IBM TotalStorage LTO Ultrium
Tape Drive

SCSI Reference

GA32-0450-07

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GA32-0450-07

Note

Before using this manual and the product it supports, read the information under Appendix B, “Notices,” on page 291.

Eighth Edition (July 2007)

This edition applies to the *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference* and to all subsequent releases and modifications unless otherwise indicated in new editions.

Read This First

This is the eighth edition of the *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference* (July 2007).

Summary of Changes

Second Edition, April 2004

The following changes were made in this edition:

- Added features of the 3580 Tape Drive Models L23 and H23.
- Modified to show that the generation 2 drive code ignores the Page Control (PC) field.
- Modified parameters and descriptions in Table 54 on page 58.
- Modified Table 55 on page 59 to show added support for TapeAlerts 51, 52, and 53 and to show removed claim support for flags 19, 35, and 38.
- Modified the Medium Type field definition in section "Mode Parameter Header" on page 107.
- Modified sections"Mode Page 0Fh: Data Compression Mode Page" on page 114 and "Mode Page 10h: Sequential Access Device Configuration Page" on page 116 to reflect that now the Emerald drive's behavior matches that of the Sapphire drive.
- Modified the Text Generation value in Table 152 on page 157.
- Modified section Table 153 on page 158 to show that Medium Auxiliary Memory parameters 1400h-17FFh of Application Specific Data can be written to Cartridge Memory as long as space is available.
- Modified section"READ POSITION" on page 173 to correctly state the behavior of the READ POSITION command after a READ type command.
- Modified section "SET CAPACITY (not Ultrium 1)" on page 234 to show that Check Condition status is returned with Illegal Field in CDB (5/2400h) if the Capacity Proportion Value of a new cartridge becomes smaller than 17.2 GB.

Third Edition, December 2004

The following changes were made in this edition:

- Added Generation 3 (Ultrium 3 Support).
- Added LTO Gen 3 log pages, as appropriate.
- Added support for IBM® TotalStorage® 3580 Tape Drive Models L33/L3H.
- Added support for IBM TotalStorage Ultrium 3 Tape Drive.
- Added support for IBM TotalStorage 400® GB Data Cartridge.
- Added new required items to Inquiry pages in the section entitled "INQUIRY" on page 21.
- Changed values of BQue field and CmdQ field in the section entitled "Standard Inquiry Data" on page 22.
- Added new log sense data and additional supported log pages (see "LOG SENSE" on page 50).
- Replaced TapeAlert Log Parameters in Table 55 on page 59.

- Created a mode page that can be saved and used to configure behavior changes to a drive (see “Mode Page 2Fh: Behavior Configuration Mode Page” on page 131).
- Added speed matching and defined a byte field to be used to distinguish between a full performance drive and a non-performance limited drive (see “Sense Data Format” on page 187).

Fourth Edition, March 2005

The following changes were made in this edition:

- Added Fibre Channel support.

Fifth Edition, May 2006

The following changes were made in this edition:

- Added Space (16) command to Chapter 3.
- Added Chapter 8 Firmware Download.

Sixth Edition, December 2006

The following changes were made in this edition:

- Added additional sense values to Chapter 7, “Sense Keys and Additional Sense,” on page 253
- Added support for the Tape Data Encryption Security Protocol of the Security Protocol In and Security Protocol Out comands

Seventh Edition, June 2007

Information to update this edition was obtained from the following Functional Change Request documents (FCRs):

- FCR 3056 - LTO Emulate WORM Additions
- FCR 3048 - LTO WORM Read Attribute Behavior
- FCR 3059r1 - Add support for Load_Unload Hold bit
- FCR 3078 - SPC-4 Set Timestamp and Report Timestamp
- FCR 3080 - Encryption Counters
- FCR 3089 - Component Revision Level Inquiry Page
- FCR 3096 - LTO TapeAlert 22 Clearing Behavior Change
- FCR 3097 - LTO Limit ERP
- FCR 3099 - LTO HH Changes
- FCR 3103 - New Thread_Unthread Additional Sense Code
- FCR 3104 - Log Pages 14h & 16h
- FCR 3105 - LTO Set Capacity - Return to LP4
- FCR 3106 - Log Page 11h on LUN 0
- FCR 3107 - Allow Read Attribute when CM Accessible
- FCR 3108 - LTO Read dump w strictly increasing offsets
- FCR 3109r1 - Send Diagnostic (Read Thermal Sensor)
- FCR 3112 - LTO4 (J2E Encryption Method)
- FCR 3121r2 - License Keys (LTO)(Internal with Inquiry Data)
- FCR 3122 - LTO LogPage 30h - Tape Usage Log Updates
- FCR 3123 - Component Revision Level Inquiry Page
- FCR 3124 - LTO Dead Media reporting (page 2F)

- FCR 3128 - LTO Log Page 31 Clarification
- FCR 3130 - LTO pSCSI U320 Support
- FCR 3132 - Mode Parameter Speed Field

Eighth Edition, July 2007

Information to update this edition was obtained from the following Functional Change Request documents (FCRs):

- FCR 3133 - LTO Inquiry page C8h
- FCR 3136r0 - LTO ITD Pages (Entire Set)
- FCR 3112 - LTO 4 (J2E Encryption Method)
- FCR 3130 - LTO pSCSI U320 Support
- FCR 3131 - Direct Key Labels
- FCR 3139 - Mode Page 2F Cleanup for Pubs.

Contents

Tables

Preface

This publication contains information about how to use and program all models of the IBM LTO Ultrium Tape Drive.

Organization

The information in this book is organized as follows:

- Chapter 1, "Introduction," on page 1 describes the features and supported attachments for each type of tape drive.
- Chapter 2, "Summary of Drive Generation Differences," on page 7 lists the differences in command timeout values between the IBM Ultrium Internal Tape Drive, the IBM TotalStorage LTO Ultrium 2 Tape Drive, and the IBM TotalStorage LTO Ultrium 3 Tape Drive (known respectively as the Generation 1, Generation 2, and Generation 3 drives).
- Chapter 3, "Command Support," on page 17 lists the SCSI commands that are supported by the tape drives.
- Chapter 4, "Error Sense Information," on page 245 describes the error sense information for the tape drives.
- Chapter 7, "Sense Keys and Additional Sense," on page 253 describes the sense keys and additional sense information for the tape drives.
- Chapter 9, "Attachment Features," on page 265 describes the features of the SCSI and Fibre Channel and Serial Attached SCSI drives.
- Chapter 10, "Firmware Download," on page 277 describes identifying level hardware of drive and identifying level hardware for which the Firmware image is intended.

Related Publications

- *IBM TotalStorage Ultrium Tape Drive 3580 Models L23 and H23 Setup and Operator Guide*, GA32-0460, tells how to install and run the IBM 3580 Ultrium Tape Drive Models L23 and H23.
- *IBM 3580 Ultrium Tape Drive Setup, Operator, and Service Guide*, GA32-0415, tells how to install and run the IBM 3580 Ultrium Tape Drive. The guide also describes how to administer basic service procedures.
- *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F Setup, Operator, and Service Guide*, GA32-0455, tells how to install and run the IBM Ultrium 2 Tape Drive. The guide also describes how to administer basic service procedures.
- *IBM TotalStorage 3580 Tape Drive Models L33/L3H Setup, Operator, and Service Guide*, GC26-7708, tells how to install and run the IBM 3580 Tape Drive Models L33/L3H. The guide also describes how to administer basic service procedures.
- *IBM TotalStorage Ultrium 3 Tape Drive Setup, Operator, and Service Guide*, GC26-7697, tells how to install and run the IBM TotalStorage Ultrium 3 Tape Drive. The guide also describes how to administer basic service procedures.
- *IBM Ultrium Internal Tape Drive Models T200 and T200F Setup, Operator, and Service Guide*, GA32-0435, tells how to install and run the IBM Ultrium Internal Tape Drive. The guide also describes how to administer basic service procedures.
- *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, provides instructions for attaching IBM-supported hardware to open-systems operating systems. It indicates what devices and levels of operating systems are supported,

gives the requirements for adapter cards, and tells how to configure servers to use the device driver with the Ultrium family of devices.

- *IBM Ultrium Device Drivers Programming Reference*, GC35-0483, supplies information to application owners who want to integrate their open-systems applications with IBM-supported Ultrium hardware. The reference contains information about the application programming interfaces (APIs) for each of the various supported operating-system environments.
- *Fibre Channel Arbitrated Loop (FC-AL-2)*, published by the American National Standards Institute (ANSI) as NCITS 332:1999.
- *Fibre Channel Tape and Tape Medium Changers (FC-TAPE)*, published by the American National Standards Institute. Final draft available as T11/99-069v4 on the web at `http://www.t11.org`; actual document available from ANSI as NCITS TR-24:1999.
- *Fibre Channel Protocol for SCSI*, Second Version (FCP-2), published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *SCSI Parallel Interface-3 (SPI-3)*, published by InterNational Committee on Information Technology Standards (INCITS) and available on the web at `http://www.t10.org`.
- *SCSI-3 Stream Commands (SSC)*, published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *SCSI Stream Commands-2 (SSC-2)*, published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *SCSI Primary Commands-2 (SPC-2)*, published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *SCSI Primary Commands-3 (SPC-3)*, published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *Automation/Drive Interface - Commands (ADC*), published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *Automation/Drive Interface - Commands (ADC-2)*, published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *IBM TotalStorage Ultrium 4 Tape Drive Setup, Operator, and Service Guide, GC27-2102*, tells how to install and run the IBM TotalStorage Ultrium 3 Tape Drive. The guide also describes how to administer basic service procedures.

Portions of this manual were adapted from documentation provided by the InterNational Committee on Information Technology Standards (INCITS).

Chapter 1. Introduction

The products that are discussed in this book are high-performance, high-capacity data-storage devices that connect to and provide additional storage for supported servers. They include all models of the IBM LTO Ultrium Tape Drive.

Certain of the products use a Small Computer Systems Interface (SCSI); others use a Fibre Channel interface. Table 1 on page 2 lists the type of interface and other features for each product.

All products use the Small Computer Systems Interface (SCSI) Architecture Model. The transports used are shown in Table 1 on page 2.

Figure 1 shows the IBM 3580 Ultrium Tape Drive and the IBM TotalStorage LTO Ultrium Tape Drive Model T200. The IBM TotalStorage Ultrium Tape Drive Model T800 looks similar to the IBM TotalStorage LTO Ultrium Tape Drive Model T200.

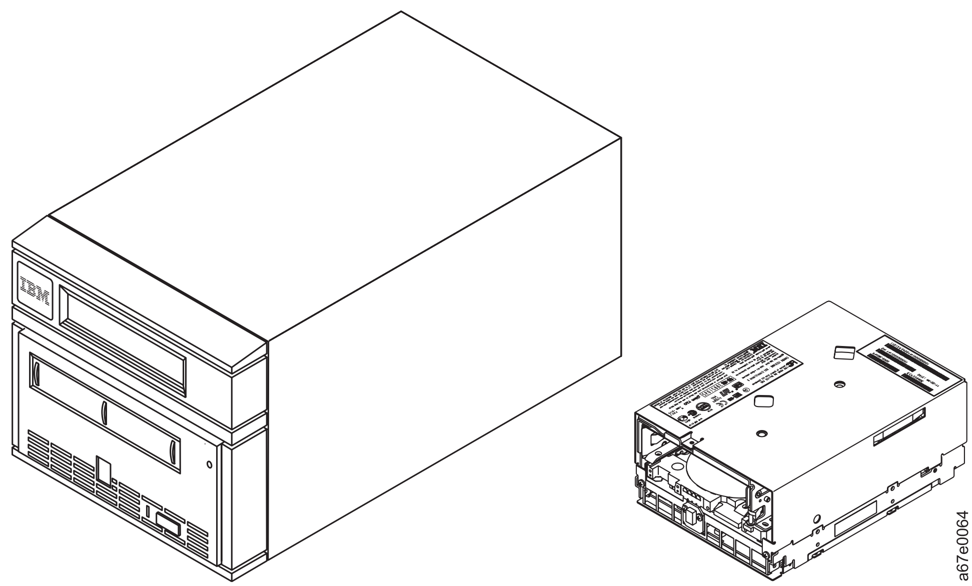

Figure 1. The IBM 3580 Ultrium Tape Drive and the IBM TotalStorage LTO Ultrium Tape Drive Model T200. Model T200 resembles Model T200F, T400, and T400F in appearance. It is shown on the right without a front bezel. The IBM TotalStorage Ultrium Tape Drive Model T800 looks similar to the IBM TotalStorage LTO Ultrium Tape Drive Model T200.

Designed to perform unattended backups as well as to retrieve and archive files, the Ultrium Tape Drives include the features that are described in Table 1.

Table 1. Features of the IBM Ultrium Tape Drives and the IBM 3580 Ultrium Tape Drive

Feature	Ultrium 1	Ultrium 2	Ultrium 3	Ultrium 3 Half-Height Ultrium	Ultrium 4
Native storage capacity	100 GB	200 GB	400 GB	400 GB	800 GB
Storage capacity at 2:1 compression	200 GB	400 GB	400 GB	800 GB	1.6 TB
Native sustained data transfer rate	15 MB/s	35 MB/s	80 MB/s	60 MB/s	120 MB/s
Data transfer rate at 2:1 compression	30 MB/s	70 MB/s	160 MB/s	120 MB/s	240 MB/s
Burst data transfer rate (Ultra 160)	80 MB/s	160 MB/s	160 MB/s	160 MB/s	160 MB/s
Burst data transfer rate (1GFC)	100 MB/s	100 MB/s	100 MB/s	N/A	100 MB/s
Burst data transfer rate (2GFC)	N/A	200 MB/S	200 MB/S	N/A	200 MB/S
Burst data transfer rate (4GFC)	N/A	N/A	400 MB/s	N/A	400 MB/s
Burst data transfer rate (3G SAS)	N/A	N/A	N/A	300 MB/s	300 MB/s
Burst data transfer rate (Ultra 320)	N/A	N/A	N/A	N/A	320 MB/s
Type of interface	U2 SC-D	U160 LC-D	U160 LC-D	U160 SAS	U160 LC-D SAS U320

Note: All sustained data rates are dependent on the capabilities of the interconnect (for example, an UltraSCSI bus is limited to less than 40MB/sec).
U2: Ultra2 LVD/SE SCSI
U160: Ultra 160 LVD SCSI
U320: Ultra 320 LVD SCSI
SC-D: SC-Duplex Fibre Channel, with the use of SCSI protocol
LC-D: LC-Duplex Fibre Channel, with the use of SCSI protocol
SAS: Serial-Attached SCSI

Supported Servers and Operating Systems

The Ultrium Tape Drives are supported by a wide variety of servers and operating systems, as well as adapters. These attachments can change throughout the products' life cycles. To determine the latest supported attachments, visit the web at `http://www.ibm.com/storage/lto` and click on Technical Support or LTO Support.

SCSI and Fibre Channel Attachment

The Ultrium Tape Drives attach to servers and operating systems shown in Table 2. An attachment includes (but is not limited to) the servers and operating systems in the table.

For specific instructions about attachment, see one or more of the following:

- The chapter about installation in the *IBM Ultrium Internal Tape Drive Models T200 and T200F Setup, Operator, and Service Guide*
- *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F Setup, Operator, and Service Guide*
- *IBM 3580 Ultrium Tape Drive Setup, Operator, and Service Guide* for Models L11, H11, L13, and H13
- *IBM TotalStorage Ultrium Tape Drive 3580 Models L23 and H23 Setup and Operator Guide*
- *IBM TotalStorage 3580 Tape Drive Models L33/L3H Setup, Operator, and Service Guide*
- *IBM TotalStorage Ultrium 3 Tape Drive Setup, Operator, and Service Guide*
- *IBM TotalStorage Ultrium 4 Tape Drive Setup, Operator, and Service Guide*

Table 2. Supported Servers and Operating Systems for SCSI and Fibre Channel Attachment

Supported Servers	**Supported Operating Systems**
IBM AS/400® or @server iSeries™	OS/400®
IBM RS/6000®, RS/6000 SP™, or @server pSeries®	AIX®
IBM @server zSeries® 800 or 900	Linux®
Hewlett-Packard	HP-UX
Sun Microsystems	Solaris
32-bit, Intel-compatible servers	MicrosoftWindows 2000 or Windows NT®
	Red Hat Linux
64-bit, Intel® Itanium® servers	Red Hat Linux
Supported SAN Components for Fibre Channel Attachment Visit the web at: `http://www.storage.ibm.com/hardsoft/tape/supserver/support.html`	

Supported Device Drivers

IBM maintains the latest levels of device drivers and driver documentation for the IBM Ultrium Tape Drives on the Internet. You can access this material from your browser or through the IBM FTP site by performing one of the following procedures. **(Note: If you do not have Internet access and you need information about device drivers, contact your Marketing Representative.)**

- Using a browser, type one of the following:
  - `http://www.ibm.com/storage`
  - `ftp://ftp.software.ibm.com/storage/devdrvr`
  - `ftp://207.25.253.26/storage/devdrvr`
- Using an IBM FTP site, enter the following specifications:
  - FTP site: `ftp.software.ibm.com`
  - IP Addr: `207.25.253.26`
  - Userid: `anonymous`
  - Password: (use your current e-mail address)
  - Directory: `/storage/devdrvr`

IBM provides PostScript- and PDF-formatted versions of its documentation in the /storage/devdrvr/doc directory:

- IBM_ultrium_tape_IUG.ps and IBM_ultrium_tape_IUG.pdf contain the current version of the *IBM Ultrium Device Drivers Installation and User's Guide*
- IBM_ultrium_tape_PROGREF.ps and IBM_ultrium_tape_PROGREF.pdf contain the current version of the *IBM Ultrium Device Drivers Programming Reference*

Device drivers and utilities for each supported server are beneath /storage/devdrvr/ in the following directories (the device driver for the iSeries or AS/400 server is included in the OS/400 operating system):

- AIX
- HPUX
- Linux
- Solaris
- Tru64
- WinNT
- Win2000

For more information about device drivers, refer to any of the preceding directories.

Supported Tape Cartridges

The IBM LTO Ultrium Tape Drives support LTO Cartridges as described in Table 3.

Table 3. IBM LTO Ultrium Tape Drive Support of LTO Cartridges

LTO Generation	Type	Data Capacity Native	Data Capacity Compressed	Supported by			
				Ultrium 4	Ultrium 3	Ultrium 2	Ultrium 1
4	A	800 GB	1600 GB	Write and Read	No	No	No
3	A	400 GB	800 GB	Write and Read	Write and Read	No	No
2	A	200 GB	400 GB	Read Only	Write and Read	Write and Read	No
1	A	100 GB	200 GB	No	Read Only	Write and Read	Write and Read
1	B	50 GB	100 GB	No	Read Only	Write and Read	Write and Read
1	C	30 GB	60 GB	No	Read Only	Write and Read	Write and Read
1	D	10 GB	20 GB	No	Read Only	Write and Read	Write and Read

1. Ultrium Tape Drives reads tapes that have been written by other licensed Ultrium drives.
2. Ultrium Tape Drives write tapes that can be read by other licensed Ultrium drives.
3. Ultrium Tape Drives offer read/write capability for certified LTO Ultrium tape cartridges as specified in this table.
4. The tape cartridges define the format to which it is written. (for example Ultrium 2 cartridges can only be written to Ultrium 2 format regardless of which generation drive writes it.
5. Ultrium 3 and Ultrium 4 support WORM cartridges.

The Ultrium 4 Tape Drive (Generation 4) uses the IBM TotalStorage 800 GB Data Cartridge, and is compatible with the cartridges of its predecessors (called Generation 1, Generation 2 and Generation 3). The Ultrium 4 Tape Drive performs the following functions:

- Reads and writes Generation 4 cartridges to Generation 4 format
- Reads and writes Generation 3 cartridges to Generation 3 format
- Reads Generation 2 cartridges in Generation 2 format
- Does not write Generation 4 cartridges to Generation 3 or Generation 2 format
- Does not write Generation 3 cartridges to Generation 4 or Generation 2 format
- Does not write Generation 2 cartridges to Generation 4 or Generation 3 format
- Does not write or read Generation 1 cartridges in any format

The Ultrium 3 Tape Drive (Generation 3) uses the IBM TotalStorage 400 GB Data Cartridge, and is compatible with the cartridges of its predecessors (called Generation 1 and Generation 2). The Ultrium 3 Tape Drive performs the following functions:

- Reads and writes Generation 3 cartridges to Generation 3 format
- Reads and writes Generation 2 cartridges to Generation 2 format
- Reads Generation 1 cartridges in Generation 1 format
- Does not write Generation 3 cartridges to Generation 2 or Generation 1 format

- Does not write Generation 2 cartridges to Generation 3 or Generation 1 format
- Does not write Generation 1 cartridges to Generation 3 or Generation 2 format

The Ultrium 3 Tape Drive reads tapes that have been written by other licensed Ultrium 3 drives. It also writes tapes that can be read by other licensed Ultrium 3 drives.

Ultrium 3 Tape Drives offer read/write capability for certified LTO Ultrium tape cartridges that have capacities of 400 and 200 GB. They also offer read capability for certified LTO Ultrium tape cartridges that have a capacity of 100 GB.

The Ultrium 2 Tape Drive (Generation 2) uses the IBM TotalStorage LTO Ultrium 200 GB Data Cartridge and is compatible with the cartridges of its predecessor, the IBM Ultrium Internal Tape Drive (called Generation 1). The Ultrium 2 Tape Drive performs the following functions:

- Reads and writes Generation 2 cartridges to Generation 2 format
- Reads and writes Generation 1 cartridges to Generation 1 format
- Does not write Generation 2 cartridges to Generation 1 format
- Does not write Generation 1 cartridges to Generation 2 format

The Ultrium 2 Tape Drive reads tapes that have been written by other licensed Ultrium 2 drives. It also writes to tapes that can be read by other licensed Ultrium 2 drives.

Ultrium 2 Tape Drives offer read/write capability for certified LTO Ultrium tape cartridges that have capacities of 200 and 100 GB.

Ultrium 1 Tape Drives offer read/write capability for certified LTO Ultrium tape cartridges that have a capacity of 100 GB.

Chapter 2. Summary of Drive Generation Differences

This chapter provides a summary of the differences in host attachment protocol between the Ultrium Internal Tape Drive (Generation 1), the TotalStorage LTO Ultrium 2 Tape Drive (Generation 2), and the TotalStorage Ultrium 3 Tape Drive (Generation 3), the TotalStorage Ultrium 3 Half-High Tape Drive (Generation 3HH), and the TotalStorage Ultrium 4 Tape Drive (Generation 4).

The features of the Generation 2 drive that differ from the Generation 1 drive include:

- 64-MB read-and-write cache
- Speed matching
- Channel calibration
- SET CAPACITY SCSI command
- Ultra160 SCSI interface
- Drive external SCSI termination required
- Fibre Channel 2-Gb/s interface
- Fibre Channel support for direct connection to an F port (for example, a McData switch)
- Parallel SCSI Ultra 320 interface

The features of the Ultrium 3 Tape Drive that differ from those of the Ultrium 2 Tape Drive include the following:

- 128 MB read-and-write cache
- New media, new media shell color (dark bluish gray, Pantone color number 7546C)
- Expanded request sense length to 96 bytes

The features of the Ultrium 4 Tape Drive that differ from those of the Ultrium 3 HH, Ultrium 3, and Ultrium 2 Tape Drive include the following:

- Half-Height drive option with:
  1. Serial Attached SCSI (SAS) Interface, or
  2. Ultra160 SCSI interface
- 128 MB read-and-write cache
- Encryption of data on Ultrium 4 cartridges
  1. T 10 key management method
  2. Transparent management method
     a. when using IBM device driver, or
     b. when in a 3584
- New log pages
  1. Device Statistics log page (14h)
  2. Tape Diagnostic data log page (16h)
  3. Performance Characteristics log page (37h)
- Fibre Channel 4Gbit/sec interface
- Serial Attached SCSI (SAS) interface

Differences in Command Timeout Values

Due to differences between each of the of the Ultrium drives, the maximum amount of time it takes for various SCSI commands to execute and return status has changed. Table 4 provides a list of all recommended host command time-outs from commands defined by the referenced SCSI-3 standard or by this product as vendor-unique for sequential access devices. The table lists the following information for each command: the operation code, recommended timeout, and notes.

It is strongly recommended that device drivers or host software implement device reservations using the Reserve or Persistent Reserve commands. Due to the sequential nature of tape devices, many host commands are serialized, and command time-outs consequently have an additive effect. Using reservations will prevent this from causing application disruptions in a multi-initiator or SAN environment. Similar additive timeout effects can occur if the host is using command queueing (that is, simple queuing).

