

specifications

hp ultrium drives

technical reference manual

generation 2 SCSI and FC drives

volume 4: specifications



Part Number: C7379-90900 Volume 4

Edition 4, February 2003

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Revision History

Version	Date	Changed Pages
Edition 1	Feb 2001	All
Edition 4	Feb 2003	For Ultrium Generation 2 SCSI and FC drives only

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

Related Documents

The following documents provide additional information:

Documents Specific to HP Ultrium Drives

- **Software Integration Guide**, volume 2 of the HP Ultrium Technical Reference Manual
- **The SCSI Interface**, volume 3 of the HP Ultrium Technical Reference Manual
- **Specifications**, volume 4 of the HP Ultrium Technical Reference Manual
- **HP Ultrium Configuration Guide**, volume 5 of the HP Ultrium Technical Reference Manual
- **Background to Ultrium Drives**, volume 6 of the HP Ultrium Technical Reference Manual
- **HP Ultrium Technology** White Paper, which describes the features and benefits of HP Ultrium drives

Please contact your HP supplier for copies.

Documentation Map

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

Drives—general

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

Installation and Configuration

	SCSI Drives	FC Drives
Connectors	1 HW Integration: <i>ch. 7</i>	1 HW Integration: <i>ch. 4</i>

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

Operation

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

Cartridges

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

Interface

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SCSI Guide	3 SCSI	
Commands	3 SCSI: <i>ch. 4</i>	
Error codes	1 HW Integration: <i>ch. 10</i>	1 HW Integration: <i>ch. 6</i>
Implementation	3 SCSI: <i>ch. 1</i>	
Interpreting sense data	2 SW Integration: <i>ch. 3</i>	
Messages	3 SCSI: <i>ch. 2</i>	

	SCSI Drives	FC Drives
Mode pages —see the MODE SENSE command	3	SCSI: <i>ch. 4</i>
Pre-execution checks	3	SCSI: <i>ch. 3</i>
Responding to Sense Keys and ASC/Q	2	SW Integration: <i>ch. 6</i>
Sense Keys and ASC/Q —see REQUEST SENSE command	3	SCSI: <i>ch. 4</i>

Maintenance and Troubleshooting

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

Dealing with Errors

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

Ultrium Features

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Adaptive Tape Speed (ATS)	6	Background: <i>ch. 1</i>
Autoload	1	HW Integration: <i>ch. 2</i>
Automation Control Interface (ACI)	1	HW Integration: <i>ch. 2</i> 6 Background: <i>ch. 1</i>

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

General Documents and Standardization

- For a general backgrounder on LTO technology and licensing, go to <http://www.lto-technology.com>.
- Small Computer System Interface (SCSI-1), ANSI X3.131-1986. This is the ANSI authorized standard for SCSI implementation, available through ANSI
- Enhanced Small Computer System Interface (SCSI-2), ANSI X3T9.2-1993 Rev. 10L, available through ANSI
- Information Technology — SCSI Parallel Interface-3 (SPI-3), T10 Project 1302D, Working Draft Revision 14

Copies of General Documents can be obtained from:

ANSI 11 West 42nd Street
New York, NY 10036-8002
USA

ISO CP 56
CH-1211 Geneva 20
Switzerland

ECMA 114 Rue du Rhône
CH-1204 Geneva
Switzerland

Global Engineering Documents 2805 McGaw
Irvine, CA 92714
USA

Tel: +41 22 849 6000

Web URL: <http://www.ecma.ch>

Tel: 800 854 7179 or 714 261 1455

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Features



Feature		Specification
Recording format		Linear Tape Open Ultrium 1 and Ultrium 2
Data compression		ALDC
Data encoding method		PRML
Variable speed recording		10–30 MB/s
Read-While-Write		Standard—data is verified immediately after it is written
Auxiliary memory in cartridge (CM)		Standard part of the Ultrium format
Data interfaces	SCSI	Ultra-160 SCSI Wide (native) Ultra HVD SCSI (via LVD-HVD convertor fitted to drive) <i>Connector:</i> 68-pin high density Stub length (SCSI IC to connector) 22 mm average
	FC	2 GB Fibre Channel, Class 3, Dual Port, Multi-Mode <i>Connector:</i> LC (native)
Library interface		Bi-directional RS422 (serial protocol RS422 19200 baud/8 bits)

