Manager received notification of an ADT port Logout while waiting for TMF response to abort synchronizing PAMR command.
9474h	Not reserved. If the OIR bit is set in Device Config mode page, commands will return this if there is no persistent reservation.
9475h	Initialization in progress. The Automation Controller is initializing the drive.
9476h	Invalid field in medium attribute. An invalid field is the SCSI Set Medium Attribute command parameter list.
9477h	Truncated medium attribute. A medium attribute in a SCSI Set Medium Attribute parameter list is truncated.
9478h	Invalid field in Log Data cache. An invalid field in the SCSI Set Log Data Cache command parameter list.

Error	Description
9479h	Truncated log page descriptor. A log page descriptor in a SCSI Set Log Date Cache command is truncated.
947Ah	Invalid field in parameter list.
947Bh	Invalid field in SP Out data.
947Ch	SP Out parameter list length error in CDB.
947Dh	Data encryption parameters changed by another initiator Unit Attention.
947Eh	Data encryption parameters changed by vendor specific event Unit Attention.
947Fh	SP Key instance CTR changed.
9480h	Unsupported encryption cartridge.
9481h	Firmware upgrade already in progress. Another initiator has already started a FW download sequence.
9482h	Firmware upgrade image not MOD4.
9483h	Firmware upgrade image has bad CS on first chunk.
9484h	Firmware upgrade reboot in progress.
9485h	The boot info area of the serial flash is corrupt. EnFUG command set will not work.
9486h	No key is available when asked to encrypt or decrypt.
9487h	<code>SetManagementURI</code> command is only allowed when the drive is not ready.
9488h	Parameter list length specified has too many URI descriptors. Only used with the <code>SetManagementURI</code> command.
9489h	Logical EOT has been detected.
948Ah	Decrypt key fail limit reached. Exhaustive search attack prevention.
948Bh	Stored HAT count in NV is greater than Max HAT Retries.
948Ch	Stored default Map ID for this port is invalid.
948Dh	Write command allocation length error. If encryption mode is set to encrypt, only 8 MB record size is allowed.
948Eh	Too many stalled auto mode commands already exist in the slow device server queue.
948Fh	The drive has detected invalid sense data from the remote SMC device server.
9490h	KMS did not provide a key.
9491h	Parameter list length error in the CDB.
9492h	A command descriptor in the Set Snapshot Command Set parameter list was truncated.
9493h	The configuration descriptor in the Set Snapshot Config parameter list was truncated.

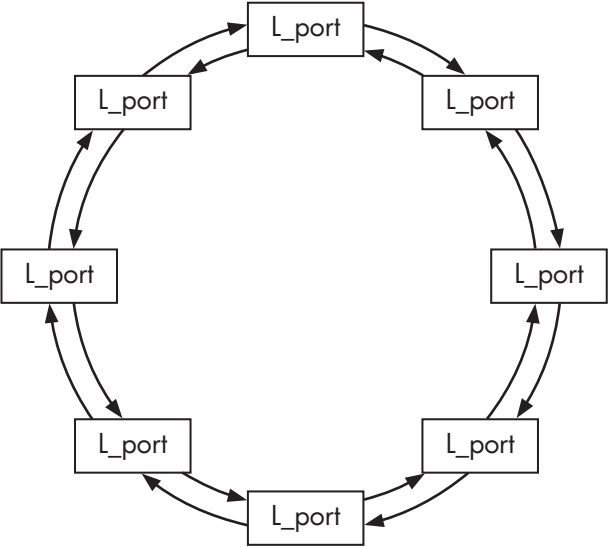
## Automation/Drive Interface (from 9800h)