Note: The time-outs in the following table are based on the time from the start of execution of the command, to its reported completion. Since applications are generally concerned with the time from the command being issued, to its reported completion, it should be noted that this overall time may be affected by currently executing operations. Some of these conditions include:

- A prior command was issued with the Immediate bit set in the CDB
- Multiple concurrent commands with Simple queueing are executed
- Multi-initiator configurations without reservations
- Non-host operations, such as manual unloads, power-on self tests, and so on
- Commands issued shortly after certain aborted commands
- Commands that force flushes when unwritten write data is in the buffer

Table 4. Command Timeout Values (Ultrium 1, 2, and 3 Full-Height) - Sorted by OpCode

Op Code	Command	Timeout for Ultrium Tape Drive (in minutes)	Timeout for Ultrium 2 Tape Drive (in minutes)		Timeout for Ultrium 3 Full-Height Tape Drive (in minutes)		
			Gen 1 Cartridge	Gen 2 Cartridge	Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge
00h	Test Unit Ready	1	1	1	1	1	1
01h	Rewind	8	9	8	8	8	9
03h	Request Sense	1	1	1	1	1	1
05h	Read Block Limits	1	1	1	1	1	1
08h	Read	18	18	18	16	16	17
0Ah	Write	18	18	18	N/A	16	18
0Bh	Set Capacity	N/A	13	13	N/A	11	12
10h	Write FileMark	15	15	15	N/A	15	17
11h	Space(6) (normal)	16	15	14	14	14	16
	Space(6) (slow)	173	138	151	127	165	140
12h	Inquiry	1	1	1	1	1	1
13h	Verify	18	18	18			

Table 4. Command Timeout Values (Ultrium 1, 2, and 3 Full-Height) - Sorted by OpCode (continued)

Op Code	Command	Timeout for Ultrium Tape Drive (in minutes)	Timeout for Ultrium 2 Tape Drive (in minutes)		Timeout for Ultrium 3 Full-Height Tape Drive (in minutes)		
			Gen 1 Cartridge	Gen 2 Cartridge	Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge
15h/55h	Mode Select (6/10)	1	1	1	1	1	1
16h/56h	Reserve Unit (6/10)	1	1	1	1	1	1
17h/57h	Release Unit (6/10)	1	1	1	1	1	1
19h	Erase	204	138	151	N/A	160	134
1Ah/5Ah	Mode Sense (6/10)	1	1	1	1	1	1
1Bh	Load (Cartridge Insert -> BOM)	11	12	12	8	8	8
	Load (Lp4 -> BOM)	8	9	8	8	8	9
	Unload (BOM -> Cartridge Eject)	10	10	10	10	10	11
	Unload (LP4 -> Cartridge Eject)	11	12	11	11	11	12
1Ch	Receive Diagnostic Results	1	1	1	1	1	1
1Dh	Send Diagnostic	29	35	35	13	39	34
1Eh	Prevent/Allow Medium Removal	1	1	1	1	1	1
2Bh/92h	Locate(10/16) (normal)	16	15	14	14	14	16
	Locate(10/16) (slow)	173	138	151	127	165	140
34h	Read Position	1	1	1	1	1	1
3Bh	Write Buffer	8	8	8	8	8	8
3Ch	Read Buffer	8	8	8	7	7	8
44h	Report Density Support	1	1	1	1	1	1
4Ch	Log Select	1	1	1	1	1	1
4Dh	Log Sense	1	1	1	1	1	1
5Eh	Persistent Reserve In	1	1	1	1	1	1
5Fh	Persistent Reserve Out	1	1	1	1	1	1
8Ch	Read Attribute	1	1	1	1	1	1
8Dh	Write Attribute	1	1	1	1	1	1

Table 4. Command Timeout Values (Ultrium 1, 2, and 3 Full-Height) - Sorted by OpCode (continued)

Op Code	Command	Timeout for Ultrium Tape Drive (in minutes)	Timeout for Ultrium 2 Tape Drive (in minutes)		Timeout for Ultrium 3 Full-Height Tape Drive (in minutes)		
			Gen 1 Cartridge	Gen 2 Cartridge	Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge
91h	Space(16) (normal)	N/A	N/A	N/A	14	14	16
	Space(16) (slow)	N/A	N/A	N/A	127	165	140
A0h	Report LUNs	1	1	1	1	1	1
A2h	Security Protocol In (SPIN)	N/A	N/A	N/A	N/A	N/A	1
A3h:0Ch	Report Supported Op Codes	N/A	N/A	N/A	1	1	1
A3h:0Dh	Report Supported Task Management Functions	N/A	N/A	N/A	1	1	1
A3h:0Fh	Report Timestamp	N/A	N/A	N/A	1	1	1
A4h:0Fh	Set Timestamp	N/A	N/A	N/A	1	1	1
B5h	Security Protocol Out (SPOUT)	N/A	N/A	N/A	N/A	N/A	N/A

Table 5. Command Timeout Values (Ultrium 3 Half-Height and Ultrium 4) - Sorted by OpCode

Op Code	Command	Timeout for Ultrium 3 Half-Height Tape drive (in minutes)			Timeout for Ultrium 4 Tape Drive (in minutes)		
		Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 4 Cartridge
00h	Test Unit Ready	1	1	1	1	1	1
01h	Rewind	11	11	13	8	9	9
03h	Request Sense	1	1	1	1	1	1
05h	Read Block Limits	1	1	1	1	1	1
08h	Read	21	21	23	16	17	22[4]
0Ah	Write	N/A	21	24	N/A	18	23[5]
0Bh	Set Capacity	N/A	14	16	N/A	12	12
10h	Write FileMark	N/A	21	23	N/A	17	22[7]
11h	Space(6) (normal)	20	20	22	14	16	21
	Space(6) (slow)	199	264	201	165	140	183
12h	Inquiry	1	1	1	1	1	1
13h	Verify	21	21	23	16	17	22[4]

Table 5. Command Timeout Values (Ultrium 3 Half-Height and Ultrium 4) - Sorted by OpCode (continued)

Op Code	Command	Timeout for Ultrium 3 Half-Height Tape drive (in minutes)			Timeout for Ultrium 4 Tape Drive (in minutes)		
		Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 4 Cartridge
15h/55h	Mode Select (6/10)	1	1	1	1	1	1[3]
16h/56h	Reserve Unit (6/10)	1	1	1	1	1	1
17h/57h	Release Unit (6/10)	1	1	1	1	1	1
19h	Erase	N/A	191	255	N/A	134	180[1]
1Ah/5Ah	Mode Sense (6/10)	1	1	1	1	1	1
1Bh	Load (Cartridge Insert -> BOM)	9	9	9	8	8	8[2]
	Load (LP4 -> BOM)	11	11	13	8	9	9[2]
	Unload (BOM -> Cartridge Eject)	12	12	14	10	11	11
	Unload (LP4 -> Cartridge Eject)	14	14	16	11	12	13
1Ch	Receive Diagnostic Results	1	1	1	1	1	1
1Dh	Send Diagnostic	13	39	40	13	34	35
1Eh	Prevent/ Allow Medium Removal	1	1	1	1	1	1
2Bh/92h	Locate(10/ 16) (normal)	20	20	22	14	16	21
	Locate(10/ 16) (slow)	199	264	201	165	140	183
34h	Read Position	1	1	1	1	1	1
3Bh	Write Buffer	10	10	11	8	8	8[6]
3Ch	Read Buffer	9	9	10	7	8	8
44h	Report Density Support	1	1	1	1	1	1
4Ch	Log Select	1	1	1	1	1	1
4Dh	Log Sense	1	1	1	1	1	1

Table 5. Command Timeout Values (Ultrium 3 Half-Height and Ultrium 4) - Sorted by OpCode (continued)

Op Code	Command	Timeout for Ultrium 3 Half-Height Tape drive (in minutes)			Timeout for Ultrium 4 Tape Drive (in minutes)		
		Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 4 Cartridge
5Eh	Persistent Reserve In	1	1	1	1	1	1
5Fh	Persistent Reserve Out	1	1	1	1	1	1
91h	Space(16) (normal)	20	20	22	14	16	21
	Space(16) (slow)	199	264	201	165	140	183
BCh	Read Attribute	1	1	1	1	1	1
BDh	Write Attribute	1	1	1	1	1	1
A0h	Report LUNs	1	1	1	1	1	1
A2h	Security Protocol In	N/A	N/A	N/A	N/A	N/A	1
A3h:0Ch	Report Supported Op Codes	1	1	1	1	1	1
A3h:0Dh	Report Supported Task Management Functions	1	1	1	1	1	1
A3h:0Fh	Report Timestamp	1	1	1	1	1	1
A4h:0Fh	Set Timestamp	1	1	1	1	1	1
B5h	Security Protocol Out	N/A	N/A	N/A	N/A	N/A	1

Table 6. Command Timeout Values (Ultrium 3 Half-Height and Ultrium 4) - Alphabetical

Op Code	Command	Timeout for Ultrium 3 Half-Height Tape drive (in minutes)			Timeout for Ultrium 4 Tape Drive (in minutes)		
		Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 4 Cartridge
19h	Erase	N/A	191	255	N/A	134	180[1]
12h	Inquiry	1	1	1	1	1	1
1Bh	Load (Cartridge Insert -> BOM)	9	9	9	8	8	8[2]
	Load (LP4 -> BOM)	11	11	13	8	9	9[2]

Table 6. Command Timeout Values (Ultrium 3 Half-Height and Ultrium 4) - Alphabetical (continued)

Op Code	Command	Timeout for Ultrium 3 Half-Height Tape drive (in minutes)			Timeout for Ultrium 4 Tape Drive (in minutes)		
		Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 4 Cartridge
2Bh/92h	Locate(10/ 16) (normal)	20	20	22	14	16	21
	Locate(10/ 16) (slow)	199	264	201	165	140	183
4Ch	Log Select	1	1	1	1	1	1
4Dh	Log Sense	1	1	1	1	1	1
15h/55h	Mode Select (6/10)	1	1	1	1	1	1[3]
1Ah/5Ah	Mode Sense (6/10)	1	1	1	1	1	1
5Eh	Persistent Reserve In	1	1	1	1	1	1
5Fh	Persistent Reserve Out	1	1	1	1	1	1
1Eh	Prevent/ Allow Medium Removal	1	1	1	1	1	1
08h	Read	21	21	23	16	17	22[4]
BCh	Read Attribute	1	1	1	1	1	1
05h	Read Block Limits	1	1	1	1	1	1
3Ch	Read Buffer	9	9	10	7	8	8
34h	Read Position	1	1	1	1	1	1
1Ch	Receive Diagnostic Results	1	1	1	1	1	1
17h/57h	Release Unit (6/10)	1	1	1	1	1	1
44h	Report Density Support	1	1	1	1	1	1
A0h	Report LUNs	1	1	1	1	1	1
A3h:0Ch	Report Supported Op Codes	1	1	1	1	1	1
A3h:0Dh	Report Supported Task Management Functions	1	1	1	1	1	1
A3h:0Fh	Report Timestamp	1	1	1	1	1	1

Table 6. Command Timeout Values (Ultrium 3 Half-Height and Ultrium 4) - Alphabetical (continued)

Op Code	Command	Timeout for Ultrium 3 Half-Height Tape drive (in minutes)			Timeout for Ultrium 4 Tape Drive (in minutes)		
		Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge	Gen 4 Cartridge
03h	Request Sense	1	1	1	1	1	1
16h/56h	Reserve Unit (6/10)	1	1	1	1	1	1
01h	Rewind	11	11	13	8	9	9
A2h	Security Protocol In (SPIN)	N/A	N/A	N/A	N/A	N/A	1
B5h	Security Protocol Out	N/A	N/A	N/A	N/A	N/A	1
1Dh	Send Diagnostic	13	39	40	13	34	35
0Bh	Set Capacity	N/A	14	16	N/A	12	12
A4h:0Fh	Set Timestamp	1	1	1	1	1	1
11h	Space(6) (normal)	20	20	22	14	16	21
	Space(6) (slow)	199	264	201	165	140	183
91h	Space(16) (normal)	20	20	22	14	16	21
	Space(16) (slow)	199	264	201	165	140	183
00h	Test Unit Ready	1	1	1	1	1	1
1Bh	Unload (BOM -> Cartridge Eject)	12	12	14	10	11	11
	Unload (LP4 -> Cartridge Eject)	14	14	16	11	12	13
13h	Verify	21	21	23	16	17	22[4]
0Ah	Write	N/A	21	24	N/A	18	23[5]
BDh	Write Attribute	1	1	1	1	1	1
3Bh	Write Buffer	10	10	11	8	8	8[6]
10h	Write FileMark	N/A	21	23	N/A	17	22[7]

Command and Parameter differences between generations

Table 7 shows commands and parameters added since Ultrium 1 and in which generation(s) it is applicable.

Table 7. Command and Parameter differences between generations

Command or Parameter	Description	Generation		
		2	3	4
Set Capacity Command	The SET CAPACITY command is supported. The minimum capacity allowed varies from one generation to another. For more information, see "SET CAPACITY (not Ultrium 1)" on page 234.	Y	Y	Y
Echo Buffer Support	Echo Buffer mode of the READ BUFFER and WRITE BUFFER commands (see "READ BUFFER" on page 166 and "WRITE BUFFER" on page 242, respectively).	Y	Y	Y
Volume Identifier	Volume Identifier Part of the Device Attribute of Medium Auxiliary Memory. This is the volume identifier (VolSer or BarCode) value set by the library	-	-	Y
Security Protocol In (SPIN)	This command is related to managing encryption. See "SECURITY PROTOCOL IN (SPIN) A2h" on page 194.	-	-	Y
Security Protocol Out (SPOUT)	This command is related to managing encryption. See "SECURITY PROTOCOL OUT (SPOUT) B5h" on page 203.	-	-	Y
Key: - Not Supported				

Data Changes Between Generations

The sections that follow describe the data changes between Generations of the Ultrium tape drive.

Standard Inquiry Data

The length of Standard Inquiry data on Ultrium 1 drives is less than on later generations. The Standard Inquiry data reported by Ultrium drives is shown in Table 11 on page 22. The Additional Length field specifies how many bytes are returned. Currently, Ultrium 1 devices set this value to 33 (21h) and later generation devices set this value to 53 (35h). This value is subject to change. It is strongly recommended that the user parse the data returned by using the Additional Length field instead of the published values.

% Product Identification information returned is shown in Table 12 on page 24..

For more information, see "Standard Inquiry Data" on page 22.

REPORT DENSITY SUPPORT Command

The REPORT DENSITY SUPPORT command has added density values for all generations through Ultrium 4. Additionally, the units in which the Capacity value are returned has changed to match the SCSI standards. See Table 180 on page 180.

For more information, see "REPORT DENSITY SUPPORT" on page 178.

Mode Pages

On Mode Sense commands the value returned in the Medium Type field is shown in Table 97 on page 107. On Mode Select commands any value is allowed and ignored.

Fibre Channel Port Control Page (19h) Page Length changed from 0Eh in Ultrium 1 drives to 06h in later generation 2 drives. This matches the definition in the SCSI standards (FCP-2 and later). For more information, see "Mode Page 19h: Protocol Specific Port Control Page" on page 120.

READ POSITION Command

The READ POSITION command for all generation drives except Ultrium 1 behaves as described in the SCSI standards (SPC-2). For more information, see "READ POSITION" on page 173.

Request Sense Changes

For Request Sense data, the Additional Sense Length is set to n-7, and is at least 10. When the sense data is associated with an Illegal Length read, the Additional Sense Length may be 10. In Ultrium 1 and Ultrium 2 drives, n can be as large as 35. In Ultrium 3 and later generation drives, n can be as large as 95. While this length is not anticipated to change, it is recommended that the Additional Sense Length be used to parse the data. For more information, see "REQUEST SENSE" on page 187.

Behavior Changes Between Generations

Cartridge Eject for Errors

Ultrium 1 drives auto-eject data cartridges when errors occur during loads. Later generation drives do not.

Queueing Issues

For all generations of drive later than Ultrium 1, when a cartridge is inserted into the drive through means other than SCSI commands to LUN 0, it is assumed that the host will poll the drive with TEST UNIT READY commands to determine its readiness before issuing in-order commands (for example, commands other than INQUIRY, TEST UNIT READY, REQUEST SENSE, or REPORT LUNS). If this is not the case, these commands may time out in ERP (Error Recovery Procedure) situations.

Microcode Detection of Errors

The drive microcode is designed to check for logic errors, to handle hardware-detected errors, and to detect and report microcode-related errors.

Fencing Behavior

For a description of the Fencing Behavior and Persistent Error handling, see "Persistent Errors" on page 246.

Chapter 3. Command Support

In the sections that follow, each SCSI command includes a table that describes the fields in the Command Descriptor Block (CDB). The table is similar to those published by the InterNational Committee for Information Technology Standards (INCITS). It includes bit numbering conventions that conform to ANSI standards. The conventions are as follows:

- Bit 0 is the least significant bit (LSB) and occupies the right bit position in the table
- Bits 1-6 continue from right to left in ascending order
- Bit 7 is the most significant bit (MSB) and occupies the left bit position in the table

The LUN field in the CDB has been obsoleted in SCSI-3 and is ignored for every command.

Notes:

1. For this chapter, a megabyte (MB) is equal to 1 048 576 bytes.
2. Binary numbers are represented by numbers followed by `b`. Hexadecimal numbers are represented by `0-9` and `A-F` followed by `h`. Numbers with no suffix can be assumed to be decimal.

Table 8. Supported Common SCSI Commands

Command Name	Operation Code	SCSI Spec[1]	Page	Applicable Conditions[2]					
				RVC	UAT	NRD	WRP	MFC	DCC
ERASE	19h	SSC	20	y	y	y	y	y	y
INQUIRY	12h	SPC-2	21	-	-	-	-	-	-
LOAD/UNLOAD	1Bh	SSC	45	y	y	-	-	y	y
LOCATE(10)	2Bh	SSC	47	y	y	y	-	y	y
LOCATE(16)	92h	SSC-3	47	y	y	y	-	y	y
LOG SELECT	4Ch	SPC-2	49	y	y	-	-	-	y
LOG SENSE	4Dh	SPC-2	50	-	-	-	-	-	-
MODE SELECT (6)	15h	SPC-2	103	y	y	-	-	-	y
MODE SELECT (10)	55h	SPC-2	103	y	y	-	-	-	y
MODE SENSE (6)	1Ah	SPC-2	104	-	y	-	-	-	-
MODE SENSE (10)	5Ah	SPC-2	104	-	y	-	-	-	-
PERSISTENT RESERVE IN	5Eh	SPC-2	137	y	y	-	-	-	-
PERSISTENT RESERVE OUT	5Fh	SPC-2	142	y[3]	y	-	-	-	-
PREVENT ALLOW MEDIUM REMOVAL	1Eh	SPC-2	146	-	y	-	-	-	-
READ	08h	SSC	147	y	y	y	-	y	y
READ ATTRIBUTE	8Ch	SPC-3	149	y	y	-	-	-	y
READ BLOCK LIMITS	05h	SSC	165	-	y	-	-	-	-
READ BUFFER	3Ch	SPC-2	166	y	-	-	-	-	-
READ POSITION	34h	SSC	173	y	y	-	-	-	-
RECEIVE DIAGNOSTIC RESULTS	1Ch	SPC-2	176	y	y	-	-	-	-
RELEASE UNIT (6)	17h	SPC-2	177	-	y	-	-	-	-

Table 8. Supported Common SCSI Commands (continued)

Command Name	Operation Code	SCSI Spec[1]	Page	Applicable Conditions[2]					
				RVC	UAT	NRD	WRP	MFC	DCC
RELEASE UNIT (10)	57h	SPC-2	177	-	y	-	-	-	-
REPORT DENSITY SUPPORT	44h	SSC	178	-	y	-	-	-	-
REPORT LUNs	A0h	SSC	183	-	-	-	-	-	-
REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS	A3h/0Dh	SPC-4	"REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS (Not LTO1)" on page 185	-	-	-	-	-	-
REQUEST SENSE	03h	SPC-2	187	-	-	-	-	-	-
RESERVE UNIT (6)	16h	SPC-2	192	y	y	-	-	-	-
RESERVE UNIT (10)	56h	SPC-2	192	y	y	-	-	-	-
REWIND	01h	SSC	193	y	y	y	-	y	y
SECURITY PROTOCOL IN (SPIN)	A2h	SPC-4	194	y	y	-	-	-	-
SECURITY PROTOCOL OUT (SPOUT)	B5h	SPC-4	203	y	y	-	-	y	-
SEND DIAGNOSTIC	1Dh	SPC-2	209	y	y	-	-	y	y
SET CAPACITY	0Bh	SSC-2	"SET CAPACITY (not Ultrium 1)" on page 234	y	y	y	y	y	y
SPACE	11h	SSC	236	y	y	y	-	y	y
SPACE (16)	91h	SSC-3	Table 249 on page 236	y	y	y	-	y	y
TEST UNIT READY	00h	SSC	238	y	y	y	-	-	y
VERIFY	13h	SSC	239	y	y	y	-	y	y
WRITE	0Ah	SSC	240	y	y	y	y	y	y
WRITE ATTRIBUTE	8Dh	SPC-3	241	y	y	y	y	-	y
WRITE BUFFER	3Bh	SPC-2	240	y	y	-	-	-	-
WRITE FILE MARKS	10h	SSC	244	y	y	y	y	y	y

Table 8. Supported Common SCSI Commands (continued)

Command Name	Operation Code	SCSI Spec[1]	Page	Applicable Conditions[2]					
				RVC	UAT	NRD	WRP	MFC	DCC

Note 1: SCSI specifications are as follows:

SSC-3 = *SCSI Stream Commands - 3*

SSC-2 = *SCSI Stream Commands - 2*

SSC = *SCSI-3 Stream Commands*

SPC-2 = *SCSI Primary Commands-2*

SPC-3 = *SCSI Primary Commands-3*

SPC-4 = *SCSI Primary Commands-4*

Note 2: Applicable Conditions are as follows:

y = condition can apply to the command

- = condition cannot apply to the command

RVC = reservation conflict

UAT = unit attention

NRD = not ready

WRP = write protect

MFC = medium format corrupted. These commands are also considered Medium Access Commands

DCC = deferred check condition

Note 3: Reported as appropriate for the type of Service Action and Reservation Type requested and the current reservation state of the drive.

Note 4: If the drive sets the CRH bit to one in the parameter data returned by the REPORT CAPABILITIES service action of the PERSISTENT RESERVE IN command, then in the presence of a Persistent Reservation, a RELEASE(6) or RELEASE(10) command will complete with GOOD status, but the persistent reservation will not be released, if the command is received from:

1. An I_T nexus that is a persistent reservation holder; or
2. An I_T nexus that is registered if a registrants only type persistent reservation is present.

In all other cases, the command will be processed as defined in SPC-2.

Note 5: A RESERVE(6) or RESERVE(10) command will complete with GOOD status, but no reservation will be established and the persistent reservation will not be changed, if the command is received from:

1. An I_T nexus that is a persistent reservation holder; or
2. An I_T nexus that is registered if a registrants only type persistent reservation is present.

In all other cases, the command will be processed as defined in SPC-2.

ERASE

Table 9. ERASE Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (19h)							
1	Obsolete			Reserved			Immed	Long
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

EOD is written at the current position, which marks it as end of data.

If the Long field is set to 0, no further writing occurs. If the Long field is set to 1, the Data Set Separator (DSS) pattern is written from EOD to the end of the medium to overwrite any data that is currently on the tape.

If the Immediate (Immed) field is set to 1, then the drive validates the command and waits for any previous command from any server to complete, including any immediate commands that are currently being processed. It also waits for any buffered data to be flushed to tape. It then reports a deferred error for any preceding command or buffered data, if appropriate. If there is no deferred error, the drive reports Good status and initiates the command. If the Immediate (Immed) field is set to 0, status is not returned until after the command has completed.

After the command is successfully completed, the drive is positioned immediately before End Of Data (not End Of Tape).

INQUIRY

The INQUIRY command instructs the drive to return data about itself to the initiator.

Table 10. INQUIRY Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (12h)							
1	Obsolete			Reserved				EVPD
2	Page Code							
3	Reserved							
4	Allocation Length							
5	Control							

If the Enable Vital Product Data (EVPD) field is set to 0 and the Page Code is 0, Standard Inquiry Data is returned.

If the Enable Vital Product Data (EVPD) field is set and the Page Code is 0, the Supported Vital Product Data Pages page is returned. This page lists the EVPD pages that are supported by the drive in this configuration.

If the Enable Vital Product Data (EVPD) field is set, if the Page Code is not 0, and if there is an Inquiry data page that corresponds to that page code, then that page is returned. See Table 13 on page 25 for supported data pages. The contents of page D0h are not specified in this document.

If the preceding conditions do not apply, Check Condition status is returned. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400).

Standard Inquiry Data

Standard Inquiry Data for a valid LUN is described in Table 11.

Table 11. Standard Inquiry Data Valid LUN

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	RMB	Reserved						
2	ISO version (00b)		ECMA version (000b)			Version (3h)		
3	AERC(0)	Obsolete	NACA(0)	HiSup(0)	Response Data Format (2h)			
4	Additional Length							
5	Reserved							
6	BQue(0)	EncSrv(0)	VS(0)	MultiP	MChngr(0)	Obsolete	Adr32(0)	Adr16
7	RelAdr(0)	Obsolete	WBs16	Sync	Linked(0)	TransDis(0)	CmdQ	VS(0)
8 : 15	Vendor Identification IBM							
16 : 31	Product Identification							
32 : 35	Product Revision Level: YMDV							
36	Reserved							AutDis
37	Performance Limit							
38 : 40	Reserved							
41	OEM Specific							
42 : 55	Reserved)							
56	Reserved				Clocking		QAS (0b)	IUS
57	Reserved							

For Valid LUN:

- Peripheral Qualifier is set to 000b.
- Peripheral Device Type is set to 01h.
- RMB is set to 1b to indicate that the medium is removable.

For Invalid LUN:

- Peripheral Qualifier is set to 011b.
- Peripheral Device Type is set to 1Fh.
- RMB is set to 0b to indicate that the medium is *not* removable.

For Ultra 160 SCSI device:

- Adr16 field is set to 1, which indicates that the drive supports 16 SCSI IDs.
- WBs16 field is set to 1, which indicates that the drive supports a 16-bit wide data path on a single cable.
- Sync field is set to 1, which indicates that the drive supports synchronous data transfers.
- CmdQ field is set to 0, which indicates that the drive does not command queueing.
- Clocking field is supported on Ultrium 2 and Ultrium 3 drives only and is set to 11b because the drive supports both ST and DT modes. On Ultrium 1 devices, this field is set to 00b.
- QAS field is set to 0, which indicates that the drive does not support quick arbitration and selection.
- IUS field is set to 1, which indicates that the drive supports information unit transfers.

For Ultra 320 SCSI device:

- Adr16 field is set to 1, which indicates that the drive supports 16 SCSI IDs.
- WBs16 field is set to 1, which indicates that the drive supports a 16-bit wide data path on a single cable.
- Sync field is set to 1, which indicates that the drive supports synchronous data transfers.
- CmdQ field is set to 1, which indicates that the drive supports tagged (simple) command queueing.
- Clocking field is set to 11b, which indicates that the drive supports both ST and DT modes.
- QAS field is set to 0, which indicates that the drive does not support quick arbitration and selection.
- IUS field is set to 1, which indicates that the drive supports information unit transfers. For Fibre Channel and SAS devices:

For Fibre Channel and SAS devices:

- Adr16 field is set to 0.
- WBs16 field is set to 0.
- Sync field is set to 0.
- CmdQ field is set to 1, which indicates that the drive supports tagged (simple) command queueing.
- Clocking field is set to 0.
- QAS field is set to 0, which indicates that the drive does not support quick arbitration and selection.

- IUS field is set to 0, which indicates that the drive does not support information unit transfers.