Physical Specification

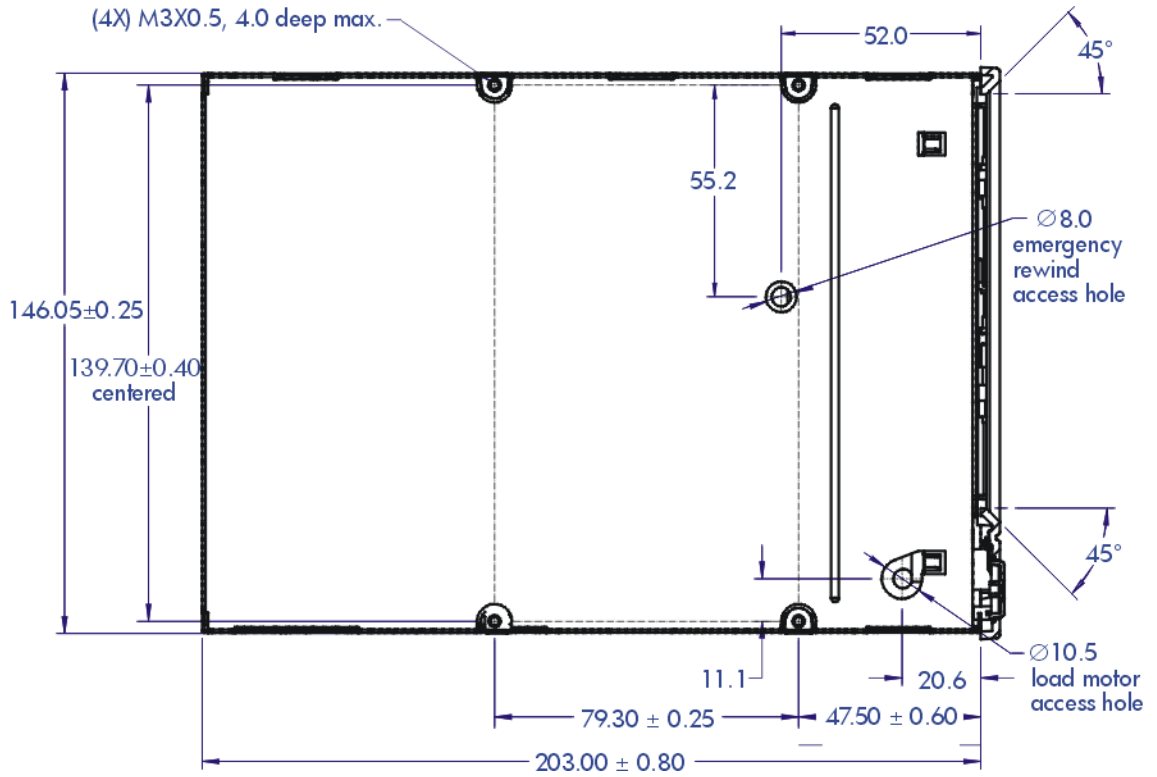


Dimensions

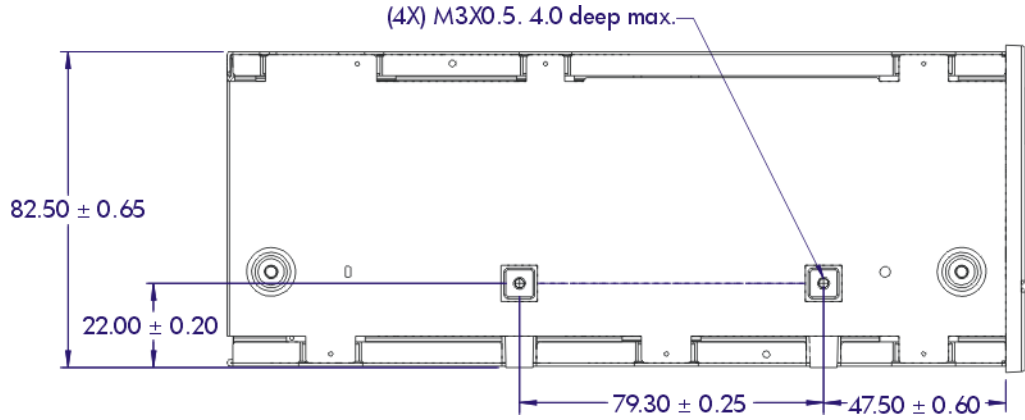
	SCSI	Fibre Channel
Internal		
<i>width:</i>	146 mm (5.75")	146 mm (5.75")
<i>height:</i>	82.5 mm (3.25")	82.5 mm (3.25")
<i>depth:</i>	203 mm (8")	213.8 mm (8.4")
External		
<i>width:</i>	208 mm (8.2")	n/a
<i>height:</i>	121 mm (4.75")	n/a
<i>depth:</i>	298 mm (11.7")	n/a
Rack-Mount		
<i>width:</i>	208 mm (8.2")	n/a
<i>height:</i>	121 mm (4.75")	n/a
<i>depth:</i>	298 mm (11.7")	n/a