Error	Description
9801h	<i>Resource issue:</i> The ADI failed to queue an object because the queue is full.
9802h	The ADI failed to get a queue item because the queue was empty.
9803h	<i>Resource issue:</i> The ADI was unable to allocate a new Frame Control Block.
9804h	<i>Resource issue:</i> The ADI does not have sufficient memory to complete the current operation.
9805h	<i>Firmware defect:</i> An invalid queue was referenced.
9806h	<i>Resource issue:</i> Unable to allocate a new exchange ID; all Exchange IDs are in use.
9807h	<i>Firmware defect:</i> The firmware generated an invalid state-machine event.
9808h	<i>Firmware defect:</i> The firmware referenced an invalid firmware state-machine.
9809h	<i>Firmware defect:</i> The firmware referenced an invalid FCB handle.
980Ah	Unable to get a new task object.
980Bh	The SCSI Exchange ID table is full.
980Ch	A new exchange has been started with an ID of an existing exchange.
980Dh	Received a SCSI Command IU containing an invalid field.
980Eh	Received a SCSI Data IU containing an invalid field.
980Fh	Received a SCSI Response IU containing an invalid field.
9810h	Received a SCSI operation from a device server with an invalid Context ID.
9811h	Unable to generate a frame because it exceeds the maximum payload size.
9812h	Received more SCSI data than is permitted within a burst.
9813h	Received a Data IU with an offset outside the current burst.
9814h	Received a command from a device server that cannot be supported.
9815h	The ADT Port did not receive an ACK for a frame it transmitted.
9816h	Temporary code need to replace with <code>SI_ERR_TASK_QUEUE_FULL</code> when available.
9817h	<i>Self-test failed:</i> Unexpected FCBs allocated.
9818h	<i>Self-test failed:</i> Unexpected exchange open.
9819h	<i>Self-test failed:</i> Queue not empty.
981Ah	<i>Self-test failed:</i> SCSI Exchange not in the state IDLE.
981Bh	Detected an excessive number of framing errors.
981Ch	<i>Self-test failed:</i> Non-zero library ACK offset.
981Dh	Received Transfer Ready IU contained an invalid Buffer Offset field.
981Eh	Received an ACK frame but not for frame it was expecting.
981Fh	Received an NAK frame but not for frame it was expecting.
9820h	Giving up initiating a Port Login after a number of failed attempts.
9821h	Discarding an ACK frame it received after the acknowledgement timeout.

Error	Description
9822h	Did not receive acknowledgement within the Acknowledgement Period.
9823h	Received a frame with a checksum error.
9824h	Received a frame when the port was disabled.
9825h	Received Transfer Ready IU was shorter than expected.
9826h	Received Transfer Ready IU was longer than expected.
9827h	Received Transfer Ready IU contained a Burst Length value of zero.
9828h	Failed to execute a SCSI operation because it is logged-out.
9829h	Failed to execute a SCSI operation because it is busy doing something else.
982Ah	Aborted bridged SCSI command due to a communication failure.
982Bh	Unsupported task management function.
982Ch	Invalid SCSI response code.
982Dh	Invalid field in SCSI IU.
982Eh	More data transferred than requested.
982Fh	Task management function failed.
9830h	Service delivery failed.
9831h	Invalid LUN in task management IU.
9832h	Failed to transmit SCSI command or Task Management Function IU.
9833h	Received zero length SCSI data IU.
9834h	Received a data IU unexpectedly.
9835h	Unexpected null frame pointer.
9836h	The drive has detected a library firmware defect.
9837h	Specified port is not a recognized ADT port.
9838h	Instructs Bridging Manager <i>not</i> to resend a command with a UNIT ATTENTION sense key.
9839h	A function will send a response when it has finished.
983Ah	The library NAKed a frame from the drive. Reported in the ADI/AMI command history log.
F801h	GWIF pending.
F802h	GWIF no change.

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# Glossary

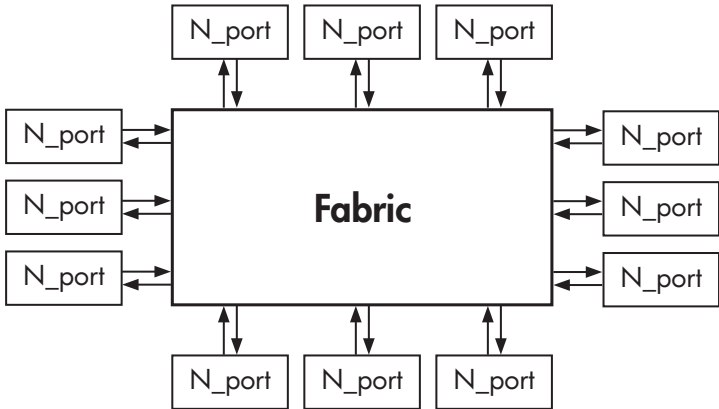
<b>AL_PA</b>	Arbitrated Loop Physical Address. A 1-byte value used in the arbitrated loop topology used to identify L_ports. This value will then also become the last byte of the address identifier for each public L_port on the loop. The AL_PA can be set through an ACI Set Drive Configuration command.
<b>ANSI</b>	American National Standards Institute, which sets standards for, amongst other things, Fibre Channel, SCSI and the safety of electrical devices.
<b>arbitrated loop</b>	One of the three Fibre Channel topologies. Up to 126 NL_ports and 1 FL_port, or 127 NL_ports, are configured in a unidirectional loop. Ports arbitrate for access to the loop based on their AL_PA. Ports with lower AL_PAs have higher priority than those with higher AL_PAs.
	