For all devices:

- The Additional Length field specifies how many bytes follow. Currently Ultrium 1 devices set this value to 33 (21h), and Ultrium 2 and Ultrium 3 devices set this value to 53 (35h). This value is subject to change. It is strongly recommended that the user parse the data returned by using the Additional Length field instead of the published values.
- Vendor Identification returns `IBM` in ASCII with trailing blanks.
- Product Vendor Identification returns `ULTxxxx-TDy` in ASCII with trailing blanks. If the drive is an IBM drive, `xxxx` equals 3580; if it is an OEM drive, `xxxx` equals RIUM. The character `y` indicates the generation of the drive. See the table below for the value returned.

Table 12. Product Identification Table

Generation	IBM Drive	OEM Drive
1	ULT3580-TD1	ULTRIUM-TD1
2	ULT3580-TD2	ULTRIUM-TD2
3	ULT3580-TD3	ULTRIUM-TD3
3 Half-Height	ULT3580-HH3	ULTRIUM-HH3
4	ULT3580-TD4	ULTRIUM-TD4

- Product Revision Level has four parts:
  - `Y` is the last character of the year (for example, 2 indicates the year 2002)
  - `M` is the month, in the alphanumeric set 1 through 9, A, B, or C
  - `D` is the day, in the alphanumeric set 1 through 9, A through V
  - `V` is the version, in the alphanumeric set 0 through 9, A through Z, with 0 being the earliest and Z the latest (to avoid interpretation errors, the characters i, l, and 0 are not used)
- If the Performance Limit field is set to 0, the drive is a full performing drive. If the Performing Limit field is set to a non-zero value, the Limit of the drive is defined by the following equation:

Limit in MB/s = (Max Performance in MB/s) * ((Performance Limit) / 256)

- Automation Disabled (AutDis) field set indicates that the drive is not capable of full automation function. When this field is 0, it indicates that the drive is capable of full automation function.
- The OEM Specific field is intentionally not specified. See the documentation from the OEM vendor to determine the field's definition and application.

Supported Vital Product Data Page

Table 13. Supported Vital Product Data Inquiry Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (00h)							
2	Reserved							
3	Page Length (n-3)							
supported VPD page list								
4	Supported Vital Product Data Page Code (00h)							
5	Firmware Designation Page Code (03h)							
6	Unit Serial Number Page Code (80h)							
7	Device Identification Page Code (83h)							
8	Mode Page Policy Page Code (87h)							
9	SCSI Ports Page Code (88h)							
10	Sequential-Access Device Capabilities Page Code (B0h)							
11	Drive Component Revision Levels Page Code (C0h)							
12	Drive Serial Numbers Page (C1h)							
13	Device Unique Configuration Page (C7h)							
14	Mode Parameter Default Settings Page (C8h)							
15	Vendor-Unique ITD Page (D0h/E0h)							
16	Vendor-UniqueITD Page (D1h/E1h)							

The Supported Vital Product Data Page contains pages that the device will return. Only those drives that have the AS/400 (iSeries) attachment enabled will have valid data in pages D0h/D1h/E0h/E1h. The contents of pages D0h/D1h/E0h/E1h are not specified in this document. OEM drives may add pages not specified in this document.

The Page Length field indicates how many bytes follow.

Firmware Designation Page (03h)

The Firmware Designation Page is used to identify which code image can be downloaded to which drive. See Chapter 10, "Firmware Download," on page 277 for Firmware Download procedures.

Table 14. Firmware Designation Page

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (03h)							
2	Reserved							
3	Page Length (21h)							
4 7	Reserved							
8 11	Load ID (Identifies downloadable firmware with the drive level hardware)							
12 15	Firmware Revision Level (Defined in Standard Inquiry Data, bytes 32-35)							
16 19	PTF Number (00000000h)							
20 23	Patch Number (00000000h)							
24 31	RU Name (8-byte EBCDIC representation of the RU name.)							
32 36	Library Sequence Number							

The Load ID and RU Name and which drive level hardware they designate are defined in .

Mode Page Policy Page (87h)

The Mode Page Policy Page (see Table 15) indicates which mode page policy is in effect for each mode page supported by the logical unit.

Table 15. Mode Page Policy page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (87h)							
2	Page Length (n-3)							
3								
mode page policy descriptor list								
4 : 7	Mode page policy descriptor (first)							
	:							
n-3 : n	Mode page policy descriptor (last)							

Each mode page policy descriptor (see Table 16) contains information describing the mode page policy for one or more mode pages or subpages. The information in the mode page policy descriptors in this page describe the mode page policy for every mode page and subpage supported by the logical unit.

Table 16. Mode Page policy descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Policy Page Code					
1	Policy Subpage Code							
2	MLUS	Reserved					Mode Page Policy	
3	Reserved							

The Policy Page Code field and Policy Subpage Code field indicate the mode page and subpage to which the descriptor applies.

The first mode page policy descriptor in the list contains a Policy Page Code field set to 3Fh and a Policy Subpage Code field set to FFh, indicating that the descriptor applies to all mode pages and subpages not described by other mode page policy descriptors. The Policy Page Code field is set to 3Fh and the policy Subpage Code field is set to FFh only in the first mode page policy descriptor in the list.

If the Policy Page Code field contains a value other than 3Fh or a policy Subpage Code field contains a value other than FFh, then the Policy Page Code field and the Policy Subpage Code field indicate a single mode page and a subpage to which the descriptor applies.

A Multiple Logical Units Share (MLUS) bit set to 1 indicates the mode page and subpage identified by the Policy Page Code field and policy Subpage Code field is shared by more than one logical unit. An MLUS bit set to zero indicates the logical unit maintains its own copy of the mode page and subpage identified by the Policy Page Code field and Policy Subpage Code field. The MLUS values are described in Table 18

The Mode Page policy field (see Table 17) indicates the mode page policy for the mode page and subpage identified by the Policy Page Code field and policy Subpage Code field. The mode page policies are described in Table 17.

Table 17. Mode page policy values

Value	Description
00b	Shared
01b	Per target port
10b	Per initiator port
11b	Per I_T nexus

Table 18. Mode Page Policy for LUN 0 (SSC Device)

Page Name	Page Code	Subpage Code	MLUS	Mode Page Policy
Read-Write Error Recovery Page	01h	00h	0	Shared (00b)
Disconnect/Reconnect Page	02h	00h	1	Per I_T nexus (11b)
Control Extension Mode Page	0Ah	01h	1	Shared (00b)
Data Compression Mode Page	0Fh	00h	0	Shared (00b)
Sequential Access Device Configuration Page	10h	00h	0	Shared (00b)
Fibre Channel Logical Unit Control Page	18h	00h	0	Per I_T nexus (11b)
Fibre Channel Port Control Page	19h	00h	1	Per target port (01b)
Information Exceptions Mode Page	1Ch	00h	0	Shared (00b)

For LUN 0, this would lead to returning a Mode Page Policy Descriptor of page 3Fh and subpage FFh stating MLUS (0) and Mode Page Policy (000b - Shared). This would be followed by descriptors for the Disconnect/Reconnect Page, the Control Extension Mode Page, the Fibre Channel Logical Unit Control Page, and the Fibre Channel Port Control Page.

Table 19. Mode Page Policy LUN 2 (ADC Device)

Page Name	Page Code	Subpage Code	MLUS	Mode Page Policy
Control Extension Mode Page	0Ah	01h	1	Shared (00b)
ADC Device Configuration mode page Node descriptor subpage	0Eh	01h	0	Shared (00b)
ADC Device Configuration mode page DTD Primary Port descriptor subpage	0Eh	02h	0	Shared (00b)
ADC Device Configuration mode page Target Device Serial Number subpage	0Eh	04h	0	Shared (00b)

On LUN 2, this would lead to returning a Mode page Policy Descriptor of page 3Fh and subpage FFh stating MLUS (0) and Mode Page Policy (00b -Shared). This would be followed by descriptors for the Control Extension Mode Page.

SCSI Ports Page (88h)

The SCSI Ports Inquiry page (see Table 20) is supported on Fibre Channel and Serial Attached SCSI drives only. It provides a means to retrieve identification descriptors for all the SCSI ports in the drive.

Table 20. SCSI Ports Inquiry Page

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (88h)							
2	Reserved							
3	Page Length (n-3)							
Identification descriptor list								
4 : n	First SCSI port identification descriptor (see Table 21 on page 31)							
:								
n : m	Last SCSI port identification descriptor (see Table 21 on page 31)							

Each SCSI Port identification descriptor (see Table 21 on page 31) identifies a SCSI port. The SCSI port identification descriptors may be returned in any order. There will be one SCSI Port Identification Descriptor for each port in the drive.

Table 21. SCSI Port Identification Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved (0)							
1								
2	Relative Target Port (see Table 34 on page 42)							
3								
4	Reserved (0)							
5								
6	Initiator Port TranscriptID Length (0)							
7								
8	Reserved (0)							
9								
10	Target Port Descriptors Length (12)							
11								
Target port descriptor list								
12 : 23	Target port descriptor (see Table 22)							

Table 22. Target Port Descriptor Format

Byte	Bit 7	6	5	4	3	2	1	0
12	Protocol Identifier				Code Set (1)			
13	PIV (1)	Rsvd	Association Type (01b)		Identifier Type (3)			
14	Reserved							
15	Identifier Length (8)							
16 : 23	World Wide Port Name (WWPN)							

The Protocol Identifier value is 0h on Fibre Channel devices and 6h on SAS devices.

Sequential-Access Device Capabilities Page (B0h)

Table 23. Sequential-Access Device Capabilities Page

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (B0h)							
2	Page Length (2)							
3								
4	Reserved							WORM
5	Reserved							

The Write Once Read Many (WORM) bit is set to 1 on Ultrium 3 drives indicating the drive supports WORM mode operation. The WORM bit is set to 0 on Ultrium 2 drives indicating the drive does not support WORM mode operation.

Drive Serial Numbers

Table 24. Inquiry Page C1h: Drive Serial Numbers

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (C1h)							
2	Reserved							
3	Page Length (18h)							
4	Manufacturing Serial Number, right-justified with leading zeroes, in ASCII Serial Number of device set during manufacturing							
:								
15								
16	Reported Serial Number, right-justified with leading zeroes, in ASCII Serial Number of device reported over the primary interface (for example Inquiry pages 80h and 83h).							
:								
27								

Device Unique Configuration Data Page (C7h)

The Device Unique Configuration Data Page is supported on IBM eServer™ capable drives only. On drives that are not eServer capable this page will be returned with all zero data.

Table 25. Device Unique Configuration Data Page (C7h)

Byte	Bit 7	6	5	4	3	2	1	0
00	Peripheral Qualifier (0h)			Peripheral Device Type (1h)				
01	Page Code (C7h)							
02	Reserved							
03	Page Length (71h)							
04	ASCII Length (04h)							
05 - 08	SCDD Signature (“SCDD”)							
09	Max Supported LUNs (00h)							
10 - 13	(MSB) Native Capacity in MB (00061A80h) (LSB)							
14	Rsvd	SFM (0)	SAVPG (0)	AUTSNS 0 - PSCSI 1 - SAS	ACA (0)	FLQUE (0)	CRDFRU (0)	MICDWN (1)
15	Reserved							
16 - 18	(MSB) Max Microcode Download Transfer Length (49999Ah) (LSB)							
19 - 20	(MSB) Max Queue Depth 00 01h - pSCSI 00 1Eh - SAS (LSB)							
21 - 23	(MSB) SCSI Reset Delay Time (0000FAh)							
24 - 26	(MSB) Max Block Transfer Size per SCSI Command (FFFFFFh) (LSB)							
27	Drive Technology (06h) (Half-Inch Cartridge)							
28	Device Interface Field 07h - pSCSI 08h - SAS							
29 - 40	(MSB) Test Media P/N (12 ASCII characters) ("23R7042øøøøø") (LSB)							
41	Cleaning Code Page (3Ch)							
42	Trace Buffer ID (01h)							
43	No. of Densities Supporting Write/Read (02h)							
44	Write/Read Density 1 (42h)							
45	Write/Read Density 2 (44h)							
46	No. of Supported Densities (Read Only) (01h)							
47	Read Only Density 1 (40h)							
48	Read Only Density 2 (00h)							

Table 25. Device Unique Configuration Data Page (C7h) (continued)

Byte	Bit 7	6	5	4	3	2	1	0
49	Read Only Density 3 (00h)							
50	Read Only Density 4 (00h)							
51	Read Only Density 5 (00h)							
52	Read Only Density 6 (00h)							
53	Read Only Density 7 (00h)							
54	RSVD	SFM (0)	MEMDMP (1)	STSTPG (1)	DIAGSR (0)	RETEN (0)	RDCMP (0)	WRCMP (1)
55	Reserved							
56	(MSB)	Erase Command Timeout - Seconds (3BC4h)						
57								(LSB)
58	(MSB)	Load/Unload Timeout - Seconds (0348h)						
59								(LSB)
60	(MSB)	Locate Command Timeout - Seconds (3DE0h)						
61								(LSB)
62	(MSB)	Rewind Command Timeout - Seconds (030Ch)						
63								(LSB)
64	(MSB)	Space Command Timeout - Seconds (3DE0h)						
65								(LSB)
66	(MSB)	Write Filemarks Command Timeout - Seconds (0564h)						
67								(LSB)
68	(MSB)	Read/Write Command Timeout - Seconds (05A0h)						
69								(LSB)
70	(MSB)	Write Buffer Timeout - Seconds (0294h)						
71								(LSB)
72	(MSB)	Read Buffer Timeout - Seconds (0258h)						
73								(LSB)
74	(MSB)	Receive Diagnostic Results Command Timeout - Seconds (003Ch)						
75								(LSB)
76	(MSB)	Send Diagnostics Command Timeout - Seconds (0960h)						
77								(LSB)
78	(MSB)	Reserved						
81								(LSB)
82	(MSB)	Reserved						
87								(LSB)
88	1st Operating System Parameter Count (05h)							
89	(MSB)	1st Operating System Identifier in ASCII characters ("AIX")						
91								(LSB)
92	(MSB)	Reserved for other Operating System Identifiers (20202020h)						
95								(LSB)

Table 25. Device Unique Configuration Data Page (C7h) (continued)

Byte	Bit 7	6	5	4	3	2	1	0
96	(MSB)	Failing Function Code (Right-justified with leading blanks) “ø2617”						
100								(LSB)
101	Reserved							
102	Reserved							
103	Reserved							
116								

Mode Parameter Default Settings Page (C8h)

This page is used on drives that are eServer capable. On drives that are not eServer capable this page will be returned with all zero data. The Mode Parameter Default Settings Page is used by sending the Mode Page data starting at byte 14 as the parameter data of a Mode Select command to the drive to set the default values required by AIX to use the drive as an internal device.

Table 26. Mode Parameter Default Settings page (C8h)

Byte	Bit 7	6	5	4	3	2	1	0
00	Peripheral Qualifier (0h)			Peripheral Device Type (1h)				
01	Page Code (C8h)							
02	Reserved							
03	Page Length (1Eh)							
04	Reserved							
05–07	1st Operating System Identifier in ASCII characters (“AIX”)							
08–10	2nd Operating System Identifier in ASCII characters (0x202020)							
11–13	3rd Operating System Identifier in ASCII characters (0x202020)							
14–17	Mode Select (6) Mode Parameter Header (00h 00h 10h 08h)							
18–25	Mode Select (6) Mode Block Descriptor (44h 00h 00h 00h 00h 00h 00h 00h)							
Mode Parameter for Data Compression Mode Page (0Fh)								
26	PS(0)	Rsvd	Reserved (00h)					
27	Additional Page Length (0Eh)							
28	DCE	DCC(1b)	Page Code (0Fh)					
29	DDE(1b)	RED(00b)		Reserved (00h)				
30–33	Compression Algorithm (00000001h)							
34–37	Decompression Algorithm (00000001h)							
38–41	Reserved (00000000h)							
Mode Parameter for Mode Page 2Fh								
42	PS(0)	Rsvd	Page Code (2Fh)					
43	Page Length (06h)							
44	Fence Behavior (Mid-Tape Recovery (MTR) Fence Only - 00h)							
45	Clean Behavior (Periodic Clean Notification Enabled - 01h)							
46	″Emulate WORM″ (Normal Operation - 00h)							
47	Sense Data Behavior (Use 96-byte Request Sense data - 01h)							

Table 26. Mode Parameter Default Settings page (C8h) (continued)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
48	Reporting Behavior							
	Rsvd	Rsvd	Rsvd	Rsvd	Rsvd	CCWM(1)	DDEOR(1)	CLNCHK(1)
49	Firmware Update Behavior							
	Rsvd	Rsvd	Rsvd	Rsvd	Rsvd	Rsvd	Rsvd	DFMRDL(1)
50	Unload On Error Behavior							
	Reserved (00b)		UOE-C (00b)		UOE-F (00b)		UOE-D (00b)	

Unit Serial Number Page

Table 27. Unit Serial Number Inquiry Page

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (80h)							
2	Reserved							
3	Page Length (0Ah)							
4 : 13	Unit Serial Number							

The Unit Serial Number Page contains a single value that is a 10-byte ASCII string. The string, with the Vendor Identification and Product Identification fields in the Standard Inquiry Data, uniquely identifies the drive. Valid Serial Number values are 0 through 9, A through D, and F. On eServer enabled drives this is the last 10 characters of the 11S identifier

Device Identification Page

Table 28. Device Identification Inquiry Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (83h)							
2	Reserved							
3	Page Length SCSI drives: (n-3) Fibre Channel drives: (m-3) SAS drives (q-3)							
4 : n	Device Identification Descriptor							
n+1 : m	Protocol Identification descriptor							

Parallel SCSI devices return only the Device Identification Descriptor (see Table 29). Fibre Channel and SAS devices return the Device Identification Descriptor (see Table 29) followed by the Protocol Identification Descriptor (see Table 31 on page 41). SAS devices also return the Target Device Name Descriptor (Table 36 on page 43).

Table 29. Device Identification Descriptor Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
4	Reserved				Code Set (2h)			
5	Reserved				Identifier Type			
6	Reserved							
7	Identifier Length (n-7)							
8 : n	Identifier							

Table 30 on page 41 describes the Identifier format.

Table 30. Identifier Format

Byte	Bit 7	6	5	4	3	2	1	0
8 : 15	Vendor Identification							
16 : 31	Product Identification							
32 : 41	Serial Number							

The Code Set field is 2, indicating the Identification Descriptor contains only ASCII data.

This device supports an Identifier Type of 1. In this case, the Device Identification Descriptor is the Vendor Identification followed by the Product Identification field from the Standard Inquiry Data and the Serial Number field from the Unit Serial Number Inquiry Page (see "Unit Serial Number Page" on page 39).

The Parallel SCSI drive reports only the single Identification Descriptor of Identifier Type 1.

The Protocol Identification descriptor is returned only on Fibre Channel and SAS attached devices. The format is given in Table 31.

Table 31. Protocol Identification descriptor

Byte	Bit 7	6	5	4	3	2	1	0
42 : 53	Logical Unit Descriptor							
54 : 61	Port Identifier Descriptor							
62 : 73	Port Name (NAA) Descriptor							

Table 32. Logical Unit (NAA) Descriptor Format

Byte	Bit 7	6	5	4	3	2	1	0
42	Protocol Identifier				Code Set (1h)			
43	PIV (1)	Rsvd	Association Type (00b)		Identifier Type (3h)			
44	Reserved							
45	Identifier Length (8)							
46 : 53	World Wide Node Name (WWNN)							

The Protocol Identifier value is 0h on Fibre Channel devices and 6h on SAS devices.

Table 33. Port Identifier Descriptor Format

Byte	Bit 7	6	5	4	3	2	1	0
54	Protocol Identifier				Code Set (1h)			
55	PIV (1)	Rsvd	Association Type (01b)		Identifier Type (4)			
56	Reserved							
57	Identifier Length (4)							
58 : 59	Obsolete (0)							
60 : 61	Relative Target Port							

% The Protocol Identifier value is 0h on Fibre Channel devices and 6h on SAS
% devices.

Relative Target Port is the Relative Target Port through which the command was received. Relative Target Port values are defined in Table 34. The port identifier descriptor is only returned on Ultrium 3 drives.

Table 34. Relative Target Port Values

Value	Description
0000h	Reserved
0001h	Relative port 1, historically known as port A or FC port 0
0002h	Relative port 2, historically known as port B or FC port 1
0003h	Relative port 3, RS422 port
0004h - FFFFh	Relative port 4 through 65 535

Table 35. Port Name (NAA) Descriptor Format

Byte	Bit 7	6	5	4	3	2	1	0
62	Protocol Identifier				Code Set (1)			
63	PIV (1)	Rsvd	Association Type (01b)		Identifier Type (3)			
64	Reserved							
65	Identifier Length (8)							
66 : 73	World Wide Port Name (WWPN)							

The Protocol Identifier value is 0h on Fibre Channel devices and 6h on SAS devices.

World Wide Port Name (WWPN) is the WWPN through which the command was received. The port name descriptor is only returned on Ultrium 3 drives.

Table 36. Target Device Name Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
74	Protocol Identifier (6h)				Code Set(1h)			
75	PIV(1)	Rsvd	Association Type (10b)		Identifier Type (3h)			
76	Reserved							
77	Identifier Length (8)							
78 : 85	SAS address of drive in NAA IEEE Registered format (This is the World Wide Node Name (WWNN) of LUN 0)							

Drive Component Revision Levels Pages

Table 37. Drive Component Revision Levels Pages

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (C0h)							
2	Reserved							
3	Page Length (27h)							
4 : 15	Code Name (GTYYMMDDsCCC)							
16 : 22	Reserved (00000000000000h)							
23 : 30	Date (YYYYMMDD)							
31 : 42	Reserved (000000000000000000000000h)							

The Date field contains the date the code was built, with the year defined first.

LOAD/UNLOAD

Table 38. LOAD/UNLOAD Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Bh)							
1	Obsolete			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved				Hold	EOT(0)	Reten (0)	Load
5	Control							

If the Load field is set to 1and there is a tape in the drive, it is positioned to BOM. If the Load field is set to 1 and there is no tape in the drive, Check Condition status is returned. The Sense Key is set to Not Ready (2) and the ASC/ASCQ is set to Parameter Medium Not Present (3A00).

If the Load field is set to 0, there is a tape in the drive, and medium removal prevention has not been set, then the tape is unloaded and ejected. If the Load field is set to 0, there is a tape in the drive, and medium removal prevention has been set, then Check Condition status is returned. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Medium Removal Prevented (5302).

If the Load field is set to 0 and the tape is in the ejected position, the command is presented with Check Condition status and associated sense data of 2/0402 (Not Ready, Initialization Required). If the Load field is set to 0 and there is no cartridge present, the command is presented with Check Condition status and associated data of 2/3A00 (Not Ready, Medium Not Present).

If the Immediate (Immed) field is set to 1, then the drive validates the command and waits for any previous command from any server to complete, including any immediate commands that are currently being processed. It also waits for any buffered data to be flushed to tape. It then reports a deferred error for any preceding command or buffered data, if appropriate. If there is no deferred error, the drive reports Good status and initiates the command. If the Immediate (Immed) field is set to 0, status is not returned until after the command has completed.

The Retension (Reten) field is not supported and will be ignored.

The End Of Tape (EOT) field is not supported and should be set to 0. If the EOT field is set to 1, then Check Condition status is returned. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400).

Table Table 39 on page 46 describes the behaviors for the command.

Table 39. LOAD/UNLOAD actions depending on Load and Hold bit settings and medium position

Medium Position on command receipt	Load	Hold	Statue	Behavior and Medium Position at command completion
No tape present	0	x	Check Condition Status is returned with Not Ready, Medium Not Present (2/3A00)	No action is taken No tape present
No tape present	1	x	Check Condition Status is returned with Not Ready, Medium Not Present (2/3A00)	No action is taken No tape present
Ejected Position	0	x	Check Condition Status is returned with Not Ready, Initializing Command Required (2/0402)	No action is taken Ejected Position
Ejected Position	1	0	Good Status returned	Seated and tape is threaded and ready for access at LBA 0
Ejected Position	1	1	Good Status returned	Seated with Cartridge Memory (CM) accessible but tape is not threaded
Seated but tape not threaded	0	0	Good Status returned	Ejected Position
Seated but tape not threaded	0	1	Good Status returned	No action taken Position it was at prior to command
Seated but tape not threaded	1	0	Good Status returned	Seated and tape is threaded and ready for access at LBA 0
Seated but tape not threaded	1	1	Good Status returned	No action taken Position it was at prior to command
Seated with tape threaded	0	0	Good Status returned	Ejected Position
Seated with tape threaded	0	1	Good Status returned	Seated with Cartridge Memory (CM) accessible but tape is not threaded
Seated with tape threaded	1	0	Good Status returned	Seated and tape is rewound and ready for access at LBA 0 (i.e. this is equal to issuing a rewind command)
Seated with tape threaded	1	1	Check Condition Status is returned with Illegal Request, Invalid Field in CDB (5/2400)	No action is taken Position it was at prior to command

The Retension (Reten) bit is not supported and will be ignored.

LOCATE

The LOCATE command causes the logical position on tape to be set to the value indicated by the Block Address field. The value indicates the total number of records and marks between BOM and the desired logical position. A value of 0 causes the tape to be positioned at BOM.

Table 40. LOCATE (10) command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (2Bh)							
1	Obsolete			Reserved		BT(0)	CP(0)	Immed
2	Reserved							
3 : 6	Block Address							
7	Reserved							
8	Partition (0)							
9	Control							

Table 41. LOCATE(16) Command (Ultrium 4 and Later)

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (92Bh)							
1	Reserved			Dest_Type		Rsvd	CP (0)	IMMED
2	Reserved							BAM (0)
3	Partition (00h)							
4	(MSB)	Block Address						
11								(LSB)
12	Reserved							
14								
15	Control							

If the Immediate (Immed) field is set to 1, then the drive validates the command and waits for any previous command from any server to complete, including any immediate commands that are currently being processed. It also waits for any buffered data to be flushed to tape. It then reports a deferred error for any preceding command or buffered data, if appropriate. If there is no deferred error, the drive reports Good status and initiates the command. If the Immediate (Immed) field is set to 0, status is not returned until after the command has completed.

If the LOCATE command fails for anything other than Illegal Request, the logical position is not guaranteed and a READ POSITION command should be issued to determine the current logical position of the tape.

The Block Type (BT) and Change Partition (CP) fields are not supported and should be set to 0. The Partition field is not supported and will be set to 0. If the Partition field is set to anything other than 0, then Check Condition status is returned. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400).