Detailed Dimensions

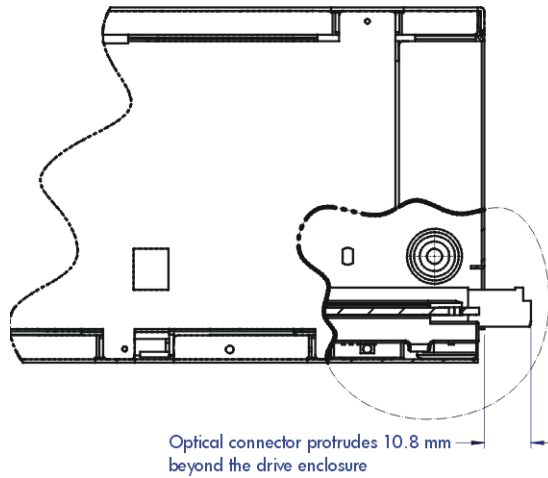
Plan



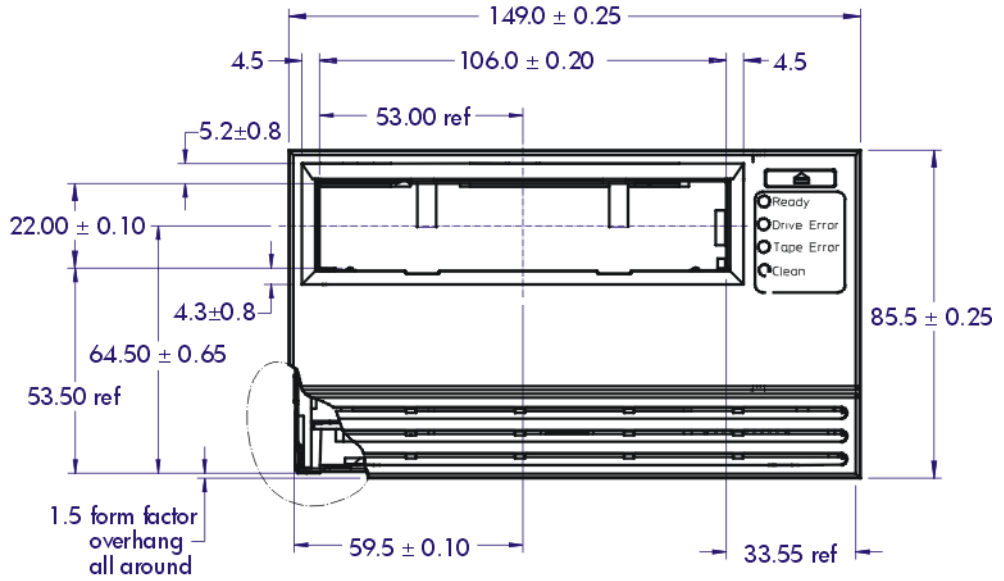
Side



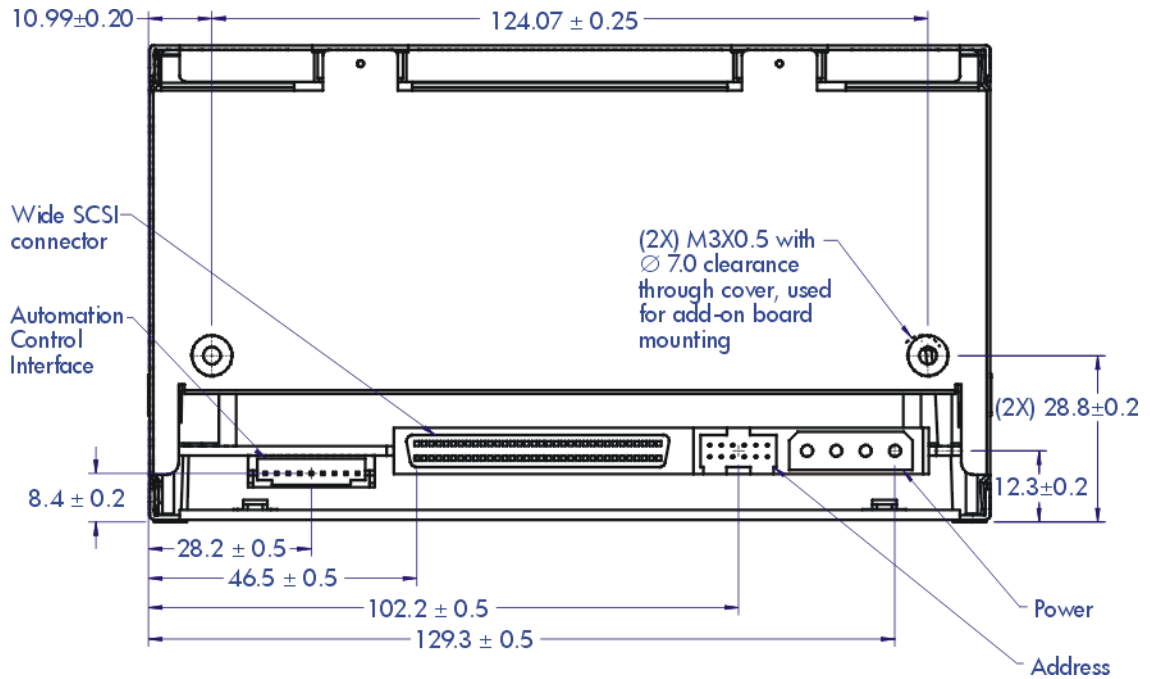
With Fiber Channel, the connector stands out at the back of the drive:



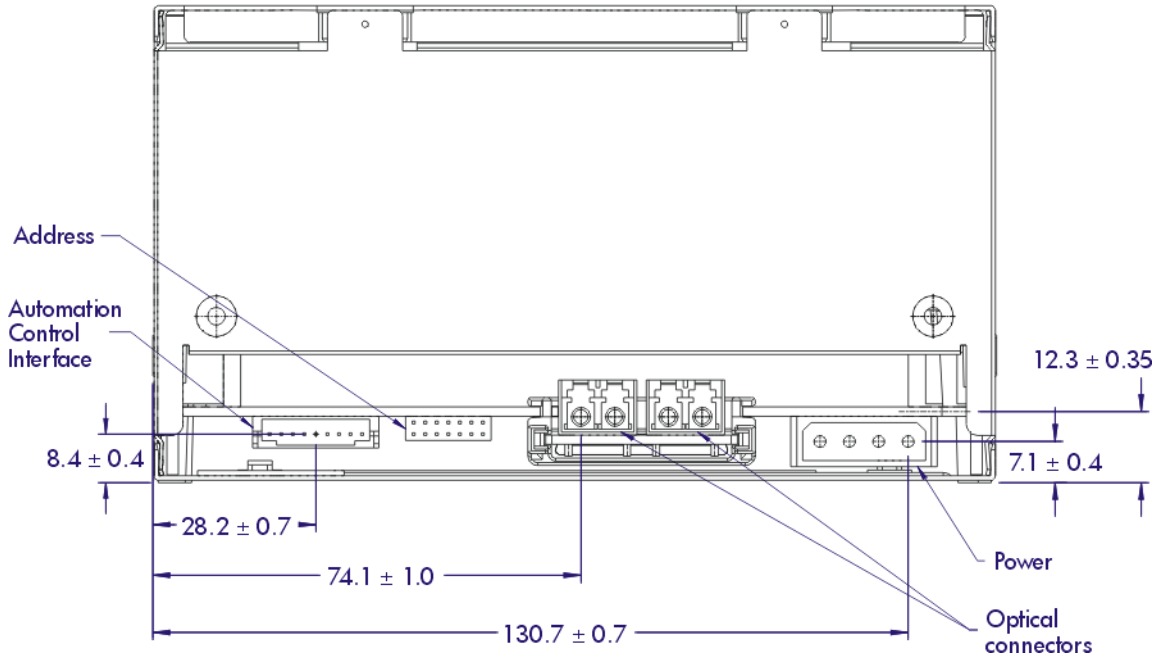
Front



Rear View—SCSI



Rear View—Fibre Channel



Product Weight

	SCSI	Fibre Channel
<i>Internal*</i>	1.90 kg (4.2 lb)	1.90 kg (4.2 lb)

**including front panel and ESD bag but excluding rails*

Drive Orientation

An HP Ultrium drive will operate in the 0°, -90° and +90° when viewed from the front panel. In addition, in the 0° axis, the drive will operate with +20° nose-up tilt.