<b>autoload</b>	When a tape cartridge is inserted, a tape drive with autoload will automatically load it without the host having to send a load command. If a drive does not have autoload, the drive will take no action until it receives a load command.
<b>BOM</b>	Beginning Of Media. The first point on the tape that can be accessed by the drive.
<b>buffered mode</b>	A mode of data transfer in write operations that facilitates tape streaming. It is selected by setting the Buffered Mode Field to <b>1</b> or <b>2</b> in the SCSI MODE SELECT Parameter List header.

<b>channel</b>	A means of data communication between processors and between processors and peripherals. A channel provides a direct or switched point-to-point connection between the communicating devices. A channel is typically hardware-intensive and transports data at the high speed with low overhead. Contrast this with <a href="#">networks</a> .
<b>compression</b>	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.
<b>compression ratio</b>	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.
<b>decompression</b>	A procedure in which the original data is generated from compressed data.
<b>DFA</b>	Direct Fabric Attach. The connection between an N_port and an F_port.
<b>ECMA</b>	European Computer Manufacturers Association. The European equivalent of ANSI.
<b>EOD</b>	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.
<b>EOM</b>	End Of Media format. The last usable point on the tape.
<b>EW-EOM</b>	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.
<b>F_port</b>	Fabric port. A port on a fabric switch operating according to point-to-point topology, to which N_ports may be directly connected. An F_port uses the address identifier FFFFFFFh.
<b>fabric</b>	see <a href="#">switched fabric</a>
<b>fabric zoning</b>	Isolation of two separate switched fabric (FC_SW) zones by the switch.
<b>FC</b>	see <a href="#">fibre channel</a>
<b>FC_FLA</b>	Fibre Channel Fabric Loop Attach. An ANSI standard that describes the rules by which NL_ports and FL_ports communicate with each other.
<b>FC_GS</b>	Fibre Channel Generic Service. An ANSI standard that describes services such as Directory Service that allow a host to identify which storage devices are available and what their addresses are.
<b>FC_SW</b>	Fibre Channel Switch Fabric. An ANSI standard that describes how fibre channel switches are required to behave. See <a href="#">switched fabric</a> .



<b>FC-AL</b>	Fibre Channel Arbitrated Loop. An ANSI standard that describes how several Fibre Channel ports can share a single communication ring. Using optical fiber to connect devices, FC-AL is compatible with SCSI for high-performance storage systems. See also <a href="#">arbitrated loop</a> .
<b>FCP</b>	Fibre Channel Protocol. There are three: <a href="#">arbitrated loop</a> , <a href="#">point-to-point</a> and <a href="#">switched fabric</a> .
<b>fibre channel</b>	<p>Fibre Channel provides an inexpensive yet expendable means of quickly transferring data between workstations, mainframes, supercomputers, desktop computers, storage devices, displays and other peripherals. Although it is called Fibre Channel, its architecture represents neither a channel nor a real network topology. It allows for an active intelligent interconnection scheme, called a fabric, to connect devices. All a Fibre Channel port has to do is to manage a simple point-to-point connection between itself and the fabric.</p> <p>Several common ULPs (Upper Level Protocols) including IP and SCSI can be used with Fibre Channel, merging high-speed I/O and network functionality in a single connectivity technology.</p>
<b>filemark</b>	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.
<b>FL_port</b>	Fabric-Loop port. An F_port which is capable of supporting an attached arbitrated loop. An FL_port on a loop will have the AL_PA 00h, giving the fabric highest priority access to the loop. An FL_port is the gateway to the fabric for NL_ports on a loop.
<b>forced eject</b>	Functionality in the drive that should unload the cartridge in an emergency of if the cartridge fails to eject normally. To force ejection, press and hold the Eject button for 10 seconds. Wait for the cartridge to be ejected. This may take up to 15 minutes (the maximum rewind time).
<b>FRU</b>	Field Replaceable Unit, an assembly or group of components that is replaced in its entirety by Service Engineers when it contains a fault.
<b>hard error</b>	An uncorrectable data error.
<b>host</b>	The host computer system acting as controller for the drive.
<b>L_port</b>	Loop port. A generic term for an NL_port or FL_port, in other words, any Fibre Channel port that supports the arbitrated loop topology.
<b>load</b>	The process in which the drive takes in an inserted cartridge and goes online.
<b>LUN</b>	Logical Unit Number, by which different devices at a particular SCSI ID can be addressed individually. The drive has a fixed LUN of 0.
<b>LVD</b>	Low-Voltage Differential