The Dest_Type field is used in conjunction with the Block Address field to locate to the appropriate position of the medium. The Dest_Type field specifies whether the location specified is a block address or logical file identifier. The Dest_Type field is defined in Table 42.

Table 42. Dest_Type field definitions

Code	Description	Logical Position upon successful completion
00b	Block Address	BOP side
01b	Logical file identified	BOP side of the logical file
10b	Obsolete	
11b	Reserved	

LOG SELECT

The LOG SELECT command causes log data on the drive to be reset to its default value or to be set to an initiator-specific value.

Table 43. LOG SELECT Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (4Ch)							
1	Obsolete			Reserved			PCR	SP(0)
2	PC		Reserved					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length							
9	Control							

If the Parameter Code Reset (PCR) field is set to 1, the Parameter List Length is 0. The action taken by the drive is specified for the values of the Page Control (PC) field as follows:

- 00b means that no action is taken and Good status is returned.
- 01b means that all resettable logs on the drive are reset to default values.
- 10b means that no action is taken and Good status is returned.
- 11b means that all resettable logs on the drive are reset to default values.

If the Parameter Code Reset (PCR) field is set to 0, the Parameter List Length is not 0. The action taken by the drive is specified for the values of the Page Control (PC) field as follows:

- 00b means that Check Condition status is returned. The Sense Key is set to Illegal Request and the ASC/ASCQ is set to Invalid Field in CDB (2400).
- 01b means that data from the server is written to the indicated logs, provided that the logs are writable.
- 10b means that Check Condition status is returned. The Sense Key is set to Illegal Request and the ASC/ASCQ is set to Invalid Field in CDB (2400).
- 11b means that data from the server is written to the indicated logs, provided that the logs are writable.

The Save Page (SP) field is not supported and must be set to 0.

LOG SENSE

The LOG SENSE command causes log data to be sent to the initiator.

Table 44. LOG SENSE Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (4Dh)							
1	Obsolete			Reserved			PPC(0)	SP(0)
2	PC		Page Code					
3	Reserved							
4	Reserved							
5 : 6	Parameter Pointer (0)							
7 : 8	Allocation Length							
9	Control							

The log values returned are controlled by the Page Control (PC) field value as follows:

- 00b means that the maximum value for each log entry is returned.

  Note: For page 2Eh (TapeAlert) only, the PC field is ignored. Current® values are always returned.
- 01b means that the current values are returned.
- 10b means that the maximum value for each log entry is returned.
- 11b means that the power-on values are returned.

The Parameter Pointer Control (PPC) must be set to 0. Returning changed parameters is not supported. The Save Page (SP) field must be set to 0. Saved pages are not supported. The Parameter Pointer will be 0.

Cartridge-specific log parameter counts are set to 0 when a cartridge has successfully loaded.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Log Page Format

All log pages (except page 0) consist of a log page header, followed by a number of log parameters. The log page header has the format indicated in Table 45.

Table 45. Log Page Header Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page Code					
1	Reserved							
2 : 3	Page Length							

The Page Code is a byte value that uniquely identifies what log page is being returned. The Page Length describes how many bytes are to follow for the entire log page.

Each log parameter has the format indicated in Table 46.

Table 46. Log Parameter Format

Byte	Bit 7	6	5	4	3	2	1	0
0 : 1	Parameter Code							
2	DU	DS (1)	TSD (0)	ETC (0)	TMC (0)		LBIN	LP
3	Parameter Length (n-3)							
4 : n	Parameter Bytes							

The Parameter Code is a 2-byte value that uniquely identifies the parameter within the log.

The Disable Update (DU) field is set for any parameter that the server can neither write nor reset.

The List Parameter (LP) field is 0 for parameters that are counters and 1 for parameters that are not counters.

If the LP field is 1 and the parameter is a binary parameter, then the List Binary (LBIN) field is set to 1. Otherwise it is set to 0.

The TSD, ETC and TMC fields are always 0 and the DS field is always 1.

The Parameter Length field gives the length of the Parameter Bytes field in bytes. The Parameter Bytes field contains the actual parameter data.

Log Page 00h: Supported Log Pages

The Supported Log Pages Log Page code is 00h. The parameter list contains a series of 1-byte entries for the log pages that are supported. At least those logs described in this document are listed. Any additional logs that are supported may or may not be listed.

> **WARNING**
> Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 47. Supported Log Pages Log Page Definition

Product(s)	Pointer
Ultrium 1 and Ultrium 2 non-RoHS	See Table 48
Ultrium 2 RoHS and Ultrium 3	See Table 49
Ultrium 4	See Table 50 on page 53

Table 48. Supported Log Pages Log Page Format (Ultrium 1 and Ultrium 2 non-RoHS)

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2	(MSB)	Page Length (n-3)						
3								(LSB)
4	(00h) Supported Log Pages							
5	(02h) Write Error Counters							
6	(03h) Read Error Counters							
7	(0Ch) Sequential Access Device Log Page							
8	(18h) Log Page							
9	(2Eh) TapeAlert							
10	(30h) Tape Usage Log							
11	(31h) Tape Capacity							
12	(32h) Data Compression							

Table 49. Supported Log Pages Log Page Format (Ultrium 2 RoHS and Ultrium 3)

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2	(MSB)	Page Length (n-3)						
3								(LSB)
4	(00h) Supported Log Pages							
5	(02h) Write Error Counters							

Table 49. Supported Log Pages Log Page Format (Ultrium 2 RoHS and Ultrium 3) (continued)

Byte	Bit 7	6	5	4	3	2	1	0
6	(03h) Read Error Counters							
7	(06h) Non-Medium Errors							
8	(0Ch) Sequential Access Device Log Page							
9	(18h) Log Page							
10	(2Eh) TapeAlert							
11	(30h) Tape Usage Log							
12	(31h) Tape Capacity							
13	(32h) Data Compression							
14	(33h) Write Errors							
15	(34h) Read Forward Errors							
16	(38h) Blocks/Bytes Transferred							
17	(39h) Host Port 0 Interface Errors							
18	(3Bh) Host Port 1 Interface Errors							
19	(3Ch) Vendor-Specific							
20	(3Dh) Subsystem Errors							

Table 50. Supported Log Pages Log Page Format (Ultrium 4)

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2	(MSB)	Page Length (n-3)						
3								(LSB)
4	(00h) Supported Log Pages							
5	(02h) Write Error Counters							
6	(03h) Read Error Counters							
7	(06h) Non-Medium Errors							
8	(0Ch) Sequential Access Device Log Page							
9	(18h) Log Page							
10	(2Eh) TapeAlert							
11	(30h) Tape Usage Log							
12	(31h) Tape Capacity							
13	(32h) Data Compression							
14	(33h) Write Errors							
15	(34h) Read Forward Errors							
16	(37h) Performance Characteristics							
17	(38h) Blocks/Bytes Transferred							
18	(39h) Host Port 0 Interface Errors							
19	(3Bh) Host Port 1 Interface Errors							

Table 50. Supported Log Pages Log Page Format (Ultrium 4) (continued)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
20	(3Ch) Vendor-Specific							
21	(3Dh) Subsystem Errors							

This data can be neither reset nor written.

Log Page 02h: Write Error Counters

The Write Error Counters log is page 02h. Parameters 0 through 2 are not supported and are returned as 0. All parameter lengths are 4 bytes long, except parameter 8000 which is 8 bytes long.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 51. Write Error Log Parameters

Parameter Code (in Hex)	Counter: Description	Size
0000h	Not supported	4
0001h	Not supported	4
0002h	Not supported	4
0003h	Total Corrected Write Errors: These errors are corrected by ECC and do not require error recovery procedures (ERPs). Each count represents one block in error that was corrected and written.	4
0004h	Total Write Retries:	4
0005h	Total Write Kilobytes Processed: Each count represents a kilobyte (1024 bytes) of data processed across the host interface during write-type commands. The count does not include ERP retries.	4
0006h	Total Uncorrected Write Errors: The total number of write errors that could not be corrected by ECC, no servo error was reported, and the error was not a transient error. Each count represents one block in error that was not corrected, but was recovered by ERPs and successfully written.	4
8000h	Unspecified	8
8001h	Unspecified	4

This data can be reset to 0, but cannot be written.

Log Page 03h: Read Error Counters

The Read Error Counters log is page 03h. Parameters 0 through 2 are not supported and are returned as 0. All parameter lengths are 4 bytes long, except parameter 8000 which is 8 bytes long.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

The supported fields are listed in Table 52.

Table 52. Read Error Log Parameters

Parameter Code (in Hex)	Counter: Description	Size
0000h	Not supported	4
0001h	Not supported	4
0002h	Not supported	4
0003h	Total Corrective Read Errors: These are errors that are corrected by ECC and do not require error recovery procedures (ERPs). Each count represents one block in error that was corrected and read.	4
0004h	Total Read Retries:	4
0005h	Total Read Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed across the host interface during read-type commands. The count does not include ERP retries.	4
0006h	Total Uncorrected Read Errors: The total number of read errors that could not be corrected by ECC, no servo error was reported, and the error was not a transient error. Each count represents one block in error that was not corrected, but was recovered by ERPs and successfully read.	4
8000h	Unspecified	8

This data can be reset to 0, but not written.

Log Page 06h: Non-Medium Errors (Not Ultrium 1 or Ultrium 2 non-RoHS)

This page sums the occurrences of error events other than write or read failures. parameter codes do not discriminate among the various types of events.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 53. Non-Medium Errors log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0000h	Total Non-Medium Error Count:	4

Log Page 0Ch: Sequential Access Device Log

The Sequential Access Device Log Page is 0Ch.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 54. Sequential Access Device Log Parameters

Parameter Code (in Hex)	Counter: Description	Length
0000h	Number of data bytes received from an initiator(s) during WRITE command operations.	8
0001h	Number of data bytes written to the media as a result of WRITE command operations, not counting ECC and formatting overhead. This is also the number of data bytes after compression.	8
0002h	Number of data bytes read from the media during READ command operations, not counting ECC and formatting overhead. This is also the number of compressed data bytes read from media before decompression.	8
0003h	Number of data bytes transferred to the initiator(s) during READ command operations.	8
0100h	Cleaning Required	8
8000h	Megabytes processed to tape since last cleaning (written after compression/read before decompression)	4
8001h	Lifetime load cycles of the drive	4
8002h	Lifetime cleaning cycles of the drive	4
8003h	Lifetime Power-on time (in seconds)	4

A non-zero value of the Cleaning Required parameter indicates that a condition requiring cleaning has been detected and a subsequent cleaning cycle has not been completed. The Cleaning Required parameter is persistent across hard resets and power cycles.

Log Page 2Eh: Tape Alert

The TapeAlert log page is page 2Eh. There are 64 parameters, numbered from 1 through 64 (01h through 40h). Table 55 shows the parameters that are supported for all generations of the Ultrium Tape Drive. The supported parameters are 0 in the absence of the condition that generates the flag and are set to a non-zero value when the condition occurs. All unsupported parameters are always set to 0.

All parameters are 1 byte long. Each parameter is either 0 to indicate that the corresponding condition has not occurred or non-zero to indicate that the corresponding condition has occurred. All log parameters are set to 0 when the log is read. The Log parameters are also set to 0 at power-on, on a reset condition, or by a LOG SELECT command. Specific flags may be set to 0 when corrective action has removed the condition that caused the flag to be set. For all parameters, the DU field is 1, the LP field is 0, and the LBIN field is 0.

The PC field for this page is ignored. Current values are always returned.

For a description of service actions associated with the supported parameters, refer to the *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F Setup, Operator, and Service Guide*, the *IBM Ultrium Internal Tape Drive Models T200 and T200F Setup, Operator, and Service Guide*, or the *IBM 3580 Ultrium Tape Drive Setup, Operator, and Service Guide*.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 55. TapeAlert Log Parameters

Parameter Code		Description	Set	Clear[1]	Type
In Hex	In Decimal				
01h - 02h	1 - 2	N/A			
03h	3	The operation has stopped because an error has occurred while reading or writing data which the drive cannot correct.		R	Warning
04h	4	Media can no longer be written or read, or performance is severely degraded.		R	Critical
05h	5	The tape is damaged or the drive is faulty.		R	Critical
06h	6	The drive can no longer write data to the tape.		R	Critical
07h	7	Media Life	E	L	Warning
08h	8	The cartridge is not data-grade.		R	Warning
09h	9	The WRITE command was attempted to a write-protected tape.		R	Critical
0Ah	10	A manual or software unload was attempted when Prevent Media Removal was on.		R	Informational
0Bh	11	The tape in the drive is a cleaning cartridge.		R	Informational
0Ch	12	You attempted to load a cartridge with an unsupported tape format (for example, Ultrium 2 cartridge in Ultrium 1 drive).		R	Informational
0Dh - 0Eh	13 - 14	N/A			
0Fh	15	The memory chip failed in the cartridge.		R	Critical

Table 55. TapeAlert Log Parameters (continued)

10h	16	The operation has failed because the tape cartridge was manually ejected while the tape drive was actively writing or reading.		L	Warning
11h	17	Media loaded is Read-Only format.	E	R	Informational
12h	18	The tape directory on the tape cartridge has been corrupted. File search performance will be degraded. The tape directory can be rebuilt by reading all the data on the cartridge.		R	Warning
13h	19	Nearing media life		R	Informational
14h	20	Clean now		C	Critical
15h	21	Clean periodic		C	Warning
16h	22	Expired cleaning media	C	L	Critical
17h	23	Invalid cleaning tape	C	R	Critical
18h - 1Dh	24 - 29	N/A			
1Eh	30	The drive has a hardware fault that requires a reset to recover.			Critical
1Fh	31	The drive has a hardware fault that is not related to the read/write operation, or the drive requires a power cycle to recover.			Critical
20h	32	The drive has identified an interface fault.			Warning
21h	33	Eject media		U, R	Critical
22h	34	Firmware download failed			Warning
23h	35	N/A			
24h	36	The drive’s temperature limits are exceeded.	S		Warning
25h	37	The drive’s voltage limits are exceeded.	S		Warning
26h	38	Predictive failure of drive hardware			Critical
27h	39	Diagnostics required			Warning
28h - 32h	40 - 50	N/A			
33h	51	Tape directory invalid at unload	E	L	Warning
34h	52	Tape system area write failure	E	R	Critical
35h	53	Tape system area read failure	E	R	Critical
36h	54	N/A			
37h	55	Loading failure	E	R	Critical
38h	56	Unrecoverable unload failure	E	U	Critical
39h-3Ah	57-58	N/A			
3Bh	59	(WORM Medium - integrity check failed) set when the drive determines that the data on tape is suspect from a WORM point of view.		L	Critical
3Ch	60	(WORM Medium - Overwrite Attempted) set when the drive rejects a Write operation because the rules for allowing WORM writes have not been met.)	E		Critical
3Dh-40h	61 - 64	N/A			

Table 55. TapeAlert Log Parameters (continued)

Legend: TapeAlert Set/Cleared when: N/A Not set/supported L Load - medium is loaded C Clean - cleaner tape is loaded U Unload - medium is ejected E Error - error code is posted R Removal - medium is FULLY removed S Sensor - sensor check **Note:** [1]All TapeAlerts are cleared on POR/Reset.

Log Page 11h: DT Device Status Log Page

The DT Device Status log page (see Table 56) defines log information pertaining to the DT device (i.e. tape drive) and DT device primary ports.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 56. DT Device Status Log Page

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page Code (11h)					
1	Reserved							
2	(MSB)	Page Length (n-3)						
3								(LSB)
4	DT Device Status Log Parameters							
n								

Table 57 defines the DT Device Status log page parameter codes.

Table 57. DT Device Status log page parameter codes

Parameter Code (in Hex)	Description	Reference
0000h	Very high frequency data	See Table 58.
0001h	Very high frequency polling delay	See Table 58.
0002h - 00FFh	Reserved	See Table 58.
0100h-0200h	DT device primary port status	Table 62 on page 66

Very high frequency data log parameter

The very high frequency data log parameter format is shown in Table 58.

Table 58. Very high frequency data log parameter format

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB)	PARAMETER CODE (0000h)						
1								(LSB)
2	DU (0)	DS (1)	TSD (0)	ETC (0)	TMC (0)		LBIN (1)	LP (1)
3	PARAMETER LENGTH (04h)							
4	VHF DATA DESCRIPTOR							
7								

The PARAMETER CODE field is set to 0000h to indicate the very high frequency data log parameter.

The PARAMETER LENGTH field is set to 04h to allow transfer of the complete parameter.

The VHF DATA DESCRIPTOR field is defined in Table 59. Returned data shall reflect the last known values since the DT device initialized.

Table 59. VHF DATA DESCRIPTOR field

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
4	PAMR	HIU	MACC	CMPR	WRTP	CQRST	CRQRD	DINIT
5	INXTN	Rsvd	RAA®	MPRSNT	Rsvd	MSTD	MTHRD MOUNTED	MTHRD MOUNTED
6	DT DEVICE ACTIVITY							
7	VS	Reserved				RRQST	INTFC	TAFC

Note: In addition to reliance on indication of initialization completion, reliance on returned values should also take into consideration conditions indicated by changes in Tape Alert flag status, and process those first as needed.

A DT device initialized (DINIT) bit set to one indicates that the DT device is able to return valid very high frequency data. A DINIT bit set to zero indicates DT device initialization is required or incomplete. The DINIT bit should be set to one before relying on any other bits in the very high frequency data log parameter.

A cleaning required (CRQRD) bit set to one indicates that a head cleaning operation is required before a data medium is able to reach load state (i) (see ADC-2), and that normal operation may not be possible if the head cleaning operation is not performed. A CRQRD bit set to zero indicates that urgent cleaning is not required. The CRQRD bit shall take priority over the CRQST bit. It shall not be considered an error for the CRQRD bit and the CRQST bit to both be set to one.

A cleaning requested (CRQST) bit set to one indicates that the DT device has requested a head cleaning. A CRQST bit set to zero indicates that no cleaning is requested.

A write protect (WRTP) bit set to one indicates that any currently present medium is physically write protected. A WRTP bit set to zero indicates that any currently present medium is not physically write protected. The WRTP bit is only valid if the MPRSNT bit is set to one. The WRTP bit should be set to zero if the MPRSNT bit is set to zero.

Note: Physically write protected refers to any mechanism used within the medium shell itself to write protect the medium (for example, sliding windows or tabs) and not logical states of write protection caused by commands to the DT device.

A compress (CMPR) bit set to one indicates that the DT device currently has data compression enabled. A CMPR bit set to zero indicates that compression is not enabled.

A medium auxiliary memory accessible (MACC) bit set to one indicates that the medium is located at a position where the Medium Auxiliary Memory (MAM) is accessible. A MACC bit set to zero indicates that the MAM is not accessible. If the MACC bit is set to one, the ADC device server shall also support commands to access the MAM. If the MACC bit is supported the MACC bit should only be set to one if the MPRSNT bit is set to one. The MACC bit is only applicable for drives and media that support MAM.

The host initiated unload (HIU) bit is set to one when the drive reaches any one of the unload states (e) - (h) (see ADC-2r07e, Clause 4.4.2), due to the RMC device server receiving a LOAD UNLOAD command (see SSC-2) with the LOAD bit set to zero. The HIU bit is set to zero when the drive transitions to any state in table 2 or table 4 of ADC-2r07e other than unload states (e) - (h) in table 4 of ADC-2r07e. The HIU bit may be set to zero following a logical unit reset of the RMC or ADC device servers.

The prevent/allow medium removal (PAMR) bit is set to one when removal of the medium in the DT device is prevented as the result of the RMC device server processing a PREVENT/ALLOW MEDIUM REMOVAL command (see SPC-3 or the relevant command set standard).

The PAMR bit is set to zero when removal of the medium in the DT device is allowed as defined by the PREVENT/ALLOW MEDIUM REMOVAL command.

A MOUNTED bit set to one indicates that the DT device is in load state (i) (see ADC-2). The MOUNTED bit set to one may correspond to the RMC device server being able to respond to a TEST UNIT READY command with a status of GOOD, however when a cleaning or microcode image medium is loaded the RMC device server may respond to a TEST UNIT READY command with a CHECK CONDITON with the sense key set to NOT READY. A MOUNTED bit set to zero indicates that the DT device is not in load state (i).

A medium threaded (MTHRD) bit set to one indicates that the medium has been threaded by the DT device, such that tape motion operations are possible. A MTHRD bit set to zero indicates that the medium has not been threaded.

Note: The value of the MTHRD bit may or may not correspond to the DT device responding with a status of GOOD to a TEST UNIT READY command, as additional processing may be required by the DT device after threading before the logical unit becomes ready.

A medium seated (MSTD) bit set to one indicates that the medium is mechanically seated within the loading mechanism (i.e., the physical loading process has completed). A MSTD bit set to zero indicates that the medium is not seated, and that further mechanical motion remains in order to complete the loading process, exclusive of tape threading.

A medium present (MPRSNT) bit set to one indicates that the DT device detects the presence of a medium. A MPRSNT bit set to zero indicates that the DT device does not detect a medium present.

A robotic access allowed (RAA) bit set to one indicates that the automation device may move a medium to or from the DT device. A RAA bit set to zero indicates that the automation device should not move a medium to or from the DT device. The DT device should indicate that access is allowed by the robotics if a medium may be successfully inserted into or removed from the DT device.

Note: The RAA bit is not intended to reflect the value of any PREVENT/ALLOW MEDIUM REMOVAL command settings (see SPC-3), nor the ability of the automation device to issue commands to the DT device.

The in transition (INXTN) bit governs the remaining bits within byte 1 to indicate the stability of the values returned and whether state transitions are taking place. An INXTN bit set to one indicates that the state currently reflected by the remaining bits in byte 1 is in transition, because the DT device is transitioning to another state. An INXTN bit set to zero indicates that the DT device is in the state reflected by the remaining bits in byte 1 and is making no attempt to leave this state. When the recovery requested (RRQST) bit is set to one, the INXTN bit is set to zero.

The DT DEVICE ACTIVITY field is used to describe the current activity of the DT device (see Table 60).

Table 60. DT DEVICE ACTIVITY field values

Value	Description
00h	No DT device activity
01h	Cleaning operation in progress
02h	Medium is being loaded
03h	Medium is being unloaded
04h	Other medium activity
05h	Reading from medium
06h	Writing to medium
07h	Locating medium
08h	Rewinding medium
09h	Erasing medium
0Ah	Formatting medium
0Bh	Calibrating medium
0Ch	Other DT device activity
0Dh	Microcode update in progress

A TapeAlert state flag changed (TAFC) bit set to one indicates that at least one TapeAlert state flag has changed from its previous value since the last retrieval of the TapeAlert Response log page by this I_T nexus.

The ADC device server sets the TAFC bit to zero after retrieval of the TapeAlert Response log page by this I_T nexus. A TAFC bit set to zero indicates that no TapeAlert state flag has changed. There may not be any difference in the TapeAlert state flags upon retrieval if the state changed again between the time of reporting through the TAFC bit and retrieving the TapeAlert Response log page. This should not be considered an error. The TAFC bit should be processed following the DINIT bit. Pending TapeAlert state flags may affect the reliability of the values returned in other bits within the VHF DATA DESCRIPTOR.

An interface changed (INTFC) bit set to one indicates that one or more fields in the DT device primary port status log parameters have changed since the last retrieval of any of the DT device primary port status log parameters from the DT Device Status log page by this I_T nexus. An INTFC bit set to zero indicates that one or more fields in the DT Device Primary Port Status log parameters have not changed since the last retrieval of any of the DT device primary port status log parameters by this I_T nexus. The INTFC bit is set to zero after retrieval of any of the DT device primary port status log parameters from the DT Device Status log page by this I_T nexus.

The recovery requested (RRQST) bit is set to one to indicate that the DT device has detected an error and that one or more requested recovery procedures are available via the ADC Requested Recovery log page. A RRQST bit set to zero indicates that no recovery procedure is requested. The RRQST bit shall remain set to one as long as a recovery procedure is available. When the RRQST bit is set to one, the INXTN bit is set to zero.

Note: The Requested Recovery log page may indicate that a recovery procedure is not requested or not defined.

Very high frequency polling delay log parameter

The very high frequency polling delay log parameter format is shown in Table 61.

Table 61. Very high frequency polling delay log parameter format

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB)	Parameter Code (0001h)						
1								(LSB)
2	DU (0)	DS (1)	TSD (0)	ETC (0)	TMC (0)		LBIN (1)	LP (1)
3	PARAMETER LENGTH (02h)							
4	(MSB)	VHF POLLING DELAY						
5								(LSB)

The PARAMETER CODE field is set to 0001h to indicate the very high frequency polling delay log parameter.

The PARAMETER LENGTH field is set to 02h to allow transfer of the complete parameter.

The VHF POLLING DELAY field indicates the minimum delay in milliseconds the automation device should wait before requesting another DT Device Status log page.

Primary Port Status descriptor

The Primary Port Status descriptor is defined in Table 62. This descriptor reports the current operating points of the specified port.

Table 62. Primary Port Status descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB)	Parameter Code						
1								(LSB)
2	DU (0)	DS (1)	TSD (0)	ETC (0)	TMC (0)		LBIN (1)	LP (1)
3	PARAMETER LENGTH (8)							
4	CURRTOP	CURRENT SPEED			LC	CONFLICT	SIGNAL	PIC

Table 62. Primary Port Status descriptor (continued)

Byte	Bit 7	6	5	4	3	2	1	0
5	Current N_Port_ID							
6								
7								
8	Reserved							
9	Reserved							
10	Reserved							
11	Rsvd	CURRENT FC-AL LOOP ID						

The Parameter Code field contains a value from 0101h to 01FFh which uniquely identifies the primary port relative to other primary ports in the drive. Once assigned, the Parameter Code value for a port will not be changed. For each primary port, the Parameter Code value is equal to 0100h plus the value of the Relative Target Port field associated with that port. The Relative Target Port field contains a value assigned by the device that uniquely identifies the port relative to other ports in the device, independent of port type. The relative target port value for a port will not be changed. The Relative Target Port is the same as the relative target port value defined in the VPD pages of inquiry. A value of 1=port 0 or port A; a value of 2=port 1 or port B. All values in this descriptor relates to the primary port specified by the Parameter Code.