Electrical Requirements



PSU Requirements

Internal and Rack-Mounted Drives

Specification	SCSI Drives		FC Drives	
	5V	12V	5V	12V
Maximum voltage	5.25V	13.2V	5.25V	13.2V
Minimum voltage	4.75V	10.8V	4.75V	10.8V
Maximum steady-state current	3.5A	1.0A	3.8A	1.0A
Maximum transient current	4.0A	3.0A	4.5A	3.0A
Maximum steady-state power	17.5W	12W	tbd	tbd
Maximum transient power	17.5W	30W	tbd	tbd
Maximum noise/ripple	150 mVpp	150 mVpp	150 mVpp	150 mVpp

Power Consumption

Activity	SCSI Drives		FC Drives
	Average	Peak	Average
Idle	11W	42W	18W
Load	17W	35W	tbd
Write	25W	33W	26W
Read	23W	31W	24W
Reposition/Rewind	22W	38W	tbd
Unload	19W	35W	tbd

Electromagnetic Compatibility

4

ITE Emissions

Parameter	Standards	
	International	European
Radiated and conducted	CISPR 22:1997 Third edition CISPR 22:1993 Second edition + Amendment 1:1995 + Amendment 2:1996 ANSI C63.4-1992 (USA only)	EN 55022:1998
Harmonic current	IEC 61000-3-2:1995 + Amendment A1:1997 + Amendment A2:1998	EN 61000-3-2:1995 + Amendment A1:1998 + Amendment A2:1998
Voltage fluctuations and flicker	IEC 61000-3-3:1994	EN 61000-3-3:1995

ITE Immunities

Parameter	Standards
Generally	<i>International:</i> CISPR 24:1997 <i>European:</i> EN 55024:1998 referencing the following:
Electrostatic discharge	IEC 61000-4-2:1995
Radiated RF electromagnetic field	IEC 61000-4-3:1995
Electrical fast transient/Burst	IEC 61000-4-4:1995
Surge	IEC 61000-4-5:1995
Conducted disturbances by RF fields	IEC 61000-4-6:1995

Parameter	Standards
Power frequency magnetic field	IEC 61000-4-8:1993
Voltage dips, interruptions & variations	IEC 61000-4-11:1994

DC Magnetic Field Interference

- IATA Dangerous Goods Regulations, 30th Edition, 1989-01-01
- U.S. CFR 49, paragraph 173.1020, revision date: 1983-11-01

Environmental

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Climatics

These apply to the mechanism unless otherwise noted. For the environmental specification of media, see [Chapter 7, "Media"](#).

Operating at 6 cu.ft/min airflow

Parameter	Specification
Operating temperature with media	at 6 cfm: 10°C to 35°C (50°F to 95°F) at 8 cfm: 10°C to 40°C (50°F to 104°F)
Maximum operating temperature rise	10°C/hr (50°F/hr)
Operating non-condensing humidity	20% to 80% RH
Maximum operating humidity rise	<30%/hr
Maximum wet bulb temperature	26°C (79°F)
Operating altitude	0 to 4 km (0 to 15,000 ft)

Non-Operating

Parameter	Specification
Non-operating temperature	-40°C to 66°C (-40°F to 151°F)
Maximum non-operating temperature rise	20°C/hr (68°F/hr)
Non-operating humidity	10% to 95% RH
Non-operating humidity rise	30%/hr
Non-operating altitude	0 to 15.25 km (0 to 50,000 ft)

General

Parameter	Specification
Suspended particle density	<200 µg/m ³

Dynamics

Parameter	Specification
Operating sine vibration	0.3G pk 5–500 Hz @ 1 octave/min with 15 min dwell at peak resonance
Operating random vibration	0.3G pk 5–500 Hz 0.000367 g ² /Hz
Operating shock	5G 3 ms half-sine (no performance change) 2G 11 ms half-sine (no performance change) 8G 11 ms half-sine (no data loss) Pulse rate: 0.1 Hz
Non-operating sine vibration	0.75G pk 5–500 Hz @ 1 octave/min with 15 min dwell at peak resonance
Non-operating random vibration	2.41G rms 5–500 Hz
Non-operating shock	90G 3 ms half-sine (no damage) 30G 26 ms trapezoidal (no damage)
Transportation sine vibration	0.5G pk 5–200–5 Hz @ 1 octave/min with 15 min dwell at peak resonance
Transportation random vibration	1.47G rms 5–200 Hz
Package drop	0.91m (36 in)

Noise

Parameter	Specification
Operating acoustic noise	<5.0 bel sound power

Airflow

HP Ultrium drives require forced airflow from front to back, or, in the case of SCSI drives only, from back to front.