<b>N_port</b>	Node port. A port on a device such as a computer system host bus adapter, disk drive or tape drive, through which the device connects to a point-to-point or fabric Fibre Channel topology.
<b>network</b>	A collection of connected nodes (like workstations, file servers or peripherals) with its own protocol that supports interaction among these nodes. A network has relatively high overhead since it is software-intensive, and consequently slower than a channel. Networks can handle a more extensive range of tasks than channels as they operate in an environment of unanticipated connections, while channels operate among only a few devices with predefined addresses.
<b>NL_port</b>	Node-Loop port. An N_port which can operate on the arbitrated loop topology.
<b>node</b>	A device that has at least one N_port or NL_port.
<b>offline</b>	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.
<b>online</b>	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.
<b>point-to-point</b>	A Fibre Channel topology in which two points communicate directly.  <pre> graph LR     subgraph " "         direction LR         N1[N_port] &lt;--&gt; N2[N_port]     end     subgraph " "         direction LR         N3[N_port] &lt;--&gt; F1[F_port]     end </pre>
<b>port</b>	An access point in a device to which a link attaches.
<b>private loop</b>	An arbitrated loop that has no attached switch port (NL-port to NL_port). In theory, private loop devices can only communicate with other devices on the same loop.
<b>private NL_port</b>	An NL_port that only communicates with other ports on the loop, not with the fabric. A private NL_port may exist on either a private loop or a public loop.
<b>public loop</b>	An arbitrated loop where one of the ports on the loop is a switch port (an FL_port), thus allowing ports or devices on the loop to communicate with hosts or devices attached to other switch ports.
<b>public NL_port</b>	An NL_port that can communicate with other ports on the loop as well as through an FL_port to other N_ports connected to the fabric.
<b>RAW</b>	see <a href="#">"read-after-write"</a>
<b>read-after-write</b>	RAW improves data integrity by reading data immediately after it is written and writing the data again if an error is found.

<b>ready-to-eject position</b>	A point at which a cartridge is held after an unload command is received by the drive (when Auto-Eject is not set) and the tape has be rewound and unthreaded. The drive will then wait at this point until it is commanded to eject the cartridge by the ACI Unload command
<b>SAN</b>	Storage Area Network. A dedicated, high-speed network that establishes a direct connection between storage elements and servers. The hardware that connects workstations and servers to storage devices in a SAN is referred to as a fabric. The SAN fabric enables any-server-to-any-storage device connectivity through the use of Fibre Channel switching technology.
<b>SFP</b>	Small Formfactor Pluggable transceiver. See <a href="#">transceiver</a> .
<b>switched fabric</b>	One of the three Fibre Channel topologies. An interconnected network of Fibre Channel host ports, device ports and switch ports. In the fabric topology, N_ports are connected to F_ports on a switch. The link is the two unidirectional fibres transmitting in opposite directions. Each fibre is attached to a transmitter of a port at one end and a receiver of another port at the other end. It is possible for fabric switches to be connected to support up to 16 million+ N_ports on a single network.
	 <pre> graph TD     subgraph Top         N1[N_port]         N2[N_port]         N3[N_port]     end     subgraph Bottom         N4[N_port]         N5[N_port]         N6[N_port]     end     subgraph Left         N7[N_port]         N8[N_port]         N9[N_port]     end     subgraph Right         N10[N_port]         N11[N_port]         N12[N_port]     end     Fabric[Fabric]     N1 &lt;--&gt; Fabric     N2 &lt;--&gt; Fabric     N3 &lt;--&gt; Fabric     N4 &lt;--&gt; Fabric     N5 &lt;--&gt; Fabric     N6 &lt;--&gt; Fabric     N7 &lt;--&gt; Fabric     N8 &lt;--&gt; Fabric     N9 &lt;--&gt; Fabric     N10 &lt;--&gt; Fabric     N11 &lt;--&gt; Fabric     N12 &lt;--&gt; Fabric </pre>
<b>TapeAlert</b>	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.
<b>transceiver</b>	A device used to convert electrical signals in the drive to optical signals for transmission in a fibre optic cable. Used in Fibre Channel drives only.
<b>ULP</b>	Upper Level Protocol. The protocol which runs on top of Fibre Channel. Typical ULPs running over Fibre Channel are SCSI (Small Computer System Interface), IP (Internet Protocol), HIPPI (High Performance Parallel Interface, and IPI (Intelligent Peripheral Interface).
<b>VHD</b>	Very High Density

**zoning**

A logical grouping of fabric-attached devices that is isolated from other devices and other zones by the switch.

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