The Additional Primary Port Status Length field specifies the additional bytes in the current Primary Port Status descriptor. Currently this is 4, but this is subject to change should the ADC specification for the DTD Primary Port Status log parameters change

A port initialization complete (PIC) bit set to one indicates that the FC_Port state machine is in the ACTIVE state (see FC-FS) and the drive’s primary port is operating in point-to-point topology, or the most recent Loop Initialization Process (LIP) has completed successfully (see FC-AL-2). A PIC bit set to zero indicates that the drive’s primary port is not in the ACTIVE state and is not synchronized (see FC-FS), or has not successfully completed the most recent LIP.

A value of one in the SIGNAL field indicates that a signal is detected at the primary port. A value of zero indicates a signal is not detected. An example of signal detection is detection of light for an optical medium.

A value of one in the CONFLICT field indicates that another device has the required Hard AL_PA or that no AL_PA is available for the primary port. A value of zero indicates there is no AL_PA conflict.

A login complete (LC) bit set to one indicates that at least one host is currently logged in to the drive through this port. Logged in is defined as having successfully completed a process login (PRLI) with the drive (see FCP-2) and still have an active session. A host is defined as an initiator port that does not have a Source ID (S_ID) that is a Well-Known name (see FC-FS). An LC bit set to zero indicates that a host is not currently logged in on this port.

The SPEED field indicates the bit rate that the port is configured to operate in. The valid values can be found in Table 63 on page 68. This field is undefined when the

PIC field is set to zero.

Table 63. Speed Values

Value	Speed
000b	1 Gb/sec.
001b	2 Gb/sec.
010b	4 Gb/sec.
100b - 111b	Reserved

A value of one in the current topology (CURRTOP) field indicates the port is operating currently in point to point mode. A value of zero indicates the port is operating currently in arbitrated loop mode. This field is undefined when the PIC field is set to zero.

The Current N_Port_ID field indicates the 24-bit N_Port_ID (as defined by FC-FS) that is assigned currently to the port. This field is undefined when the PIC field is set to zero.

The CURRENT FC-AL LOOP ID field indicates the loop identifier (see FC-AL-2) that is assigned to the drive's primary port associated with the PARAMETER CODE. The CURRENT FC-AL LOOP ID field is ignored when the PIC bit is set to zero or when the CURRTOP bit is set to one.

Log Page 14h: Device Statistics Log Page (Not Ultrium 1 or 2)

The Device Statistics log page defines data counters associated with utilization of the tape drive.

All supported parameters are persistent across I_T nexus loss, logical unit reset and power-on. The parameters are not set to zero or changed with the use of a LOG SELECT command.

> **WARNING**
> Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 64. Device Statistics log parameter codes

Parameter Code (in Hex)	Counter: Description	Size (decimal)
0000h	Lifetime media loads	4
0001h	Lifetime cleaning operations	4
0002h	Lifetime power on hours	4
0003h	Lifetime media motion (i.e., head) hours	4
0004h	Lifetime meters of tape processed	4
0005h	Lifetime media motion (head) hours when incompatible media was last loaded	4
0006h	Lifetime power on hours when the last temperature condition occurred (i.e., TapeAlert code 24h)	4
0007h	Lifetime power on hours when the last power consumption condition occurred (i.e., TapeAlert code 1Ch)	4
0008h	Media motion (i.e., head) hours since last successful cleaning operation	4
0009h	Media motion (i.e., head) hours since second to last successful cleaning operation	4
000Ah	Media motion (i.e., head) hours since third to last successful cleaning operation	4
000Bh	Lifetime power on hours when the last operator initiated forced reset and/or emergency eject occurred	4
000Ch-0FFFh	Reserved	
1000h	Media motion (i.e., head) hours for each medium type (See Table 65)	8 * n
n = Number of Medium Types supported (see Table 65 Media Type Values for number supported by each generation)		

The Medium Type Log Parameter format is specified in Table 65.

Table 65. Medium Type Log Parameter format

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB)	Parameter Code (1000h)						
1								(LSB)

Table 65. Medium Type Log Parameter format (continued)

Byte	Bit 7	6	5	4	3	2	1	0
2	DU(0)	Obsolete	TSD(0)	ETC(0)	TMC (00b)		FORMAT AND LINKING (11 b)	
3	Parameter Length (n-3)							
Medium type parameter(s)								
4	Medium type log parameter (first) (see Table 66)							
	. . .							
n	Medium type log parameter (last) (see Table 66)							

Table 66. Medium Type log parameter

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Density Code							
3	Medium Type							
4	(MSB)	Media Motion Hours						
7								(LSB)

The Density Code field contains the value returned in the general mode parameter block descriptor.

The Medium Type field contains the value returned in the mode parameter header (see Mode Parameter Header).

The Media Motion Hours field contains the number of media motion (i.e., head) hours for the type of medium specified by the combination of the Medium Type field and Density Code field.

The Medium Type log parameter is specified in Table 66. One parameter exists for each Medium Type/Density Code combination that has been loaded in the drive.

Log Page 16h: Tape Diagnostic Data Log Page (Not Ultrium 1 or 2)

The Tape Diagnostic Data log page (see Table 67) provides for a number of error-event records using the list parameter format. Each error-event record contains diagnostic information for a single error type encountered by the device including data counters associated with the error event, sense data, operation code/service action and medium type with associated media motion hours, etc. The Tape Diagnostic Data log page may be used to aid in field analysis and repair.

The Tape Diagnostic Data log page only includes parameter entries for commands that terminated with a CHECK CONDITION status having the sense key set to MEDIUM ERROR, HARDWARE ERROR or ABORTED COMMAND.

The parameter code value associated with an error-event indicates the relative time at which a command terminated with a CHECK CONDITION status. A lower parameter code indicates that the command terminated with a CHECK CONDITION status at a more recent time. The parameter code values returned is numbered consecutively from 0000h (i.e., the most recent) up to n, where n is the number of current parameter entries.

In each parameter (see Table 68 on page 72) if the REPEAT bit is set to zero, then the parameter represents only one event. If the REPEAT bit is set to one, then the parameter represents more than one consecutive events that had identical values for the MEDIUM ID NUMBER field, SENSE KEY field, ADDITIONAL SENSE CODE field and ADDITIONAL SENSE CODE QUALIFIER field in the parameter. If the REPEAT bit is set to one in the parameter, then other fields in the parameter is set to the values when the first of the consecutive events that had the identical values for the MEDIUM ID NUMBER field, SENSE KEY field, ADDITIONAL SENSE CODE field and ADDITIONAL SENSE CODE QUALIFIER field occurred.

All parameter codes are persistent across I_T nexus losses, logical unit resets, and power-on. The parameter entries are not set to zero or changed with the use of a LOG SELECT command.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 67. Tape Diagnostic Data log page

Byte	Bit 7	6	5	4	3	2	1	0
0	DS	SPF(0)	Page Code (16h)					
1	Subpage Code (00h)							
2	(MSB)	Page Length (n-3)						
3								(LSB)
Tape Diagnostic Data log parameter(s)								
4	Tape Diagnostic Data log parameter (first)							
n	Tape Diagnostic Data log parameter (last)							

The Tape Diagnostic Data log parameter format is specified in Table 68.

Table 68. Tape Diagnostic Data log parameter format

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB)	Parameter Code (1000h)						
1								(LSB)
2	DU(0)	Obsolete	TSD(0)	ETC(0)	TMC (00b)		FORMAT AND LINKING (11 b)	
3	Parameter Length (n-3)							
4	Reserved							
5	Reserved							
6	Density Code							
7	Medium Type							
8	(MSB)	Lifetime Media Motion Hours						
11								(LSB)
12	Reserved							
13	Repeat	Reserved			Sense Key			
14	Additional Sense Code							
15	Additional Sense Code Qualifier							
16	(MSB)	Vendor-Specific Code Qualifier						
19								(LSB)
20	(MSB)	Product Revision Level						
23								(LSB)
24	(MSB)	Hours Since Last Clean						
27								(LSB)
28	Operation Code							
29	Reserved			Service Action				
30	Reserved							
31	Reserved							
32	(MSB)	Medium Id Number						
63								(LSB)
64	Reserved					Timestamp Origin		
65	Reserved							
66	(MSB)	Timestamp						
71								(LSB)

The PARAMETER LENGTH field indicates the number of bytes in the Tape Diagnostic Data log parameter data that follows.

The DENSITY CODE field contains the density code of the medium loaded at the time the command terminated with the CHECK CONDITION status. The DENSITY CODE field is the same value as returned in the general mode parameter block descriptor. If no medium was loaded at the time the command terminated with the CHECK CONDITION status, then the DENSITY CODE field is set to 00h.

The MEDIUM TYPE field contains the type of medium loaded at the time the command terminated with the CHECK CONDITION status. The MEDIUM TYPE field is the same value as returned in the mode parameter header. If no medium was loaded at the time the command terminated with the CHECK CONDITION status, then the MEDIUM TYPE field is set to 00h.

The LIFETIME MEDIA MOTION HOURS field contains the number of media motion (head) hours at the time the command terminated with the CHECK CONDITION status. The LIFETIME MEDIA MOTION HOURS field is equivalent to the value contained in the Device Statistics log page with a parameter code value of 0003h at the time the command terminated with the CHECK CONDITION status.

The REPEAT bit set to one indicates this parameter represents more than one consecutive events that had identical values for the MEDIUM ID NUMBER field, SENSE KEY field, ADDITIONAL SENSE CODE field, and ADDITIONAL SENSE CODE QUALIFIER field. The REPEAT bit set to zero indicates this parameter represents a single event.

The SENSE KEY field, ADDITIONAL SENSE CODE field, and ADDITIONAL SENSE CODE QUALIFIER field contain the sense key and additional sense code values of the command that terminated with the CHECK CONDITION status.

The VENDOR-SPECIFIC CODE QUALIFIER field contains the Last Error FSC and Last Error Flag Data (i.e. bytes 65-68 of Sense Data) generated for the command that terminated with the CHECK CONDITION status.

The PRODUCT REVISION LEVEL field contains the product revision level at the time the command terminated with the CHECK CONDITION status.

The HOURS SINCE LAST CLEAN field contains the time in media motion (i.e., head) hours since the last successful cleaning at the time the command terminated with the CHECK CONDITION status. The HOURS SINCE LAST CLEAN field is equivalent to the value contained in the Device Statistics log page with a parameter code of 0008h at the time the command terminated with the CHECK CONDITION status.

The OPERATION CODE field and SERVICE ACTION field if applicable contain the operation code and service action of the command that terminated with the CHECK CONDITION status.

If medium was present at the time the command terminated with the CHECK CONDITION status, then the MEDIUM ID NUMBER field contains (in prioritized order):

1. the BARCODE field value contained in the medium auxiliary memory;
2. the MEDIUM SERIAL NUMBER field value contained in the medium auxiliary memory; or
3. the VOLUME IDENTIFIER field value contained in the medium auxiliary memory.

The TIMESTAMP ORIGIN field and TIMESTAMP field contain the timestamp origin and timestamp maintained by the tape drive at the time the command terminated with the CHECK CONDITION status. If a timestamp is not supported by the device server, the TIMESTAMP ORIGIN and TIMESTAMP fields is set to zero.

If no medium was present at the time the command terminated with the CHECK CONDITION status, the MEDIUM ID NUMBER field is filled with 20h (i.e., ASCII space).

Log Page 18h: Protocol-Specific Logical Unit Log Page

There is one copy of this page for each initiator. This page is defined for SAS-attached devices only.

Support Protocol-Specific log parameter for SAS as in spec. (attached means other end of cable from drive - initiator or expander).

The Protocol-Specific log page for SAS defined in Table 69 is used to report errors that have occurred on the phys of SAS drives.

WARNING:

This page must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 69. Protocol-Specific log page for SAS

Byte/Bit	7	6	5	4	3	2	1	0
0	Page Code (18h)							
1	Reserved							
2	(MSB)			Page Length (m-3)				
3								(LSB)
Protocol-specific log parameter list								
4	Protocol-specific log parameter (first) (See Table 70 on page 75)							
. . .								
	Protocol-specific log parameter (last) (See Table 70 on page 75)							
m								

Table 70 on page 75 defines the format for the Protocol-Specific log parameter for SAS.

Table 70. Protocol-Specific log parameter for SAS

Byte/Bit	7	6	5	4	3	2	1	0
0	(MSB) Parameter Code (relative target port identifier)							
1								(LSB)
2	Parameter control byte							
	DU (0)	DS (0)	TSD (0)	ETC (0)	TMC (0)		LBIN (1)	LP (1)
3	Parameter Length (y-3)							
4	Reserved				Protocol Identifier (6h)			
5	Reserved							
6								
7	Number of PHYs (01h)							
SAS phy log descriptor list								
8	SAS phy log descriptor (first) (See Table 71 on page 76)							
. . .								
	SAS phy log descriptor (last) (See Table 71 on page 76)							
y								

Table 71 on page 76 describes the SAS Phy log descriptor.

Table 71. SAS Phy log descriptor

<table>
<tr><th>Byte/Bit</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Reserved</td></tr>
<tr><td>1</td><td colspan="8">Phy Identifier</td></tr>
<tr><td>2</td><td colspan="8" rowspan="2">Reserved</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td>Rsvd</td><td colspan="3">Attached Device Type</td><td colspan="4">Reserved</td></tr>
<tr><td>5</td><td colspan="4">Reserved</td><td colspan="4">Negotiated Physical Link Rate</td></tr>
<tr><td>6</td><td colspan="4">Reserved</td><td>Attached SSP Initiator</td><td>Attached STP Initiator</td><td>Attached SMP Initiator</td><td>Rsvd</td></tr>
<tr><td>7</td><td colspan="4">Reserved</td><td>Attached SSP Target</td><td>Attached STP Target</td><td>Attached SMP Target</td><td>Rsvd</td></tr>
<tr><td>8</td><td colspan="8" rowspan="2">SAS Address</td></tr>
<tr><td>15</td></tr>
<tr><td>16</td><td colspan="8" rowspan="2">Attached SAS Address</td></tr>
<tr><td>23</td></tr>
<tr><td>24</td><td colspan="8">Attached Phy Identifier</td></tr>
<tr><td>25</td><td colspan="8" rowspan="2">Reserved</td></tr>
<tr><td>31</td></tr>
<tr><td>32</td><td colspan="8" rowspan="2">MSB
Invalid Dword Count
LSB</td></tr>
<tr><td>35</td></tr>
<tr><td>36</td><td colspan="8" rowspan="2">MSB
Running Disparity Error Count
LSB</td></tr>
<tr><td>39</td></tr>
<tr><td>40</td><td colspan="8" rowspan="2">MSB
Loss Of Dword Synchronization
LSB</td></tr>
<tr><td>43</td></tr>
<tr><td>44</td><td colspan="8" rowspan="2">MSB
Phy Reset Problem
LSB</td></tr>
<tr><td>47</td></tr>
</table>

Log Page 30h: Tape Usage Log

The Tape Usage Log Page Code is 30h. These are all read directly from the tape logs.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 72. Tape Usage Log Parameters

Parameter Code (in Hex)	Counter: Description	Size
0001h	**Thread Count**	4
	This field is incremented by one each time the cartridge has been loaded.	
0002h	**Total Data Sets Written**	8
	Total number of Data Sets written to the tape.	
0003h	**Total Write Retries**	4
	U13: If an error is detected in a CQ Set during Read-While-Write verification, then the Total Write Retries counter shall increment by one regardless of the number of times that that Data Set is retried.	
	U4: If an error is detected in a CQ Set during Read-While-Write verification, then that CQ Set is rewritten farther down the tape. If the Data Set was successfully rewritten, then the Total Write Retries counter shall increment by one regardless of the number of times that that Data Set is retried.	
0004h	**Total Unrecovered Write Errors**	2
	If an error is detected in a CQ Set during Read-While-Write verification, then that CQ Set is rewritten farther down the tape. If the Data Set cannot be successfully written, then the Total Unrecovered Write Errors counter shall increment by one.	
0005h	**Total Suspended Writes**	2
	U13: If a defect or disturbance that may result in incorrectly written tracks is detected while recording data, recording shall stop and this parameter is incremented. If the Data Set is interrupted one or more times, this parameter is incremented for the first interruption only.	
	U4: When writing is interrupted by a defect or disturbance that results in incorrectly written tracks is detected while recording data, and has to write the Data Set further down the tape, this parameter is incremented. If the Data Set is interrupted one or more times, this parameter is incremented for the first interruption only.	
0006h	**Total Fatal Suspended Writes**	2
	U13: If a defect or disturbance that may result in incorrectly written tracks is detected while recording data, recording shall stop. If the Data Set cannot be successfully written, then this parameter shall increment by one.	
	U4: When writing is interrupted by a defect or disturbance that results in incorrectly written tracks is detected while recording data, and has to write the Data Set further down the tape but cannot be successfully written, this parameter is incremented.	
0007h	**Total Data Sets Read**	8
	Total number of Data Sets read from to the tape.	

Table 72. Tape Usage Log Parameters (continued)

Parameter Code (in Hex)	Counter: Description	Size
0008h	**Total Read Retries**	4
	U13: Total number of Data Sets that were not successfully read on the first attempt by a dataflow error.	
	U4: Total number of Data Sets that were not successfully read on the first attempt, but which were subsequently successfully read.	
0009h	**Total Unrecovered Read Errors**	2
	U13: Total number of Data Sets that were not successfully read on the first, nor on a subsequent attempt to read it by a dataflow error.	
	U4: Total number of Data Sets that were not successfully read on the first attempt, but which were subsequently successfully read.	
000Ah	**Total Suspended Reads**	2
	U13: If a defect or disturbance that may result in incorrectly read tracks is detected while reading data, reading shall stop and this parameter is incremented. If the Data Set is interrupted one or more times, this parameter is incremented for the first interruption only.	
	U4: (0000h) This parameter is never updated.	
000Bh	**Total Fatal Suspended Reads**	2
	U13: If a defect or disturbance that may result in incorrectly read tracks is detected while reading data, reading shall stop. If the Data Set cannot be successfully read, then this parameter shall increment by one.	
	U4: (0000h) This parameter is never updated.	
U13: Ultrium 1, Ultrium2, and Ultrium 3 **U4: Ultrium 4**		

Log Page 31h: Tape Capacity Log

The Tape Capacity Log Page Code is 31h. Parameters 2 and 4 are not supported and are returned as 0. All parameter lengths are 4 bytes long. The supported fields are listed in Table 73.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 73. Tape Capacity Log Parameters

Parameter Code (in Hex)	Counter: Description	Size
0001h	**Main Partition Remaining Capacity**: A representation of the location on medium of EOD expressed in Native Capacity between EOD and EOP. This is intended to be used as a gauge to display the percentage of medium used. There is no guarantee that the amount of data expressed in this parameter will be available for writing.	4
0002h	**Alternate Partition Remaining Capacity**: (Not supported - Always returns 00000000h)	4
0003h	**Main Partition Maximum Capacity**: (Constant value representing the Native Capacity of the medium) Ultrium 1: 0001 7487 Ultrium 2: 0002 E90E Ultrium 3: 0005 D21D Ultrium 4: 000B A43B	4
0004h	**Alternate Partition Maximum Capacity**: (Not supported - Always returns 00000000h)	4

All parameters are in megabytes and assume no data compression. This data cannot be reset or written.

Note: For this command, a megabyte is equal to 1 048 576 bytes. As an example, a value of 17487h in Parameter 3 is equal to 95 367 megabytes, which is equal to 100 000 000 000 bytes.

Log Page 32h: Data Compression Log

The Data Compression Log Page Code is 32h. Parameter byte fields 0 and 1 are 2 bytes long. Parameter byte fields 2 through 9 are each 4 bytes long.

The supported fields are listed in Table 74.

> **WARNING**
> Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 74. Data Compression Log Parameters

Parameter Code (in Hex)	**Counter: Description**	**Size**
0000h	Read Compression ratio x 100	2
0001h	Write Compression Ratio x 100	2
0002h	Megabytes transferred to server	4
0003h	Bytes transferred to server	4
0004h	Megabytes read from tape	4
0005h	Bytes read from tape	4
0006h	Megabytes transferred from server	4
0007h	Bytes transferred from server	4
0008h	Megabytes written to tape	4
0009h	Bytes written to tape	4

Parameters 2 through 9 occur as pairs that represent a large number of bytes transferred. The first 4-byte parameter represents the number of whole megabytes transferred, rounded to the nearest megabyte. The second 4-byte parameter represents the difference between this number of megabytes and the actual number of bytes. This may be a signed quantity.

This data may be reset, but may not be written.

Log Page 33h: Write Errors (Not Ultrium 1 or Ultrium 2 non-RoHS)

This page contains detailed counters related to write operations. This page is reset when a cartridge is loaded.

Note: When multiple errors occur on a data set, the counter that is updated is generally based on the first error detected.

> **WARNING**
> Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 75. Write Errors log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0000h	Data sets Corrected: ECC is done by hardware. This is driven by an excessive CQs rewritten condition (TBD). Each count represents on data set in error that was successfully corrected and written.	2
0001h	Servo Transients: ERP action was required because of a servo detected error and the first retry was successfully in place (stop write without backhitch,that is, servo write skip). Each count represents one data set in error that was successfully recovered and written.	2
0002h	Data Transients: ERP action was required because of a readback check or ECC detected error and the first retry was successfully in place (no backhitch). Each count represents one data set in error that was successfully recovered and written.	2
0003h	Velocity Events: A velocity control problem occurred. Each count represents on occurrence, not just the count of affected data sets. Counts may include occurrences from both temporary and permanent errors.	2
0004h	Servo Acquisition Temps: A servo error (servo dropout or off-track shutdown) was detected while trying to acquire a DSS or data set at the beginning of a write append sequence (motion). ERP action was required, and servo transient condition criteria were not met. Each count represents one data set in error that was successfully recovered and written.	2
0005h	Data Acquisition Temps: During read-back check, the read channel failed to acquire a DSS or data set at the beginning of a write append sequence and no servo error was reported. ERP action was required, and read/ECC transient condition criteria were not met. Each count represents one data set in error that was successfully recovered and written.	2
0006h	Servo Temps: A servo error (servo dropout or off-track shutdown) was detected while writing data. ERP action was required, and servo transient condition criteria were not met. Each count represents one data set in error that was successfully recovered and written.	2
0007h	Data Temps: An uncorrectable error, CRC error, instantaneous speed variation (ISV) error, or no ending burst error occurred during readback check of a data set, and no servo error was reported. ERP action was required, and readback/ECC transient condition criteria were not met. Each count represents one data set in error that was successfully recovered and written.	2
0008h	Total Retries: The count of the total number of ERP actions. Each count represents one occurrence, not just one time per data set. Counts may include occurrences from both temporary and permanent errors.	2

Table 75. Write Errors log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
0009h	Vendor-Reserved	2
000Ah	Vendor-Reserved (Bellcord)	2
000Bh	Servo Skip Events: The count of long servo write skips, extended DSS or long spaces between data sets written. This is generally servo write skips, but may also include other write scenarios. Each count represents one occurrence, not one count per block. Counts may include occurrences from both temporary and permanent errors.	2
000Ch	Housekeeping Events: The count of write problems in the Housekeeping Data set Region. Each count represents one occurrence, not just one time per data set. Counts may include occurrences from both temporary and permanent errors.	2
000Dh	FID Events: The count of write problems while processing the FID. Each count represents one occurrence, not just one time per data set. Counts may include occurrences from both temporary and permanent errors.	2
000Eh	Vendor-Reserved (Blocks Lifted)	2
000Fh	Data set Underrun: The number of times that the drive overran the bufferprocessing capability and had to stop and restart during a write. Each count represents one occurrence, not just one time per write.	2
0010h	Vendor-Reserved	2
0011h	Servo Position Events: The number of servo detected positional compare discrepancies.	2

Log Page 34h: Read Forward Errors (Not Ultrium 1 or Ultrium 2 non-RoHS)

This page contains detailed counters related to read operations. This page is reset when a cartridge is loaded.

Note: When multiple errors occur on a data set, the counter that is updated is generally based on the first error detected. ERP counters indicate which specific ERP methods were successfully employed.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 76. Read Forward Error Counters log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0000h	Data sets Corrected: ECC is done by hardware. Each count represents one data set in error that was successfully corrected and read.	2
0001h	Servo Transients: ERP action was required because of a servo detected error and the first retry was successfully in place. Each count represents one data set in error that was successfully recovered and read.	2
0002h	Data Transients: ERP action was required because of a read channel or ECC detected error and the first retry was successfully in place. Each count represents one data set in error that was successfully recovered and read.	2
0003h	Velocity Events: A velocity control problem occurred. Each count represents one occurrence, not just the count of affected data sets. Counts may include occurrences from bot temporary and permanent errors.	2
0004h	Servo Acquisition Temps: A servo error (servo dropout or off track shutdown) was detected while trying to acquire an initial DSS or data set. ERP action was required, and servo transient condition criteria were not met. Each count represents one data set in error that was successfully recovered and read.	2
0005h	Data Acquisition Temps: The read channel failed to acquire an initial DSS or data set, and no servo error was reported. ERP action was required, and read/ECC transient condition criteria were not met. Each count represents one data set in error that was successfully recovered and read.	2
0006h	Servo Temps: A servo error (servo drop out) was detected while reading a data set. ERP action was required, and servo transient condition criteria were not met. Each count represents one data set in error that was successfully recovered and read.	2
0007h	Data Temps: An uncorrectable error, CRC error, or no ending burst error occurred while reading a data set, and no servo error was reported. ERP action was required, and read/ECC transient condition criteria were not met. Each count represents one data set in error that was successfully recovered and read.	2
0008h	Sequence Errors: A data set number out of sequence was encountered, and no Servo or read/ECC error reported. ERP action was required, and no transient condition criteria were not met. Each count represents one data set in error that was successfully recovered and read.	2
0009h	Vendor-Reserved (ERP Read Opposite)	2

Table 76. Read Forward Error Counters log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
000Ah	Vendor-Reserved (ERP Tension Adjust Hi)	2
000Bh	Vendor-Reserved (ERP Tension Adjust Lo)	2
000Ch	ERP Servo Adjust Hi: The data set was recovered by reading with servo off-track variations. Each count represents one data set in error that was successfully recovered and read.	2
000Dh	ERP Servo Adjust Lo: The data set was recovered by reading with servo off-track variations. Each count represents one data set in error that was successfully recovered and read.	2
000Eh	Vendor-Reserved (ERP Dead Reckon Nominal)	2
000Fh	Vendor-Reserved (ERP Dead Reckon Hi)	2
0010h	Servo AGA Gain ERP (read only mode)	2
0011h	Vendor-Reserved (ERP Filter Coefficients)	2
0012h	Servo Opposite Gap ERP (read only mode)	2
0013h	Vendor-Reserved (ERP Dataflow Clock Adjust)	2
0014h	Vendor-Reserved	2
0015h	Total Retries: The count of the total number of ERP actions. Each count represents one occurrence, not just one time per data set. Counts may include occurrences from both temporary and permanent errors.	2
0016h	Match Filter ERP (read mode use)	2
0017h	Housekeeping Events: The count of read problems in the Housekeeping data set Region. Each count represents one occurrence, not just one time per data set. Counts may include occurrences from both temporary and permanent errors.	2
0018h	Vendor-Reserved (Cartridge Init Errors)	2
0019h	data set Overrun: The number of times that the drive overran the buffer processing capability and had to stop and restart during a read. Each count represents one occurrence, not just one time per read.	2
001Ah	Vendor-Reserved	2
001Bh	Servo Skip Events: The count of extended DSS or long spaces between data sets read. This may include servo write skips, but may also include other write scenarios. Each count represents one occurrence, not one count per block. Counts may include occurrences from both temporary and permanent errors.	2
001Ch	Vendor-Reserved	2
001Dh	FID Events: The count of write problems while processing the FID. Each count represents one occurrence, not just one time per data set. Counts may include occurrences from both temporary and permanent errors.	2
001Eh	Servo Position Events: The number of servo detected positional compare discrepancies.	2

Log Page 37h: Performance Characteristics (Ultrium 4)

This page includes various performance and capacity measurements across the operation of the drive. Some fields are normalized qualitative measures while others are quantitative. This page uses the Subpage Code mechanism (see "LOG SENSE" on page 50) to select which groups of counters to return. This page has three scopes controlled by the Subpage Code field. Each has different reset characteristics which are described under the Subpage Code field description below.