Parameter	Specification
Airflow (operating and non-operating)	0.17 m ³ /min (6 cu ft/min)

Safety



Safety Regulatory Standards

Agency	Referenced Standard
Underwriters Laboratories (UL)	UL 60950 Third Edition
Canadian Standards Association (CSA)	CSA 22.2 60950 Third Edition
CE and TÜV	BS EN 60950:2000 Third Edition, including all amendments IEC 60950:1999 Third Edition, including all amendments
CB Report and Certificate	IEC 60950:1999 Third Edition, including all amendments (including all National Deviations)

Required Agency Approvals

Agency	National Standard
NOM-1-NYCE	Product Safety: NOM-0190SCFI-1998
GOSH	Product Safety: GOST R 50377 EMC: GOST R 51318.22-99 & GOST R 50839=2000 Acoustic Report: GOST 26329-84
PCBC	Product Safety: IEC 950, EN60950 EMC: EN55011 (CISPR 22)
VCCI	EMC: CISPR 22:1997
C-Tick	EMC: AS/NZS 3548 (EN 55022, CISPR22)
RRL	MIC No. 1996-18 (EN 55022)
BSMI	CNS 13438

Media



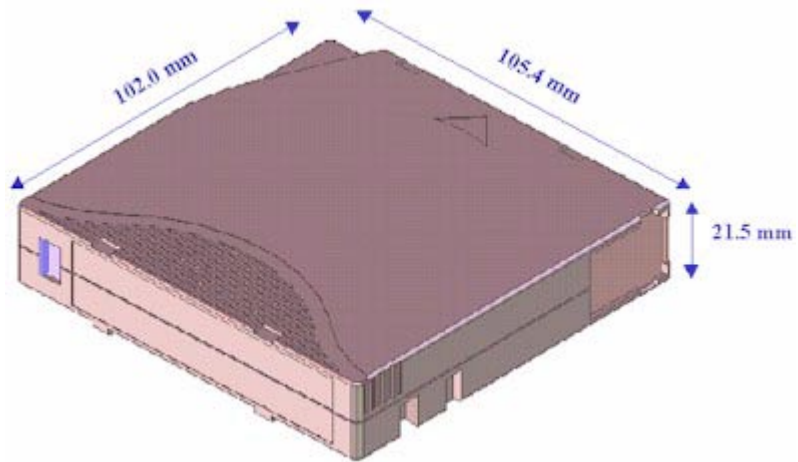
Specification

HP Product Number	Format	Capacity*	Weight	Tape Length
C7972A	U2	400 GB	220g	609m
C7971A	U1	200 GB	220g	609m

*These are the capacities at 2:1 data compression. The actual capacity depends on the compression ratio of the data. This is typically 2:1 but can be anywhere between 1:1 and 110:1.

	Ultrium 1	Ultrium 2
<i>Base film:</i>	6 µm MP++ PEN	6 µm MP++ PEN
<i>Tape length:</i>	580m	609m
<i>Tape width:</i>	12.65 mm	12.65 mm
<i>Tape thickness:</i>	8.9±0.3 µm	8.9±0.3 µm
<i>Magnetic layer thickness:</i>	<0.25 µm	<0.20 µm
<i>Track pitch:</i>	27.5 µm	20.17 µm
<i>Data tracks:</i>	384	512
<i>Data channels:</i>	8	8
<i>Bit density:</i>	4.88 kb/mm	7.32 kb/mm
<i>Maximum tape speed:</i>	5.46 m/s	7.00 m/s
<i>Rewind speed:</i>	4.1 m/s	7.00 m/s
<i>Search speed:</i>		5.5 m/s
<i>Life in archival storage:</i>	30 years	30 years
<i>Durability:</i>	1,000,000 passes	1,000,000 passes
<i>CM capacity:</i>	4 KB	4 KB — accessible

Dimensions



Environmental Specifications (Media)

Operating

Parameter	Specification
Ambient Temperature	10°C to 45°C (50°F to 113°F)
Relative Humidity (non-condensing)	10% to 80%
Maximum Wet Bulb Temperature	26°C (78.8°F)