The subpage field in "LOG SENSE" on page 50 is used as follows:

Bit **Description**

7-6 Scope

Value	Description
0h	Transient values: reset on Log Select [all Subpages are reset]
1h	Mount values: reset on load
2h	Lifetime values: reset on device power on or device reset (not target reset)
3h	Vendor-Reserved

5-4 Level

Value	Description
0h	Return summary counters
1h	Return basic counters
2h	Return advanced counters

3-0 Group

Value	Description
0h	All groups
1h	Host Interface
2h	Buffer
3h	Medium
4h	Capacity
5h	Load/Unload
6h	Servo

The Subpage field in "LOG SELECT" on page 49 may be set to 00h when the page code field is 37h. This operation will reset all group and local counters in the transient scope. Other scope cannot be explicitly reset.

The individual log subpage and parameter codes are described in the following table. Note that the counters which are returned depends on the Level and Group fields in the subpage. A group value of 0h will return all counters of a level less than or equal to that specified.

In the following tables, multiple counter codes may be represented by a single row. There will be an aspect symbol in the counter code such as 'p', 'q', 's', or '?'. The **Aspect(s)** column indicates which of the following values applies to the given code(s).

Aspect **Definition**

p=0 primary interface all ports (totals)

p=1 primary interface port 0

p=2 primary interface port 1

p=A automation interface (RS-422)

q=1 Non-Ready: NOTE: These commands include ALL commands which are processed when the drive is in a Not Ready state.

q=2 Head-of-Queue: NOTE: These commands are commands which may be processed in any order. Such commands include: Inquiry, Report LUNs, Test Unit Ready and Request Sense. These counts are updated only when the drive is in a Ready state.

q=2 Head-of-Queue: NOTE: These commands are commands which may be processed in any order. Such commands include: Inquiry, Report LUNs, Test Unit Ready and Request Sense. These counts are updated only when the drive is in a Ready state.

q=3 Read: NOTE: This aspect has more features detailed below.

q=4 Write: NOTE: This aspect has more features detailed below.

q=5 Sync: NOTE: This aspect has more features detailed below.

q=6 Seek: NOTE: This aspect has more features detailed below.

q=7 Non-Medium: NOTE: These commands are command issued to LUN 0 which are not in any other applicable category. These include many commands such as Log Sense, Log Select, Read Buffer, Reserve, etc. These counts are updated only when the drive is in a Ready state.

q=8 Non-LUN0, Non-Ready: NOTE: These commands include ALL commands which are processed by a LUN other than LUN 0 when the drive is in a Not Ready state.

q=9 Non-LUN0, Head-of-Queue: NOTE: These commands are commands which may be processed in any order. Such commands include: Inquiry, Report LUNs, Test Unit Ready and Request Sense. These counts are updated only when the drive is in a Ready state.

q=A Non-LUN0: NOTE: These commands include any commands processed by a LUN other than LUN 0. These counts are updated only when the drive is in a Ready state.

s=1 Speed 1: Highest read/write speed

s=2 Speed 2: Second highest read/write speed

s=3 Speed 3: Third highest read/write speed

s=4 Speed 4: Fourth highest read/write speed

s=5 Speed 5: Fifth highest read/write speed

s=6 Speed 6: Slowest read/write speed

s=F High speed locate (not read/write capable)

?=1 write - write phase without host holdoff. NOTE: if no (paused) data is supported for a particular counter, this aspect will include all write information

?=2 write (paused) - write phase while the host is being held off (buffer full)

?=3 read - read phase without host holdoff. NOTE: if no (paused) data is supported for a particular counter, this aspect will include all read information

?=4 read (paused) - read phase while the host is being held off (buffer empty)

?=5 position - during the processing of a seek operation

?=6 load - during the processing of an load operation

?=7 unload - during the processing of an unload operation

?=F other - not in an above phase

Table 77. Log Page 37h: Performance Characteristics: Quality Summary

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
0000h		Drive Efficiency: Overall measure of the drive's condition. 00h is unknown, from 01h (best) to FFh (worst)	rating	1	0	0
0001		Media Efficiency: Overall measure of the currently mounted media's condition. 00h' is unknown, from 01h (best) to FFh (worst)	rating	1	0	0
0010h		Primary Interface Efficiency: Overall measure of the interface (to the host) condition. 00h is unknown, from 01h (best) to FFh(worst)	rating	1	0	0
0011h		Primary Interface Port 0 Efficiency: Overall measure of the per port interface (to the host) condition. 00h is unknown, from 01h (best) to FFh (worst)	rating	1	0	0
0012h		Primary Interface Port 1 Efficiency: Overall measure of the per port interface (to the host) condition. 00h is unknown, from 01h(best) to FFh (worst)	rating	1	0	0
001Ah		Library Interface Efficiency: Overall measure of the interface (to the library) condition. 00h is unknown, from 01h (best) to FFh (worst)	rating	1	0	0

Table 78. Log Page 37h: Performance Characteristics: Device Usage

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
0040h		Time: Amount of entire sample duration	msec	6	2	5
0041h		Medium Empty Time: Duration without a tape present	msec	6	2	5
0042h		Medium Insert Time: Duration from cartridge insert to load	msec	6	2	5
0043h		Medium Mount Time: Total time from start of cartridge load until cartridge ejected	msec	6	2	5
0044h		Medium Load Time: Total time from start of cartridge load to load complete (ready)	msec	6	2	5
0045h		Medium Ready Time: Total time from load complete (ready) to start of unload	msec	6	2	5
0046h		Medium Eject Time: Time from start of unload to unload complete	msec	6	2	5
0047h		Medium Extract Time: Time from cartridge unloaded to removed	msec	6	2	5
0048h		Medium Dwell Time: Time from cartridge unloaded to (re)loaded. **Note:** This may include time which cannot be determined as dwell or extract (when time is queried with a cartridge remains in the unloaded position)	msec	6	2	5

Table 78. Log Page 37h: Performance Characteristics: Device Usage (continued)

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
0049h		Medium Clean Time: Time from cleaner recognized to eject complete	msec	6	2	5
0051h		Medium Empty Count: Number of times tape was fully removed	count	4	2	5
0052h		Medium Insert Count: Number of cartridge insertions to load position detected	count	4	2	5
0053h		Medium Mount Count: Number of mount operations	count	4	2	5
0054h		Medium Load Count: Number of load operations	count	4	2	5
0055h		Medium Ready Count: Number of ready transisions	count	4	2	5
0056h		Medium Eject Count: Number of unloads	count	4	2	5
0057h		Medium Extract Count: Number of times tape was extracted	count	4	2	5
0058h		Medium Dwell Count: Number of times tape was reloaded (from unload)	count	4	2	5
0059h		Medium Clean Count: Number of recognized cleaner loads (does not indicate successful cleans, tape may be expired)	count	4	2	5

Table 79. Log Page 37h: Performance Characteristics: Host Commands

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
0q00h	12(3456)789A	... Count	count	4	2	1
0q01h	12(3456)789A	... Timing	msec	6	2	1
0q02h	12(3456)789A	... Relative Time	% * 65536	4	1	1
0q04h	12(3456)789A	... Transfer Count to Host (in)	count	4	2	1
0q05h	12(3456)789A	... Transfer Byte Count to Host (in)	bytes	8	2	1
0q06h	12(3456)789A	... Transfer Timing to Host (in)	msec	6	2	1
0q08h	12(4)789A	... Transfer Count from Host (out)	count	4	2	1
0q09h	12(4)789A	... Transfer Byte Count from Host (out)	bytes	8	2	1
0q0Ah	12(4)789A	... Transfer Timing from Host (out)	msec	6	2	1
Note: Read type host commands include Read, Verify and Read Reverse (not all of these may be supported). These counts are updated only when the drive is in a Ready state						
0300h		Read Count: Number of blocks processed to the host by read type commands	blocks	6	2	1
0301h		Read Timing: Amount of time processing read type commands. **Note:** Due to device specific performance path resources, this may not reflect the actual time spend processing commands, but may reflect the amount of time where read commands could be processed.	msec	6	2	1
0302h		Read Relative Time: Ratio of time spent reading with respect to Medium Ready Time	% * 65536	4	1	1
0304h		... Transfer Count to Host (in)	count	6	2	1
0305h		... Transfer Byte Count to Host (in)	bytes	8	2	1

Table 79. Log Page 37h: Performance Characteristics: Host Commands (continued)

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
0306h		... Transfer Timing to Host (in)	msec	6	2	1
03D0h		Read Performance Efficiency: Ratio of performance read type commands with respect to all read type commands	% * 65536	4	1	1
03D4h		Read Filemark (perf) Relative Time: Amount of time spent sending filemark encountered status to the host with respect to time Read Timing.	% * 65536	4	2	1
Note: Write type host commands include Write and Write Filemarks [not including any synchronization portion]. These counts are updated only when the drive is in a Ready state.						
0400h		Write Count: Number of blocks processed from the host by write type commands	blocks	6	2	1
0401h		Write Timing: Amount of time processing write type commands. **Note:** Due to device specific performance path resources, this may not reflect the actual time spend processing commands, but may reflect the amount of time where write commands could be processed.	msec	6	2	1
0402h		Write Relative Time: Ratio of time spent writing with respect to Medium Ready Time	% * 65536	4	1	1
0404h		... Transfer Count to Host (in)	count	6	2	1
0405h		... Transfer Byte Count to Host (in)	bytes	8	2	1
0406h		... Transfer Timing to Host (in)	msec	6	2	1
0408h		... Transfer Count from Host (out)	count	6	2	1
0409h		... Transfer Byte Count from Host (out)	bytes	8	2	1
040Ah		... Transfer Timing from Host (out)	msec	6	2	1
04D0h		Write Performance Efficiency: Ratio of performance write commands with respect to all write type commands	% * 65536	4	1	1
04D4h		Write Filemark Relative Time: Amount of time spent writing filemarks.	% * 65536	4	2	1
Note: Sync type host commands include Write Filemarks [non-immediate]. Implicit sync type commands include mode changes while writing, non-buffered mode and idle time based syncs. These counts are updated only when the drive is in a Ready state.						
0500h		Sync Count [Host]: Number of host sync operations (non-immediate Write Filemarks, non-buffered writes)	count	4	2	1
0501h		Sync Timing [Host]: Amount of time processing host sync commands	msec	6	2	1
0502h		Sync Relative Time [Host]: Ratio of time spent processing host sync commands with respect to Medium Ready Time	% * 65536	4	1	1
0504h		... Transfer Count to Host (in)	count	4	2	1
0505h		... Transfer Byte Count to Host (in)	bytes	8	2	1
0506h		... Transfer Timing to Host (in)	msec	6	2	1
05D1h		Sync Count [Implicit]: Number of implicit sync commands (time based flushes, mode change flushes)	count	4	2	1

Table 79. Log Page 37h: Performance Characteristics: Host Commands (continued)

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
05D2h		Sync Timing [Implicit]: Amount of time processing implicit sync commands	msec	6	2	1
05D4h		Sync Relative Time [Implicit]: Ratio of time spent processing implicit sync commands with respect to Medium Ready Time	% * 65536	4	1	1
Note: Seek type host commands include Space, Locate, and Rewind. These counts are updated only when the drive is in a Ready state.						
0600h		Seek Count: Number of positioning host commands	count	4	2	1
0601h		Seek Timing: Amount of time spent processing host positioning commands	msec	6	2	1
0602h		Seek Relative Time: Ratio of time spend processing host seek commands with respect to Medium Ready Time	% * 65536	4	1	1
0604h		... Transfer Count to Host (in)	count	4	2	1
0605h		... Transfer Byte Count to Host (in)	bytes	8	2	1
0606h		... Transfer Timing to Host (in)	msec	6	2	1
06D1h		Seek Block Count: Number of blocks processed in host positioning commands	blocks	4	2	1
0Cp0h	012A	Command Count	count	6	2	1
0Cp1h	012A	Command Timing	msec	6	2	1
0Cp2h	012A	Command Relative Time	% * 65536	4	2	1
0Cp4h	012A	Command Transfer Count to Host (in)	count	6	2	1
0Cp5h	012A	Command Transfer Byte Count to Host (in)	bytes	8	2	1
0Cp6h	012A	Command Transfer Timing to Host (in)	msec	6	2	1
0Cp8h	012A	Command Transfer Count from Host (out)	count	6	2	1
0Cp9h	012A	Command Transfer Byte Count from Host (out)	bytes	8	2	1
0CpAh	012A	Command Transfer Timing from Host (out)	msec	6	2	1
0CpCh	012A	Command Queue Count	count	6	2	1
0CpDh	012A	Command Queue Latency	msec	6	2	1
0CpEh	012A	Command Queue Relative Time	% * 65536	4	2	1
0Dp1h	12A	Port Throughput Rate Maximum Bursting	bytes/sec	6	2	1
0Dp2h	12A	Port Throughput Rate Maximum Sustained	bytes/sec	6	2	1
0Dp3h	12A	Port Throughput Rate	bytes/sec	6	2	1
0Dp4h	12A	Port Throughput Efficiency	% * 65536	4	1	1
0Dp7h	12A	Port Rate Changes	count	4	2	1
0DF0h		Average Command Latency: Average amount of time commands were queued waiting for execution with respect to all commands (including unqueued commands which executed immediately).	usec	4	1	1
0DF1h		Average Dequeue Latency: Average amount of time commands were queued waiting for execution with respect to commands which where queued (not executed immediately).	usec	4	1	1

Table 79. Log Page 37h: Performance Characteristics: Host Commands (continued)

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
0DF8h		Long Queue Latency Count [>1 sec]	count	4	2	1
0DF9h		Long Queue Latency Count [>10 sec]	count	4	2	1
0DFAh		Long Queue Latency Count [>100 sec]	count	4	2	1
0DFBh		Long Queue Latency Count [>1000 sec]	count	4	2	1

Table 80. Log Page 37h: Performance Characteristics: Host Initiators

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
Note: In dual ported configurations it is possible for the same host to be identified as a different initiator when using a different logical or physical path. This can occur in failover or load balancing applications.						
0E00h		Active Initiator Count: Number of initiators which executed one or more commands.	count	4	2	1
0E01h		Primary Initiator: Ratio of commands issued by the initiator which is issuing the most commands with respect to all initiators.	% * 65536	4	2	1
0E02h		Secondary Initiator: Ratio of commands issued by the initiator which is issuing the second most commands with respect to all initiators.	% * 65536	4	2	1
0E03h		Current Initiator: Ratio of commands issued by this (the querying) initiator with respect to all initiators.	% * 65536	4	2	1

Table 81. Log Page 37h: Performance Characteristics: Host Recovery (by port)

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
0Fp0h	12A	Transfer Recoveries [by port]	count	4	2	1
0Fp1h	12A	Transfer Recover Time [by port]	msec	6	2	1
0Fp2h	12A	Resource Recoveries [by port]	count	4	2	1
0Fp3h	12A	Reset Count [by port]	count	4	2	1
0Fp8h	12A	Abort Count [by port]	count	4	2	1
0Fp9h	12A	Abort Time [by port]	msec	6	2	1

Table 82. Log Page 37h: Performance Characteristics: Mode Phase Timing Windows

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
1000h		Write Cycles	count	4	2	2
1001h		Write Pauses	count	4	2	2
1010h		Write Cycle Time	msec	6	2	2
1020h		Write Cycle Relative Time: Ratio of time in write mode with respect to Medium Ready Time.	% * 65536	4	1	2
1021h		Write Setup Relative Time	% * 65536	4	2	2
1022h		Write Ready Relative Time	% * 65536	4	1	2
1023h		Write Pause Relative Time	% * 65536	4	1	2
1024h		Write Exit Relative Time	% * 65536	4	2	2
200h		Read Cycles	count	4	2	2
1201h		Read Pauses	count	4	2	2

Table 82. Log Page 37h: Performance Characteristics: Mode Phase Timing Windows (continued)

1210h		Read Cycle Time	msec	6	2	2
1220h		Read Cycle Relative Time: Ratio of time in write mode with respect to Medium Ready Time.	% * 65536	4	1	2
1221h		Read Setup Relative Time	% * 65536	4	2	2
1222h		Read Ready Relative Time	% * 65536	4	1	2
1223h		Read Pause Relative Time	% * 65536	4	1	2
1224h		Read Exit Relative Time	% * 65536	4	2	2
1225h		Read Traverse EM Relative Time	% * 65536	4	2	2
1400h		Position Count	count	4	2	2
1410h		Position Time	msec	6	2	2
1420h		Position Relative Time: Ratio of time spent physically and logically positioning with respect to Medium Ready Time.	% * 65536	4	1	2
1430h		Position Relative Rate	bytes/sec	4	1	2
1480h		Position Count (Media)	count	4	2	2
1490h		Position Time (Media)	msec	6	2	2
14A0h		Position Relative Time (Media): Ratio of time spent physically positioning media with respect to Medium Ready Time.	% * 65536	4	1	2
14B0h		Position Relative Rate (Media)	bytes/sec	4	1	2
14F0h		Position Buffer Hits: Ratio of positioning operations where targets were already present in the buffer.	% * 65536	4	1	2
1500h		Flush Count: Number of low level buffer write flush operations. These may include operations which only affect the buffer and do not involve media motion.	count	4	1	2
1510h		Flush Time: Time spend executing operations counted by Flush Count.	msec	6	2	2
1520h		Flush Relative Time: Ratio of time spent flushing with respect to Medium Ready Time.	% * 65536	4	1	2
1580h		Flush Count (Media): Number of low level buffer write flush operations which involve [or continue] media motion.	count	4	1	2
1590h		Flush Time (Media): Time spent executing operations counted by Flush Count (Media).	msec	6	2	2
15A0h		Flush Relative Time (Media): Ratio of time spent flushing to media with respect to Write Cycle Time.	% * 65536	4	1	2
15F0h		Flush Buffer Hits: Ratio of flush operations which required media motion.	% * 65536	4	1	2
2000h		Media Idle	msec	6	2	3
2001h		Media Write	msec	6	2	3
2002h		Media Read	msec	6	2	3
2003h		Media Erase	msec	6	2	3
2004h		Media Position	msec	6	2	3

Table 82. Log Page 37h: Performance Characteristics: Mode Phase Timing Windows (continued)

20?0h	1234567F	Media Phase Timing	msec	6	2	3
20?1h	1234567F	Media Phase Cycles	count	4	2	3
2?10h	1234567F	Wrap Change Count: Total number of wrap changes.	count	4	2	3
2?11h	1234567F	Band Change Count: Total number of changes to different servo bands.	count	4	2	3
2?50h	13	Datarate Performance Impacting ERPs	% * 65536	4	1	3
2?51h	13567F	Performance Impacting ERPs	% * 65536	4	1	3
2?52h	1234567F	Performance Impact by ERPs	% * 65536	4	1	3
2?60h	135	Uncompressed Data	bytes	8	2	2
2?61h	135	Compressed Data	bytes	8	2	2
2?62h	135	Padded Data	bytes	8	2	2
2?63h	135	Degate Data	bytes	8	2	2
2?68h	135	Data sets Processed	data sets	4	2	2
2?6Ch	13	Compression Ratio	% * 65536	4	1	2
2?71h	13F	Compressed Data (Medium)	bytes	8	2	3
2?72h	13F	Padded Data (Medium)	bytes	8	2	3
2?80h	13	Maximum Host Transfer Rate	bytes/sec	4	1	2
2?81h	13	Average Host Transfer Rate	bytes/sec	4	1	2
2?82h	13	Average Host Buffer Rate	bytes/sec	4	1	2
2?83h	13	Window Host Buffer Rate	bytes/sec	4	1	2
2?84h	13	Host Buffer Efficiency	% * 65536	4	1	2
2?85h	13	Window Buffer Efficiency	% * 65536	4	1	2
2?88h	13	Average Host Transfer Length	bytes	4	2	2
2?8Ch	1	Average Host Sync Length	bytes	6	2	2
2?90h	13	Maximum Comp Transfer Rate	bytes/sec	4	1	2
2?91h	13	Average Comp Transfer Rate	bytes/sec	4	1	2
’2?92h	13	Average Comp Buffer Rate	bytes/sec	4	1	2
2?93h	13	Window Comp Buffer Rate	bytes/sec	4	1	2
2?94h	13	Comp Buffer Efficiency	% * 65536	4	1	2
2?95h	13	Window Comp Buffer Efficiency	% * 65536	4	1	2
2?98h	13	Average Comp Transfer Length	bytes	4	2	2
2?9Ch	1	Average Comp Sync Length	bytes	6	2	2
2?A0h	13	Maximum Tape Transfer Rate	bytes/sec	4	1	2
2?A1h	13	Average Tape Buffer Rate	bytes/sec	4	2	2
2?A2h	13	Window Tape Buffer Rate	bytes/sec	4	2	2
2?A3h	13	Moving Tape Buffer Rate	bytes/sec	4	2	2
2?A4h	13	Window Tape Buffer Efficiency	% * 65536	4	2	2
2?A5h	13	Moving Tape Buffer Efficiency	% * 65536	4	2	2

Table 82. Log Page 37h: Performance Characteristics: Mode Phase Timing Windows (continued)

2?A6h	13	Tape Buffer Efficiency: Ratio of amount of time we are usefully moving and ready with respect to amount of time the buffer is able to process data. A ratio larger than 1 indicates the compressed host data is arriving faster than the native device rate. Lower values indicate the device has underutilized host bandwidth.	% * 65536	4	2	2
2?A7h	13F	Tape Thrashing: Ratio of amount of time we are accelerating, decelerating or backhitching with respect to the time in mode.	% * 65536	4	2	2
2?A8h	13F	Tape Efficiency: Ratio of amount of time we are usefully moving and ready with respect to the time in mode.	% * 65536	4	1	2
2?F0h	13	Speed Changes	count	4	2	2
2?F1h	13	Speed Forced	count	4	2	2

Table 83. Log Page 37h: Performance Characteristics: Servo Speed Characteristics

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
5Fs0h	123456F	Servo Speed Relative Time	% * 65536	4	2	6

Table 84. Log Page 37h: Performance Characteristics: Static Capacity

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
7000h		Static Capacity Efficiency	% * 65536	4	1	4
7010h		Static Data sets Media	data sets	4	2	4
7011h		Static Data sets Used	data sets	4	2	4
7020h		Static Distance Media	mm	8	2	4
7021h		Static Distance Used	mm	8	2	4

Table 85. Log Page 37h: Performance Characteristics: Active Capacity

Code	Aspect(s)	Name : Description	Unit	Size	Level	Group
7?00h	13F	Active Capacity Efficiency	% * 65536	4	1	4
7?10h	13F	Active Sync Loss	% * 65536	4	2	4
7?11h	13F	Active Skip Loss	% * 65536	4	2	4
7?12h	13F	Active DSS Loss	% * 65536	4	2	4
7?13h	13F	Active CQs Loss (on-the-fly)	% * 65536	4	2	4
7?21h	13F	Active Distance Skip	mm	8	2	4
7?22h	13F	Active Distance DSS	mm	8	2	4
7?23h	13F	Active Distance CQs (on-the-fly)	mm	8	2	4
7?2Fh	13F	Active Distance Total	mm	8	2	4

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Log Page 38h: Blocks/Bytes Transferred (Not Ultrium 1 or Ultrium 2 non-RoHS)

This page is reset when a cartridge is loaded.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 86. Blocks/Bytes Transferred log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0000h	Host Write Blocks Processed: Each count represents a block processed across the host interface during a Write. The count does not include ERP retries.	4
0001h	Host Write Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed across the host interface during a Write. The count does not include ERP retries. This count may be divided by Device Write Kilobytes Processed, 0005h, to calculate an approximate write comparison ratio.	4
0002h	Host Read Blocks Processed: Each count represents a block processed across the host interface during a Read. The count does not include ERP retries.	4
0003h	Host Read Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed across the host interface during a Read. The count does not include ERP retries. This count may be divided by Device Read Kilobytes Processed, 0007h, to calculate an approximate read compression ratio.	4
0004h	Device Write Data sets Processed: Each count represents a data set processed on the medium. The count does not include ERP retries.	4
0005h	Device Write Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed on the medium. The count does not include ERP retries or any tape formatting overhead bytes.	4
0006h	Device Read Data sets Processed: Each count represents a data set processed from the medium. The count does not include ERP retries.	4
0007h	Device Read Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed from the medium. The count does not include ERP retries or any tape formatting overhead bytes.	4
0008h	Device Write Data sets Transferred: Each count represents a data set processed on the medium. The count includes ERP retries.	4
0009h	Device Write Kilobytes Transferred: Each count represents a kilobyte (1024 bytes) processed on the medium. The count includes ERP retries and any tape formatting overhead bytes.	4
000Ah	Device Read Data sets Transferred: Each count represents a data set processed from the medium. The count includes ERP retries.	4
000Bh	Device Read Kilobytes Transferred: Each count represents a kilobyte (1024 bytes) processed from the medium. The count includes ERP retries and any tape formatting overhead bytes.	4
000Ch	Nominal Capacity of Partition: The nominal capacity of the current partition (in kilobytes).	4
000Dh	Fraction of Partition Traversed: The fractional part of the current partition traversed (N/255).	1

Table 86. Blocks/Bytes Transferred log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
000Eh	Nominal Capacity of Volume: The nominal capacity of the mounted volume in kilobytes. This is not sensitive to current position.	4
000Fh	Fraction of Volume Traversed: The fractional part of the mounted volume traversed (N/255).	1
0010h	Remaining Capacity of Volume: The nominal unwritten remaining capacity of the mounted volume (in kilobytes). This is not sensitive to current position.	4
0011h	Remaining Capacity of Partition: The nominal unwritten remaining capacity of the current partition (in kilobytes). This is not sensitive to current position.	4
Note: When the tape does not have a valid EOD, or if a tape is not loaded, the drive will attempt to return a value of ’all ones’ (-1).		

Log Page 39h: Host Port 0 Interface Errors (Not Ultrium 1 or Ultrium 2 non-RoHS)

This page shows the count of errors occurring on primary port 1 (while the device is active on the interface).

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 87. Host Port Interface log parameter codes

Parameter Code (in Hex)	**Counter: Description**	**Size**
0000h	Host Protocol Errors: Each count represents one occurrence. Counts may include occurrences from both temporary and permanent errors. (On SAS drives, this parameter is not returned. See Table 69 on page 74, Protocol-Specific log page for SAS protocol error counts).	2
0007h	Host Aborts: Each count represents one occurrence. Counts may include occurrences from both temporary and permanent errors.	2
0008h	Host Resets: Each count represents one occurrence. Counts may include occurrences from both temporary and permanent errors.	2
0009h	Vendor-Reserved	2
000Ah	Vendor-Reserved	2
0010h	Host Recoveries: Each count represents one occurrence. Counts may include occurrences from both temporary and permanent errors. An example of a host recoveries is a Sequence Retransmission Request (SRR) on Fibre Channel drives. (Not returned on SAS drives)	4

Log Page 3Bh: Host Port 1 Interface Errors (Not Ultrium 1 or Ultrium 2 non-RoHS)

This page shows the count of errors occurring on primary port 2 (while the device is active on the interface).

Note: The parameters are identical to those found in "Log Page 39h: Host Port 0 Interface Errors (Not Ultrium 1 or Ultrium 2 non-RoHS)" on page 97, except this data is record for incidents that occur on primary port 2.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Log Page 3Dh: Subsystem Statistics (Not Ultrium 1 or Ultrium 2 non-RoHS)

The following counters all deal with subsystem statistics and errors. Most of the counters on this page are never reset. Most counters are maintained in VPD and persist across Log Selects, Log Sense, Power On Resets, and even microcode download. Lifetime values are written to VPD every eight operating hours when the drive is in a not ready state. The counters lock at maximum values.

WARNING

Log parameter data must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Table 88. Subsystem Statistics log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0020h	Volume Lifetime Mounts: The total number of successful cartridge unloads performed during the lifetime of a cartridge. This field may not be updated for mounts that occur with the volume physically write protected.	4
0021h	Volume Lifetime Megabytes Written: The total amount of data in Megabytes written during the lifetime of the cartridge. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed to the medium (compressed bytes), not at the host interface. This field may not be updated during mounts that occur with the volume physically write protected.	4
0022h	Volume Lifetime Megabytes Read: The total amount of data in Megabytes read during the lifetime of the cartridge. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed from the medium (compressed bytes), not at the host interface. This field may not be updated during mounts taht occur with the volume physically write protected.	4
0040h	Drive Lifetime Mounts: The total number of successful cartridge unloads performed during the lifetime of the drive.	4
0041h	Drive Lifetime Megabytes Written: The total amount of data in Megabytes written during the lifetime of the drive. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed to the medium (compressed bytes), not at the host interface.	4
0042h	Drive Lifetime Megabytes Read: The total amount of data in Megabytes read during the lifetime of the drive. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed from the medium (compressed bytes), not at the host interface.	4
0060h	Clean Lifetime Mounts: The total number of successful cleaner cartridge operations performed during the lifetime of the drive.	4
0061h	Megabytes Written Since Clean: The total amount of data in Megabytes written since the last successful clean operation. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed from the medium (compressed bytes), not at the host interface.	4

Table 88. Subsystem Statistics log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
0062h	Megabytes Read Since Clean: The total amount of data in Megabytes read since the last successful clean operation. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed from the medium (compressed bytes), not at the host interface.	4
0063h	Mounts Since Clean: The total number of mounts performed since the last successful clean operation.	4
0080h	Library Interface Messages Received: This counter is not stored in VPD and reflects messages received for which the drive sent a positive acknowledgement since reset.	4
0081h	Library Interface Messages Transmitted: This counter is not stored in VPD and reflects messages since reset. This is incremented every time a message is sent and does not imply that an acknowledgement was received.	4
0082h	Library Interface Resets: Count of hardware reset or logical re-initializations during normal operation. This is a link reset and not a power-on reset.	4
0083h	Library Interface Buffer Errors: This includes buffer overrun or underrun conditions. This includes both H/W and S/W buffers.	4
0084h	Library Interface Sync Errors: This is incremented any time an unexpected character or set of characters occurs outside of a frame.	4
0085h	Library Interface Framing Errors: This is incremented any time there is a length problem, a bad checksum, or a missing End character.	4
0086h	Library Interface Protocol Errors: This is incremented each time an extra or unexpected acknowledgement is received, as well as every time there are consecutive messages with the same Message ID.	4
0087h	Library Interface Logical Errors: This is incremented every time a logic error is seen in the received message (for example, Message Type error).	4
0088h	Library Interface Loader Failures: This counter reflects load/unload attempts when the drive is in an incorrect state, or was otherwise unable to attempt requested loader action. This is not a failure of a load/unload that was actually attempted by the drive.	4
0089h	Library Interface NAKs Received: This is incremented every time a Negative Acknowledgement is received.	4
008Ah	Library Interface Acknowledgement Timeout: This is incremented every time a timeout occurs while waiting for an acknowledgement (for example, Link timeout).	4
008Bh	Library Interface Application Layer Timeout: This is incremented every time the drive times out waiting for an application layer Response Message.	4
0090h	Drive Lifetime Write Perms: Total number of write permanent errors that occurred on this drive.	4
0091h	Drive Lifetime Read Perms: Total number of read permanent errors that occurred on this drive.	4
0092h	Drive Lifetime Load Perms: Total number of load permanent errors that occurred on this drive.	4
0093h	Drive Lifetime Unload Perms: Total number of unload permanent errors that occurred on this drive.	4

Table 88. Subsystem Statistics log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
00A0h	Drive Lifetime Write Temps: Total number of write temporary errors that occurred on this drive. **Note:** This is not a count of ERP actions taken, and certain transient errors may not be included in this count.	4
00A1h	Drive Lifetime Read Temps: Total number of read temporary errors that occurred on this drive. **Note:** This is not a count of ERP actions taken, and certain transient errors may not be included in this count.	4
00A2h	Drive Lifetime Load Temps: Total number of load temporary errors that occurred on this drive. **Note:** This is not a count of ERP actions taken, and certain transient errors may not be included in this count.	4
00A3h	Drive Lifetime Unload Temps: Total number of unload temporary errors that occurred on this drive. **Note:** This is not a count of ERP actions taken, and certain transient errors may not be included in this count.	4
0100h	Lifetime Power On Seconds: Cumulative number of seconds that the drive has been powered on. **Note:** Since this time is only periodically updated in non-volatile storage, it is possible that this time may not be entirely accurate to the full resolution of the counter.	4
0101h	Power On Seconds: Number of seconds since the drive was powered on or has undergone a hard reset condition.	4
0102h	Reset Seconds: Number of seconds since the drive has undergone a soft reset condition.	4

Log Page 3Ch: Drive Usage Information

This page allows users to obtain the information last stored regarding the counts accumulated over the life of the drive. Log Page 3Ch is returned in Log Page 00h.

This page is updated as events and tape pulling occurs. The nonvolatile memory is updated upon error events, the tape being unthreaded, or when the cartridge unloads. The counters are not cleared by any reset and cannot be changed with the LOG SELECT command. If power is lost before the update data is written to the nonvolatile memory, the counts are not updated.

Each parameter is a positive value. The counts do not overflow. Once a count reaches its maximum value, that maximum value is always returned. The counts do not roll over at the maximum value.

Table 89. Drive Usage Information Log Parameters

Parameter Code (in Hex)	Counter: Description	Size
0001h	Write Media Blocks Counter: This counter is a lifetime statistic representing the number of physical groups (i.e. Datasets) written during a write operation. Upon reaching the maximum value, the counter does not wrap back to zero, but retains its maximum value (FFFFFFFFFFFFFFFFh).	8
0002h	Rewrite Media Blocks Counter: This counter is a lifetime statistic representing the number of physical groups (i.e. Datasets) rewritten during a write operation. Upon reaching the maximum value, the counter does not wrap back to zero, but retains its maximum value (FFFFFFFFFFFFFFFFh).	8
0003h	Read Media Blocks Counter: This counter is a lifetime statistic representing the number of physical groups (i.e. Datasets) read during a read or space operation. The counter will not increment/decrement during space reverse, space LEOP, or space fast operations. Upon reaching the maximum value, the counter does not wrap back to zero, but retains its maximum value (FFFFFFFFFFFFFFFFh).	8
0004h	Reread Media Blocks Counter: This counter is a lifetime statistic representing the number of physical groups (i.e. Datasets) reread during a read operation. Upon reaching the maximum value, the counter does not wrap back to zero, but retains its maximum value (FFFFFFFFFFFFFFFFh).	8
000Eh	Undefined Parameter (0000h)	2
000Fh	Undefined Parameter (0000h)	2
0010h	Undefined Parameter (0000h)	2
0011h	Clean Requested Flag: This flag indicates the drive should be cleaned. 02h: Drive is not requesting clean 03h: Drive is requesting clean	1
0012h	Undefined Parameter (00h)	1
0013h	Undefined Parameter (000000h)	3
0014h	Undefined Parameter (000000h)	3
0015h	Cartridge Serial Number: This is right justified with leading spaces (20h). This value is update on cartridge load and retained until the next cartridge load. If no cartridge has been loaded since last power-on this value will be set to all spaces (20h).	12

MODE SELECT

The MODE SELECT command causes configuration data to be sent to the drive. For the format of Mode data and supported Mode pages see "MODE SENSE" on page 104. Both the 10-byte and 6-byte versions of the MODE SELECT command are supported.

Table 90. 6-Byte MODE SELECT Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (15h)							
1	Obsolete			PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Parameter List Length							
5	Control							

Table 91. 10-Byte MODE SELECT Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (55h)							
1	Obsolete			PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length							
9	Control							

The Page Format (PF) field may be any value. However, the drive assumes that the format is SCSI-2. The Save Pages (SP) field is only allowed to be set to 1 when explicitly mentioned in the description of the specific mode page. The Parameter List Length field should be set to the amount of data to be sent to the drive.

The Parameter List Length field should be set to the amount of data to be sent to the drive. The Parameter List Length value is checked to ensure that it is less than or equal to the sum of the lengths of all the supported mode pages. Any command with a larger value results in a Check Condition status. The associated sense data returns with a Sense Key of Illegal Request and an ASC/ASCQ of Invalid Field in CDB (2400).

If any of the fields in the Mode pages are invalid, no parameters are altered, Check Condition status is returned, the Sense Key is set to Illegal Request, and the ASC/ASCQ is set to Invalid Field in Parameter List (2600).

MODE SENSE

The MODE SENSE command requests that the drive send its configuration data to the initiator. Pages 01h, 02h, 0Fh, 10h, and 1Ch are supported. Mode Pages 18h and 19h are supported only on Fibre Channel drives . A page 3Fh request returns all supported pages.

Both the 10-byte and the 6-byte versions of the command are supported.

Table 92. 6-Byte MODE SENSE Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Ah)							
1	Obsolete			Reserved	DBD	Reserved		
2	PC		Page Code					
3	Reserved							
4	Allocation Length							
5	Control							

Table 93. 10-Byte MODE SENSE Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (5Ah)							
1	Obsolete			Reserved	DBD	Reserved		
2	PC		Page Code					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Allocation Length							
9	Control							

If the Disable Block Descriptors (DBD) field is set to 1, then no block descriptors are returned with the mode data. If it is set to 0, then block descriptors are returned.

The type of data returned is determined by the value of the Page Control (PC) field as follows:

- 00b means the current configuration.
- 01b means the changeable bitmap (changeable = 1; unchangeable = 0).
- 10b means the default (power-on) values.
- 11b means the saved values. Because the drive does not support saved values, the default values are returned.

The PC field only affects the mode parameters within the modes pages. It does not affect the mode parameter header or the mode block descriptor. Within the mode parameters, the PC field does not affect the PS field, the Page Code, or the Additional Page Length fields. These fields will return the current values, as there is no meaning if they are changed.

The Page Code must be set to the page to be returned.

Mode Data Format

Mode data returned by a MODE SENSE command or sent with a MODE SELECT command consists of a Mode Parameter Header, an optional Mode Block Descriptor, and zero or more Mode Parameter Pages.

Table 94. Mode Data Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : m	Mode Parameter Header							
m + 1 : m + 8	Mode Block Descriptor							
m + 9 : n	Mode Parameter Pages							

Mode Parameter Header

Table 95. Mode Parameter Header 6-Byte Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Mode Data Length							
1	Medium Type							
2	WP	Buffered Mode			Speed			
3	Block Descriptor Length							

Table 96. Mode Parameter Header 10-Byte Command

Byte	Bit 7	6	5	4	3	2	1	0
0 : 1	Mode Data Length							
2	Medium Type							
3	WP	Buffered Mode			Speed			
4	Reserved							
5	Reserved							
6 : 7	Block Descriptor Length							

In a MODE SENSE command, the Mode Data Length indicates the total amount of data available to be transferred. In a MODE SELECT command, this field is 0.

For Ultrium 1 devices, the Medium Type field is not used and must be set to 0.

For Ultrium 2 and Ultrium 3 devices, the Medium Type field on Mode Sense data is set to 00h when no media is loaded, to 18h when Ultrium 1 media is loaded, to 28h when Ultrium 2 media is loaded, and to 38h when Ultrium 3 media is loaded. On Mode Select commands, any value is allowed and ignored.

When the WORM media is loaded, the Medium Type field is logically or'ed with 0x04. Table 97 lists the Medium Type values.

Table 97. Media Type Values

Medium Loaded	Generation Drive 1	2	3	4
No media	00h	00h	00h	00h
Ultrium 1 Data	00h	18h	18h	18h
Ultrium 2 Data	N/A	28h	28h	28h
Ultrium 3 Data	N/A	N/A	38h	38h
Ultrium 3 WORM	N/A	N/A	3Ch	3Ch

Table 97. Media Type Values (continued)

Medium Loaded	Generation Drive			
	1	2	3	4
Ultrium 4 Data	N/A	N/A	N/A	48h
Ultrium 4 WORM	N/A	N/A	N/A	4Ch

The Write Protect field indicates whether the currently loaded tape is write protected in a MODE SENSE command. It is ignored in a MODE SELECT command.

Buffered Mode values dictate the behavior of the drive as follows:
- 0h (unbuffered) means that the drive will not report Good status on WRITE commands until the data blocks are actually written on the medium.
- 1h (buffered) means that the drive may report Good status on WRITE commands as soon as all the data specified in the WRITE command has been transferred to the logical unit's buffer. One or more blocks may be buffered prior to writing the blocks to the medium.
- 2h - 7h (unsupported modes) means that the drive will default to a value of 1h (buffered).

Speed: 0h (use default speed) (changeable)

Note: Selecting a specific speed is not recommended. The drive is designed to dynamically select the optimal speed to achieve maximum systemic performance. This is based on complex criteria including interface bandwidth, host throughput, data compressibility, etc.

The Block Descriptor Length is 0 if no Block Descriptor is transferred or 8 if a Block Descriptor is transferred. The Mode parameter value is stored for each initiator.

Mode Block Descriptor

Table 98. Mode Block Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0	Density Code							
1 : 3	Number of Blocks (0)							
4	Reserved							
5 : 7	Block Length							

The Density Code field returns a code identifying the format of the tape currently loaded in the drive. If there is no tape loaded, the code for the highest capacity format supported by the drive is returned. See Table 180 on page 180 for details of supported density codes.

The Number of Blocks field is 0.

The Block Length field indicates the length (in bytes) of each logical block to be used in subsequent READ, WRITE and VERIFY commands when the Fixed field is set to 1. (See “READ” on page 147, “VERIFY” on page 239, and “WRITE” on page 240.) A Block Length value of 0 indicates that only variable block transfers are allowed. The default value is 0. On Parallel SCSI or Fibre Channel devices this value must be an even number. On SAS devices, block lengths are limited to multiples of four. If a transfer of a unsupported block size is desired, a variable length (Fixed field set to 0 in READ, VERIFY, or WRITE command) transfer must be used.

Mode Page 01h: Read-Write Error Recovery Page

Table 99. Read-Write Error Recovery Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (0)	Reserved	Page Code (01h)					
1	Additional Page Length (0Ah)							
2	Reserved		TB (0)	Reserved	EER(1)	PER	DTE(0)	DCR(0)
3	Read Retry Limit							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Write Retry Limit							
9	Reserved							
10	Reserved							
11	Reserved							

On Ultrium 1 drives, a post error (PER) field is set to 0.

On Ultrium 2 and Ultrium 3 drives, a post error (PER) field of 1 specifies that the tape drive will return Check Condition status to report recovered errors. A PER field of 0 specifies that the tape drive will not report errors that are recovered within the limits established by the error recovery parameters. If this field is 0, the disable transfer on error (DTE) field must also be set to 0.

A DTE field of 0 specifies that the tape drive will not terminate the transfer for errors that are recovered within the limits that are established by the read-write error recovery parameters. On Ultrium drives, the DTE is always set to 0.

The Read Retry Limit is defined in Table 100

Table 100. Read Retry Limit Definition

Value	Description
00h - 04h	These values will be rounded to 05h
05h	Limited error recovery; < 5 seconds.
06h - FEh	These values may be rounded (to non-FFh)
FFh	Full Recovery Routines allowed (no time limit). (Default)

The Write Retry Limit is defined in Table 101 on page 111

Table 101. Write Retry Limit Definition

Value	Description
00h - 01h	These values will be rounded to 02h
02h	Limited error recovery; < 2 seconds.
03h - 04h	These values will be rounded to 05h
05h	Limited error recovery; < 5 seconds.
06h - FEh	These values may be rounded (to non-FFh)
FFh	Full Recovery Routines allowed (no time limit). (Default)

Mode Page 02h: Disconnect/Reconnect Page

Table 102. Disconnect/Reconnect Mode Page

Bit/Byte	7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (02h)					
1	Page Length (0Eh)							
2	Buffer Full Ratio (00h)							
3	Buffer Empty Ratio (00h)							
4	(MSB)	Bus Inactivity Limit						
5								(LSB)
6	(MSB)	Disconnect Time Limit (0000h)						
7								(LSB)
8	(MSB)	Connect Time Limit						
9								(LSB)
10	(MSB)	Maximum Burst Size						
11								(LSB)
12	EMDP(0)	Fair Arbitration (0h)			DIMM	DTDC (0h)		
13	Reserved							
14	(MSB)	First Burst Size (0000h)						
15								(LSB)

The Bus Inactivity Limit field for parallel SCSI and Fibre Channel drives is zero. For SAS drives this field is reported but is not changeable.

The Connect Time Limit field for parallel SCSI and Fibre Channel drives is zero. For SAS drives this field is reported but is not changeable.

The Maximum Burst Size field for the Fibre Channel, SAS, and Ultra 320 interfaces indicates the sequence size that the drive should attempt to use when transferring data. The value for the Maximum Burst Size field is stored for each initiator.

For Fibre Channel and SAS attached drives

- Any value is allowed and ignored.

For Ultra 320 attached drives:

- If information unit transfers are disabled the Maximum Burst Size field indicates the maximum amount of data that the SCSI target port shall transfer during a DATA phase before doing a physical disconnect if the SCSI initiator port has granted the physical disconnect privilege.
- If information unit transfer are enabled the Maximum Burst Size field indicates the maximum amount of data that the SCSI target port shall transfer in a single SPI data information unit.
- The maximum burst size is expressed in increments of 512 bytes (e.g., a value of one means 512 bytes, two means 1 024 bytes, etc.). A value of zero indicates there is no limit on the amount of data transferred per burst.

On Ultra 320 attached drives, the DIMM bit is set to one. On all other drives the DIMM bit is set to 0.

The Buffer Full Ratio and Buffer Empty Ratio fields will be 0, because buffer management is controlled by the drive.

The Bus Inactivity Limit, Disconnect Time Limit, and Connect Time limit fields are not supported and must be set to 0.

The Data Transfer Disconnect Control field is not supported and must be set to 0.

Mode Page 0Ah: Control Extension Mode Page

The mode page policy for this mode page is shared.

Table 103. Control Extension Mode Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	SPF (1b)	Page Code (0Ah)					
1	Subpage Code (01h)							
2	(MSB)	Page Length (1Ch)						
3								(MSB)
4	Reserved					TCMOS	SCIP	IALUAE(0)
5	Reserved				Initial Priority (0)			
6	Reserved							
31								

A Timestamp Changeable by Methods Outside this Standard (TCMOS) bit set to one specifies that the timestamp may be initialized by methods outside the scope of this standard (for example The LDI Set Timestamp command). A TCMOS bit set to zero specifies that the timestamp shall not be changed by any method except those defined by this standard.

A SCSI precedence (SCSIP) bit set to one specifies that the timestamp changed using a SET TIMESTAMP command takes precedence over methods outside the scope of this standard (for example The LDI Set Timestamp command). A SCSIP bit set to zero specifies that methods outside this standard (for example The LDI Set Timestamp command) may change the timestamp and that the SET TIMESTAMP command is illegal.

Mode Page 0Fh: Data Compression Mode Page

Table 104. Data Compression Mode Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS (0)	Reserved	Page Code (0Fh)					
1	Additional Page Length (0Eh)							
2	DCE	DCC(1)	Reserved					
3	DDE(1)	RED (00b)		Reserved				
4 : 7	Compression Algorithm (1)							
8 : 11	Decompression Algorithm (1)							
12	Reserved							
13	Reserved							
14	Reserved							
15	Reserved							

A data compression enable (DCE) field of 1 indicates that data compression is determined by the state of the Select Data Compression Algorithm field of the Sequential Access Device Configuration Page (10h). The Sequential Access Device Configuration Page (10h) need not be present in the same MODE SELECT command. The drive will examine the current state of the Select Data Compression Algorithm to determine if compression is to be enabled or disabled. The default for DCE is 1. If DCE is 0, the drive uses Scheme 2 of the LTO-DC algorithm (passthrough mode).

Note: The result of this is that the only way to turn compression on is for both the DCE field of the Data Compression Mode Page (0Fh) and the Select Data Compression Algorithm field of the Sequential Access Device Configuration Page (10h) to be set to 1.

A data decompression enable (DDE) field is set to 1 to specify that data decompression is enabled.

The report exception on the decompression (RED) field is set to 00b and specifies the response to certain boundaries that the drive detects in the data on the medium. Table 105 on page 115 describes those responses.

Table 105. Responses to Data Boundaries

Prior Data	Current Data	Response Sense Key (see Notes® 1 and 2)
Uncompressed	Compressed unsupported algorithm	Medium Error
Uncompressed	Compressed supported algorithm	None
Compressed supported algorithm	Uncompressed	None
Compressed supported algorithm	Compressed unsupported algorithm	Medium Error
Compressed unsupported algorithm	Uncompressed	None
Compressed unsupported algorithm	Compressed supported algorithm	None
All other combinations	- -	None

Notes:

1. `None` in the Response Sense Key column means that no Check Condition status is returned, given the data boundary condition and the current value of the Report Exception on the Decompression (RED) field.
2. The appropriate additional sense code (ASC) is specified as follows:
   - The drive will return a Check Condition status when data is encountered on a medium (during a read operation) that the device is unable to decompress. In this table, data boundaries that are marked other than `None` in Response Sense Key column will generate Check Condition status with the specified sense key.
   - If the application client selects an algorithm that the drive does not support, the drive will return a Check Condition status. The Sense Key must be set to Illegal Request and the ASC must be set to Invalid Field in Parameter List. The SELECT DATA COMPRESSION ALGORITHM field in the Device Configuration mode page will be ignored if a Data Compression mode page with the DCE field set to 1 is also received by the device in the same MODE SELECT command.

No other fields are changeable.

Mode Page 10h: Sequential Access Device Configuration Page

Table 106. Sequential Access Device Configuration Page

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS (0)</td><td>Reserved</td><td colspan="6">Page Code (10h)</td></tr>
<tr><td>1</td><td colspan="8">Additional Page Length (0Eh)</td></tr>
<tr><td>2</td><td>Reserved</td><td>CAP (0)</td><td>CAF (0)</td><td colspan="5">Active Format (0)</td></tr>
<tr><td>3</td><td colspan="8">Active Partition (0)</td></tr>
<tr><td>4</td><td colspan="8">Write Buffer Full Ratio (0)</td></tr>
<tr><td>5</td><td colspan="8">Read Buffer Empty Ratio (0)</td></tr>
<tr><td>6
:
7</td><td colspan="8">Write Delay Time</td></tr>
<tr><td>8</td><td>DBR (0)</td><td>BIS (1)</td><td>RSmk (0)</td><td>AVC (0)</td><td colspan="2">SOCF (0)</td><td>RBO (0)</td><td>REW (0)</td></tr>
<tr><td>9</td><td colspan="8">Gap Size (0)</td></tr>
<tr><td>10</td><td colspan="3">ED Defined (0)</td><td>EEG (1)</td><td>SEW (0)</td><td>SWP (0)</td><td colspan="2">Reserved</td></tr>
<tr><td>11
:
13</td><td colspan="8">Buffer Size at Early Warning (0)</td></tr>
<tr><td>14</td><td colspan="8">Select Data Compression Algorithm</td></tr>
<tr><td>15</td><td colspan="2">WTRE</td><td>OIR</td><td colspan="2">Rewind on Reset (0)</td><td>ASOCWP (0)</td><td>PERSWP (0)</td><td>PRMWP (0)</td></tr>
</table>

The WRITE DELAY TIME field specifies the maximum time, in 100 ms increments, that the device server should wait before any buffered data that is to be written, is forced to the medium after the last buffered WRITE command that did not cause the object buffer to exceed the write object buffer full ratio.