Storage (Transportation)

Parameter	Specification
Ambient Temperature	-23°C to 49°C (-9.4°F to 102°F)
Relative Humidity (non-condensing)	5% to 80%
Maximum Wet Bulb Temperature	26°C (78.8°F)

Storage (Archival)

Parameter	Specification
Ambient Temperature	16°C to 32°C (60.8°F to 89.6°F)
Relative Humidity (non-condensing)	20% to 80%
Maximum Wet Bulb Temperature	26°C (78.8°F)

LTO-Cartridge Memory (EEPROM)

- 32 kilobits (4 kilobytes)
- Organized as 128 x 32 byte blocks
- >500K write cycles, 20 year data retention life
- Write size is word wide (2 bytes) or block wide (32 bytes)

Ultrium Format Standard



Compatibility

HP Ultrium Generation 2 drives are manufactured to the LTO Ultrium specification as follows:

- They will write, read, append and format (that is, erase or initialize) Ultrium LTO-2 logo tapes in compliance with the U-28 Ultrium Generation 2 Format specification
- They will write, read, append and format (erase or initialize) Ultrium LTO-1 logo tapes in compliance with Standard ECMA 319 Data Interchange on 12,7mm—384 track Magnetic Tape Cartridges—Ultrium 1 Format.

All Ultrium media carrying the Ultrium logo must be certified by the Compliance Verification Entity (CVE). HP branded media has passed the CVE verification process and completed HP on-going media quality and reliability testing.

HP Ultrium Generation 2 drives have demonstrated compliance and data interchangeability with other LTO manufacturers' Generation 1 and Generation 2 drives as follows:

- They have passed the U2-ML (Ultrium Generation 2 Tape Mechanism) compliance verifications, conducted by the Technology Provider Companies (TPC).
- They have successfully completed and passed HP interchange testing, which includes:
 - Write, read and append to tapes written by HP and other manufacturers Ultrium Generation 2 drives
 - Write, read and append to tapes written by Ultrium Generation 1 drives that are currently available in the market

Future Compatibility

In future, HP Ultrium drives will always be capable of reading and writing tapes from the current generation and at least one generation before. HP Ultrium drives will always maintain write and read compatibility with other manufacturers' Ultrium drive and tapes that meet the LTO Ultrium format specification.

Write Integrity

HP Ultrium drives will always write and append tracks in compliance with the LTO Ultrium format specification within the specified environmental conditions for the drive.

Reliability



Description	Specification
MTBF (100% duty cycle)	250,000 hours
Load/unload life	100,000 swaps
MSBF (automation swaps)	100,000 swaps
Head life (typical)	60,000 hours
Media durability	1,000,000 passes
Maximum cartridge uses	20,000 threads
Backup failure rate	<0.1%
Restore failure rate	<0.001%
Interchange failure rate	<0.1%
Uncorrectable error rate	1 in 10^{17} bits
Undetected error rate	1 in 10^{27} bits
Tape pulling life (5 years at 100% duty cycle)	43,800 hours

Performance Specification

10

Transfer Rates

		SCSI	FC
Sustained transfer rate	<i>Native:</i>	30 MB/s	30 MB/s
	<i>Compressed (2:1):</i>	60 MB/s	60 MB/s
Burst transfer rate	<i>Ultra3 SCSI wide:</i>	160 MB/s	
	<i>Ultra3 FC:</i>		2 GB/s: class 3
ATS data rate range		3:1 → 10–30 MB/s (U2), 6.6–20 MB/s (U1)	

The bandwidth of the data compression engine determines the drive's streaming capabilities based on the compression ratio of the data it is handling as follows:

<i>Compression Engine Bandwidth:</i>	120 MB/s
<i>Maximum Streaming Compression Ratio:</i>	3:1

The drive will match the throughput of any host up to the maximum native transfer rate multiplied by the current compression ratio. There will not be any performance penalty for hosts that are slower than the maximum. This capability is accomplished with a 64 MB buffer and the Adaptive Tape Speed (ATS) algorithm.

Data Compression

The compression engine uses an enhanced algorithm based on ALDC where data expansion due to redundant data is minimized to <5%. This is achieved by having two compression schemes (normal and pass-through) with the ability to switch dynamically between them.

It is possible to force the drive to use Scheme 2 (pass-through mode) of the LTO-DC algorithm using the Data Compression mode page or the SDCA parameter in the Sequential Access Mode Page.

Timings

Capacity Full Backup Times

The following table shows approximate backup times for the available tape cartridges:

Cartridge	Time
200 GB Ultrium 1	1 hr 55 min
400 GB Ultrium 2	1 hr 55 min

Load/Unload Times

The load and unload times are as follows:

	SCSI	FC
Typical load time to BOT, ready to read or write	<19s	<19s
Unload time, excluding rewind	<19s	<19s
Automation eject (tape unthreaded)	<1s	<1s

Access Times (Time to Data)

		Time
Average access time from BOT	200 GB Ultrium 1:	46s
	400 GB Ultrium 2:	46s
Maximum access time from BOT	200 GB Ultrium 1:	92s
	400 GB Ultrium 2:	92s

The search speed used will be 5.5–7.0 m/s depending in the tape position.

Mean Reposition Times

Streaming Speed	1.83 m/s	5.5 m/s
Reposition Time	1.75s	2.5s

Turn-Around Time at End of Wrap

The maximum time to turn around at an end of a wrap is 1.5 seconds.

Time to Rewind

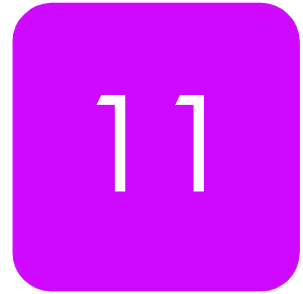
The following table shows times for an HP Ultrium drive to rewind a tape from EOT to BOT for the available tape cartridge capacities. Rewind speed is 5.5–7.0 m/s

200 GB Ultrium 1 Tape	88s
400 GB Ultrium 2 Tape	88s

Cleaning Time

<180s using a cleaning cartridge.

Automation Control Interface



Specification

Physical Interface

- RS-422
- A default of 9600 baud at power-on, after a tape drive reset and after an ACI reset. After that, the library can configure the tape drive to use other baud rates (19200, 38400, 57600 and 115200 baud for HP Ultrium drives) using the Set Baud Rate command.
- 1 start bit, 8 data bits, 2 stop bits, no parity

Protocol

- Binary data packets, including checksum, packet length, status, sequence number,
- XON/XOFF flow control
- Immediate acknowledgement of transmission
- Constant polling not necessary— the drive returns status upon completion of each command

ACI Command Set

The following ACI commands are supported on HP Ultrium drives:

Mandatory Commands		Optional Commands	
00h	Get Drive Info	40h	Send SCSI Command
01h	Load	42h	Send Firmware Image
02h	Unload	43h	Get Firmware Segment
03h	Get Drive Status	44h	Get SCSI CDB
04h	Set Drive Configuration	45h	Send SCSI Data
05h	Get Drive Configuration	46h	Get SCSI Data

Mandatory Commands

06h	Reset
07h	Set Baud Rate
08h	No Op
09h	Get Error Info
0Ah	Acknowledge Attention

Optional Commands

47h	Send SCSI Status
48h	Configure SCSI Surrogate
49h	Get Buffer Size
4Ah	Send Firmware Segment
4Bh	Set Time
4Ch	Get Time

Cartridge Memory

12

Cartridge Memory (LTO-CM)

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

Interface Specification

- Contactless, passive RF interface using a proximity inductive coupling with a range in the order of millimetres.
- Power to the transponder is coupled through the interface.
- The range depends on implementation (10 to 20 mm is the maximum). The best error rate performance will occur at short distances.
- The memory can be read from below (by a drive) or from the front (in libraries).
- The transfer-rate performance of the cartridge memory is as follows:
 - Reads: 2 byte: ~20 Kb/s 32 byte: ~70 Kb/s 4 KB: ~0.5s
 - Writes: 2 byte: ~1.4 Kb/s 32 byte: ~18.5 Kb/s 4 KB: ~1.8s
 - 32 byte read: ~ 5.8 ms 32 byte write: ~ 15.8 ms

Further Information

- For general information about LTO-CM, see “LTO Cartridge Memory” in Chapter 5, “Cartridges” in **Background to Ultrium Drives**, Volume 6 of the Ultrium Technical Manual.
- For suggestions of how to make use of cartridge memory in libraries, see “LTO Cartridge Memory (LTO-CM)” in Chapter 5, “Supporting Ultrium Features” in **Software Integration**, Volume 2 of the Ultrium Technical Manual.[click here.](#)

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