WARNING
Changing the Write Delay Time may result in adverse performance

The Active Partition field will be 0 because multiple partitions are not supported.

The Change Active Format (CAF) and Active Format fields will be 0 because changing formats is not supported.

The Write Buffer Full Ratio and Read Buffer Empty Ratio fields will be 0 because buffer management is done by the drive.

The Data Buffer Recovery (DBR), Report Set Marks (RSmk), Stop On Consecutive File Marks (SOCF), Recover Buffer Order (RBO), Report Early Warning on Read (REW), and Synchronize at Early Warning fields must be set to 0 because these features are not supported.

The Automatic Velocity Control (AVC) field must be set to 0 because velocity control is managed by the drive.

The Gap Size field must be set to 0 because there is no concept of inter-block gaps in the format.

The Block Identifiers Supported (BIS) field must be set to 1 because block identifiers are supported.

The enable EOD generation (EEG) field must be set to 1 because the drive always generates EOD.

The Buffer Size at Early Warning field will be 0, as this cannot be set.

The default value for the Select Data Compression Algorithm is 1 and indicates that data compression is enabled if the state of the DCE field of the Data Compression Mode Page (0Fh) is set to 1. The Data Compression Mode Page (0Fh) need not be present in the same MODE SELECT command. The drive will examine the current state of the DCE to determine if compression is to be enabled or disabled. If Select Data Compression Algorithm is 0, the drive uses Scheme 2 of the LTO-DC algorithm (passthrough mode).

Note: The result of this is that the only way to turn compression on is for both the DCE field of the Data Compression Mode Page (0Fh) and the Select Data Compression Algorithm field of the Sequential Access Device Configuration Page (10h) to be set to 1.

The WORM Tamper Read Enable (WTRE) field is supported only on Ultrium 3 drives.

The WORM Tamper Read Enable (WTRE) field has no effect on the processing of a locate, read, space, or verify operation when the drive contains a non-WORM medium.

Only If Reserved (OIR): Changeable on some Ultrium 3 code levels. Default is zero. Set to zero and not changeable on Ultrium 1 and Ultrium 2 drives.

The WTRE field specifies how the drive responds to detection of compromised integrity of a WORM medium when processing a locate, read, space, or verify operation.

Value	Action Taken by Drive
00b	If the drive detects compromised integrity on a WORM medium, it will return CHECK CONDITION status and set the sense key to MEDIUM ERROR and the additional sense code to WORM MEDIUM - INTEGRITY CHECK. (3/300Dh). The position of the medium may have changed.
01b	Detection of compromised integrity on a WORM medium shall not affect processing of a task. **Note:** An application client should set the WTRE bit to 01b only for the recovery of data from a WORM medium where the integrity of the stored data has been compromised.
10b	If the drive detects compromised integrity on a WORM medium it will return CHECK CONDITION status and set the sense key to MEDIUM ERROR and the additional sense code to WORM MEDIUM - INTEGRITY CHECK. (3/300Dh). The position of the medium may have changed.
11b	Reserved

The drive sets the WTRE field to 10b following a unit attention condition for a not-ready-to-ready transition.

Mode Page 18h: Protocol-Specific Logical Unit Control Page

There is one copy of this page for each initiator. This page is defined for Fibre-Channel-attached devices in Table 107. This page is defined for SAS attached devices in Table 108.

Table 107. Fibre Channel Logical Unit Control Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS (0)	Reserved	Page Code (18h)					
1	Page Length (06h)							
2	Reserved				Protocol Identifier (0h)			
3	Reserved							EPDC
4 : 7	Reserved							

Enable Precise Delivery Control (EPDC), when set to 1b, enables checking of a Fibre Channel Command Reference Number and ensures that the command packets are delivered in order.

The Protocol Identifier is set to 0h, which indicates that this is for use with the FCP protocol.

Table 108. SAS Logical Unit Control Page

Bit/Byte	7	6	5	4	3	2	1	0
0	PS	SPF(0)						
1	Page Length (06h)							
2	Reserved			TLR (1)	Protocol Identifier (6h)			
3	Reserved							
4	(MSB) Reserved							
7								(LSB)

Mode Page 19h: Protocol Specific Port Control Page

There is one copy of this page per primary port. This page is defined for Fibre channel drives in Table 109 and for SAS drives in Table 110 on page 121.

Ultra 320 drives provide the short format page shown in Table 111 on page 122 as well as additional subpages defined in Table 112 on page 123 and "Report Transfer Capabilities mode subpage" on page 125. Note that SPI-5 states for Parallel SCSI devices, "Each SCSI target port shall maintain an independent set of Port Control mode page parameters for each SCSI initiator port." The Ultra 320 drives only support set of Port Control mode page parameters.

Table 109. Fibre Channel Port Control Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS (0)	Reserved	Page Code (19h)					
1	Page Length							
2	Reserved							
3	DTFD (0)	PLPB (0)	DDIS (0)	DLM (0)	RHA (0)	ALWI (0)	DTIPE (0)	DTOLI (0)
4 : 5	Reserved							
6	Reserved					RR_TOV Units		
7	Resource Recovery Time Out Value (RR_TOV)							
8	Reserved						Control MCM (01b)	
9 : 10	Reserved							
11	Originator CMRs Per Port (0)							
12	Reserved							
13	Responder CMRs Per Port (0)							
14 : 15	MCM_TOV (0)							

The Page Length field is returned by Mode Sense commands and should be set by Mode Select commands on Ultrium 1 drives as 0Eh, and on Ultrium 2 and Ultrium 3 drives as 06h.

The Page Length field returns the number of remaining bytes. On Ultrium 1 drives this value is 0Eh. On Ultrium 2 and Ultrium 3 drives this value is 06h.

The Resource Recovery Time Out Value (RR_TOV) is the minimum amount of time that the drive will wait for an expected response before implicitly cleaning up the resources that are related to that initiator. This may, depending on the circumstances, implicitly log-out the initiator that stopped communicating with the drive.

Care should be taken when adjusting this value, because a value that is too small has the potential to cause resources to be discarded prior to the completion of a class 3 error recovery and to prematurely log-out an initiator. It also has the potential, when the value is set too large, to cause command time-outs for non-failing initiators in a multi-initiator environment, if one of the initiators fails.

The Protocol Identifier is set to 0h, which indicates that this is for use with the FCP protocol.

Resource Recovery Time Out Value (RR_TOV) Units can have the following values:
- 000b (no timer is specified)
- 001b (timer is specified in .001-second units)
- 011b (timer is specified in .1-second units)
- 101b (timer is specified in 10-second units)

RR_TOV Value can be between 0 and FFh.

The following conditions will round the RR_TOV. If the value is rounded, a Recovered Error, Mode Parameters Rounded Check Condition is presented.
- The value of RR_TOV that is determined by the RR_TOV Units and RR_TOV Value fields is less than the minimum supported value (RR_TOV set to Minimum Value)
- The value of RR_TOV that is determined by the RR_TOV Units and RR_TOV Value fields is greater than the maximum supported value (RR_TOV set to Maximum Value)
- The RR_TOV Units is an unsupported value (RR_TOV set to Default Value)

Note that when the RR_TOV value is returned from the drive, it may be returned using different RR_TOV Units than were used to set the value in a previous Mode Select command.

Table 110. SAS Port Control Page

<table>
<tr><th>Bit/Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS</td><td>SPF (0)</td><td colspan="6">Page Code (19h)</td></tr>
<tr><td>1</td><td colspan="8">Page Length (06h)</td></tr>
<tr><td>2</td><td colspan="3">Reserved</td><td>Ready LED Meaning (0)</td><td colspan="4">Protocol Identifier</td></tr>
<tr><td>3</td><td colspan="8">Reserved</td></tr>
<tr><td>4</td><td colspan="8">(MSB)
I_T Nexus Loss Time (07D0h)</td></tr>
<tr><td>5</td><td colspan="8">(LSB)</td></tr>
<tr><td>6</td><td colspan="8">(MSB)
Initiator Response Timeout (07D0h)</td></tr>
<tr><td>7</td><td colspan="8">(LSB)</td></tr>
</table>

Protocol Specific Port Control Page short format (Ultra 320 attached drives only)

The Protocol Specific Port Control Page short format for Ultra 320 drives is defined in TableáTable 111.

Table 111. Protocol Specific Port Control Page short format (U320 only)

Bit/Byte	7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (19h)					
1	Page Length (06h)							
2	Reserved				Protocol Identified (1h)			
3	Reserved							
4	(MSB)	Synchronous Transfer Timeout (0000h)						
5								(LSB)
6	Reserved							
7	Reserved							

Negotiated Settings mode subpage

The Negotiated Settings mode subpage is used to report the negotiated settings of the drives port and is defined in Table 112.

Table 112. Negotiated Settings mode subpage (U320 drives only)

Bit/Byte	7	6	5	4	3	2	1	0
0	PS	SPF (1)	Page Code (19h)					
1	Subpage Code							
2	(MSB)	Page Length (0Ah)						
3								(LSB)
4	Reserved							
5	Reserved				Protocol Identified (1h)			
6	Transfer Period Factor							
7	Reserved							
8	REQ/ACK Offset							
9	Transfer Width Exponent							
10	Rsvd	Protocol Options Bits						
		RTI	RD_STRM	WR_ FLOW	HOLD_ MCS	QAS_ REQ	DT_REQ	IU_REQ
11	Reserved				Transceived Mode (10b)		Sent PCOMP_EN	Received PCOMP_EN
12	Reserved							
13	Reserved							

The Transfer Period Factor field indicates the negotiated transfer period factor for the current I_T nexus. See Table 113 on page 124.

Table 113. Transfer Period Factor

Value	Description	Transfer Rate
00h-06h	Reserved	N/A
07h	Transfer period equals 3.125 ns	Fast-320
08h	Transfer period equals 6.25 ns	Fast-160
09h	Transfer period equals 12.5 ns	Fast-80
0Ah	Transfer period equals 25 ns	Fast-40
0Bh	Transfer period equals 30.3 ns	Fast-40
0Ch	Transfer period equals 50 ns	Fast-20
0Dh - 18h	Transfer period equals the TRANSFER PERIOD FACTOR x 4	Fast-20
19h - 31h	Transfer period equals the TRANSFER PERIOD FACTOR x 4	Fast-10
32h - FFh	Transfer period equals the TRANSFER PERIOD FACTOR x 4	Fast-5

The REQ/ACK Offset field indicates the negotiated REQ/ACK offset for the current I_T nexus

The Transfer Width Exponent field indicates the negotiated transfer width exponent for the current I_T nexus. See Table 114

Table 114. Transfer Width Exponent

Value	Description
00h	Specifies 8 bit data bus (i.e., narrow transfer agreement).
01h	Specifies 16 bit data bus (i.e., wide transfer agreement).
02h	Obsolete
03h-FFh	Reserved

The Protocol Options Bits field contain the negotiated protocol options for the current I_T nexus.

The Received PCOMP_EN bit contains the value of the PCOMP_EN bit received by the SCSI target port for the current I_T nexus.

The Sent PCOMP_EN bit contains the value of the PCOMP_EN bit sent by the SCSI target port for the current I_T nexus.

Report Transfer Capabilities mode subpage

The Report Transfer Capabilities mode subpage is used to report transfer capabilities of the drives port and is defined in Table 115

Table 115. Report Transfer Capabilities mode subpage (U320 drives only)

Bit/Byte	7	6	5	4	3	2	1	0
0	PS	SPF (1)	Page Code (19h)					
1	Subpage Code (04h)							
2	(MSB)	Page Length (0Ah)						
3								(LSB)
4	Reserved							
5	Reserved				Protocol Identified (1h)			
6	Minimum Transfer Period Factor (06h)							
7	Reserved							
8	Maximum REQ/ACK Offset							
9	Maximum Transfer Width Exponent (01h)							
10	Protocol Options Bits Supported							
	PCOMP _EN(1)	RTI (0)	RD_STRM (0)	WR_FLOW (0)	HOLD_MCS (0)	QAS_REQ (0)	DT_REQ (1)	IU_REQ (1)
11	Reserved							
12	Reserved							
13	Reserved							

The Minimum Transfer Period Factor field shall be set to the smallest value of the transfer period factor supported by the SCSI target port.

The Maximum REQ/ACK Offset shall be set to the largest value of the REQ/ACK offset supported by the SCSI target port.

The Maximum Transfer Width Exponent shall be set to the largest value of the transfer width exponent supported by the SCSI target port.

The SCSI target port shall set the bits in the Protocol Options Bits Supported field to indicate the protocol options supported by the SCSI target port.

Mode Page 1Ch: Information Exceptions Mode Page

Table 116. Information Exceptions Mode Page

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS (0)</td><td>Reserved</td><td colspan="6">Page Code (1Ch)</td></tr>
<tr><td>1</td><td colspan="8">Page Length (0A)</td></tr>
<tr><td>2</td><td>Perf (0)</td><td colspan="3">Reserved</td><td>DExcpt</td><td>Test</td><td>Reserved</td><td>LogErr(0)</td></tr>
<tr><td>3</td><td colspan="4">Reserved</td><td colspan="4">MRIE (3)</td></tr>
<tr><td>4
:
7</td><td colspan="8">Interval Timer (0)</td></tr>
<tr><td>8
:
11</td><td colspan="8">Report Count (0)</td></tr>
</table>

The Information Exceptions mode page is used to control Exception Reporting by using the TapeAlert log page.

A disable exception control (DExcpt) field of 0 indicates that reporting for failure prediction threshold exceeded will be enabled. The method for reporting the failure prediction threshold exceeded when the DExcpt field is set to 0 is determined from the MRIE field. A DExcpt field of 1 indicates that the target will disable reporting of the failure prediction threshold exceeded. The default value for DExcpt is 0.

If the Test field is set to 1, the next command will fail, the Sense Key will be set to Unit Attention, and the ASC/ASCQ will be set to Failure Prediction Threshold Exceeded - False (5DFF). If the Test field is set to 0, the next command is processed normally. The default for Test is 0.

The Perf and LogErr fields will be 0. These features are not supported.

The MRIE field must be set to 3 (Conditionally generate recovered error). This method instructs the drive to report informational exception conditions (if the reporting of recovered errors is allowed) by returning a Check Condition status. If the Test field is set to 0, the status may be returned after the informational exception condition occurs on any command for which Good status would have been returned. If the Test field is set to 1, the status will be returned on the next command that is normally capable of returning an informational exception condition when the Test field is set to 0. The Sense Key must be set to Recovered Error and the Additional Sense Code will indicate the cause of the informational exception condition. This will be Failure Prediction Threshold Exceeded (5D00) if the Test field is set to 0 (true error), and Failure Prediction Threshold Exceeded -False (5DFF) if the Test field is set to 1 (test).

The command that returns the Check Condition status for the informational exception will complete without error before any informational exception condition may be reported. The Interval Timer and Report Count must be set to 0. These fields are not supported.

Mode Page 1Dh: Medium Configuration Mode Page

The Medium Configuration Mode Page (see Table 117) specifies any special considerations the drive will use when processing commands when there is a WORM medium loaded in the drive. This page is supported only on Ultrium 3 drives. This page is returned when requested by a Mode Sense command indicating either this page or all pages (3Fh).

Table 117. Medium Configuration Mode Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS (0)	SPF(0)	Page Code (1Dh)					
1	Page Length (1Eh)							
2	Reserved							WORMM
3	Reserved							
4	Worm Mode Label Restrictions (01h)							
5	Worm Mode Filemark Restrictions (02h)							
6-31	Reserved							

The WORMM bit is set to 1 when the drive is operating in WORM mode. The WORMM bit is set to 0 when the drive is not operating in WORM mode. If a Mode Select command is processed that attempts to change the setting of the WORMM bit, the drive returns a Check Condition status, with the sense key set to Illegal Request, and the addition sense code set to Invalid Field In Parameter List.

The Worm Model Label Restrictions field specifies the restrictions against overwriting format labels when operating in WORM mode (see Table 118).

A series of filemarks with no interleaved logical blocks immediately preceding EOD is treated as a filemark sequence and controlled by the Worm Mode Filemarks Restrictions field.

Table 118. Worm Mode Label Restrictions field values

Worm Mode Label Restrictions	Description
00h	The drive does not allow any logical blocks to be overwritten. (Not Supported)
01h	The drive allows a tape header to be overwritten. The tape header is defined as 0, 1, or 2 logical blocks followed by nothing except 0 to *n* Filemarks and EOD. This must be overwritten from BOP.
02h	The drive allows all format labels to be overwritten. (Not Supported)
03h - FFh	Reserved

The Worm Mode Filemarks Restrictions field specifies the restrictions against overwriting a series of filemarks immediately preceding EOD when operating in WORM mode (see Table 119 on page 128). This field controls only the overwriting of a series of filemarks with no interleaved logical blocks immediately preceding EOD.

Table 119. Worm Mode Filemarks Restrictions field values

Worm Mode Label Restrictions	Description
00h - 01h	Reserved
02h	The drive allows any number of filemarks immediately preceding EOD to be overwritten, except the filemark closest to BOP.
03h	The drive allows any number of filemarks immediately preceding EOD to be overwritten. (Not Supported)
04h - FFh	Reserved

Vendor-Specific Control Mode Page

The Vendor-Specific Control Mode Page provides control over undocumented test options. Modifying these values could have adverse effects on the drives operation. As such, this page should never be used in a Mode Select operation. A Mode Sense of this page may be used to determine if the drive supports encryption. The Vendor-Specific Control Mode Page is defined in .

Table 120. Vendor-Specific Control Mode Page

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS (0)</td><td>SPF(0)</td><td colspan="6">Page Code (24h)</td></tr>
<tr><td>1</td><td colspan="8">Page Length (06h)</td></tr>
<tr><td>2</td><td colspan="8">Vendor-Specific Mode Control</td></tr>
<tr><td>3</td><td colspan="8">Vendor-Specific Velocity Setting</td></tr>
<tr><td>4
6</td><td colspan="8">Vendor-Reserved</td></tr>
<tr><td>7</td><td colspan="4">Vendor-Reserved</td><td>Encr_E</td><td colspan="2">Vendor-Reserved</td><td>Encr_C</td></tr>
</table>

The encryption enabled (Encr_E) bit set to zero indicates that encryption is not enabled in the drive. Data written will be written in clear text. The Encr_E bit set to one indicates that encryption is enabled in the drive.

Note: There are multiple encryption methods, Application Managed Encryption (AME), System Managed Encryption (SME), and Library Managed Encryption (LME). When the drive is configured for SME or LME encryption is transparent to the application and the Security Protocol In command will report no encryption support.

The encryption capable (Encr_C) bit set to zero indicates that the drive hardware does not support encryption. The Encr_C bit set to one indicates the drive hardware supports encryption but does not indicate if encryption is currently enabled.

28-31 Vendor-Reserved

Mode Page 2Fh: Behavior Configuration Mode Page

There is one copy of this page for the drive.

Ultrium drive support for the fields in this page vary by generation and/or code level. To discover if a field can be modified, issue a Mode Sense with a PC field of 01 to see if the field is changeable. This will also return the Page Length, which must be examined to determined the length of this page, because it is expected to increase as additional Behavior configurations are added to subsequent code levels.

WARNING: This page changes the normal behavior of the drive. Some settings effect error reporting and may even cause the drive to violate SCSI standards. Care should be taken to ensure that the behavior change is understood and what its effects on the system will be.

Table 121. Behavior Configuration Mode Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (2Fh)					
1	Page Length (*n*-1)							
2	Fence Behavior							
3	Clean Behavior							
4	"Emulate WORM"							
...	Sense Data Behavior							
5	Reporting Behavior							
6	Rsvd	Rsvd	Rsvd	Rsvd	Rsvd	CCDM	DDEOR	CLNCHK
. . .	A Check Condition for Dead Media (CCDM) bit set to one specifies that a Check Condition, Sense Key = 1h, ASC/ASCQ 8252h (Degraded Media) will be returned after a Rewind command when the criteria are met to set the Dead Media flag in Log Page 3Ch. A CCDM bit set to zero does not specify that a Check Condition will be returned when the Dead Media criteria are met. The default value of this bit is zero (default is one if manufactured as an eServer drive).							
n	Reserved for Future Use							
8	Unload On Error Behavior							
	Reserved		UOE-C		UOE-F		UOE-D	
. . .								
n	Reserved for Future Use							

Fence Behavior (Byte 2)

This field defines drive behavior in situations deemed dangerous for either media or data on the media.

Table 122. Fence Behavior Selection Values

Description	Value
Normal Operation (default) Mid-Tape Recovery (MTR) Fence Only	00h
Panic Fence Feature Enabled	01h
Reserved	02h - FFh

Normal Operation (0): The behavior of the drive after a Panic or Exception when in normal operation is defined below).

When the drive comes up after a Panic or Exception and no cartridge is detected, the drive will respond to SCSI commands as follows (Steps 1 and 2 are returned in response to any check condition eligible command):

1. 6/2900 sense is returned.
2. 2/3e00 is returned during POST.
3. When POST completes, enter normal operation.

When the drive comes up and detects a cartridge, it requires Mid-Tape Recovery (MTR) and will responsd to SCSI commands as follows (Steps 1 through 5 are returned in response to any check condition eligible command):

1. 6/2900 is returned.
2. 2/3e00 is returned during POST.
3. 2/0400 is returned during Mid-Tape Recovery/Unload.
4. 2/0401 is returned during Mid_Tape Recovery/Load.
5. 6/2800 is returned after cartridge is loaded.
6. Enter into the MTR Fence State.
   a. TUR commands will return GOOD status.
   b. Return 5/2C00 Sense for all medium access commands.
   c. Exit MTR Fence State when an explicit positioning command completes successfully (that is, Locate, Rewind, Load).

Panic Fence Feature Enabled (01h): The behavior of the drive after the Panic or Exception when the Panic Fence Feature is enabled is defined below.

When the drive comes up after a Panic of Exception and no cartridge is detected, the drive will respond to SCSI commands as follows (Steps 1 and 2 are returned in response to any check condition eligible command):

1. 6/2900 sense is returned.
2. 2/3e00 is returned during POST.
3. When POST completes, enter into the Panic Fence state. In the Panic Fence state:
   a. SCSI commands other than RSNS/INQ/RLUNs/Read Buffer/TUR are rejected with 5/2904 sense, indicating Panic Fence state.
   b. TUR commands will return 5/2904 sense.
   c. Load of a cartridge through any means is not allowed.
   d. SCSI Read Buffer to read dump data is accepted at any time.
   e. Once dump has been read, go to normal mode.

When the drive comes up and detects Mid-Tape Recovery (MTR), it will respond to SCSI commands as follows (steps 1 through 5 are returned in response to any check condition eligible command):

1. 6/2900 sense is returned.
2. 2/3e00 is returned during POST.
3. 2/0400 is returned during Mid-Tape Recovery/Unload.
4. 2/0401 is returned during Mid-Tape Recovery/Load.
5. 6/2800 is returned after cartridge is loaded.
6. Enter into the Panic Fence state.

a. SCSI commands other than RSNS/INQ/RLUNs/Read Buffer/TUR/Load with the load bit set to 0 are rejected with 5/2904 sense, indicating Panic Fence state.
b. TUR commands will return GOOD status while tape is loaded.
c. TUR commands will return 5/2904 sense after the tape is unloaded.
d. Unload command through SCSI/LDI/Button can be executed anytime.
e. Load of a cartridge through any means is not allowed.
f. SCSI Read Buffer to read dump data is accepted at any time.
g. Once dump has been read, if the tape is still loaded, transition to MTR Fence state. If tape is still not loaded, exit from Panic Fence state and go to normal mode.

7. MTR Fence state.
   a. TUR commands will return GOOD status.
   b. Return 5/2C00 Sense for all medium access commands.
   c. Exit MTR Fence State when an explicit positioning command completes successfully (that is, Locate, Rewind, Load).

After description of Firmware Update Behavior (i.e. at the end of the Behavior Configuration Mode Page description) add the following subsection:
- Bad Media causes a mount failure;
- FMR cartridge is loaded when it has not been requested;
- Expired cleaner cartridge is loaded; or
- An invalid or unsupported cleaner cartridge is loaded.

Clean Behavior (Byte 3)

This field defines the behavior of the drive related to cleaning.

Description	Value
Normal Operation (default)	00h
Periodic Clean Notification Enabled	01h
Reserved	02h - FFh

Periodic Clean Notification Enabled (01h): The drive shall monitor the number of write and read datasets since last cleaning. When the number of write/read datasets exceeds the criteria the drive will put itself in a clean notification needed state. The criteria used is subject to change, but the current criteria is listed in Table 123.

Table 123. Periodic Clean Notification Usage Criteria

Generation Drive	Data Sets Processed	Equivalent Full File Passes (Approximate)	Meters of tape pulled accross head
Ultrium 1	10,000,000	38	N/A
Ultrium 2	10,000,000	19	N/A
Ultrium 3	10,000,000	38	N/A
Ultrium 4	12,000,000	23	5,000,000

When entering this state the drive shall set the Drive Status Flags 1, Byte 7, Bit 6: Drive Clean Required as defined in the LDI and the drive shall set TapeAlert flag 21.

This drive will remain in this state until a successful cleaning cycle or a Power On Reset occurs. (e.g. If there is another data cartridge inserted without the drive having been cleaned, the drive will function as normal. Once the TapeAlert is reported the first time it will be cleared following normal TapeAlert rules. The Drive Status Flags will function as defined in the LDI.)

WORM Behavior (Byte 4)

This field defines the behavior of the drive related to WORM.

Table 124. WORM Behavior

Description	Value
Normal Operation (default - reset to this value on Medium Removal)	00h
Data Cartridge Emulates WORM (Ultrium 3 and later)	01h
Reserved	02h - FFh

Data Cartridge Emulates WORM (01h): Treat Data Cartridge like a WORM cartridge. When a data cartridge is inserted into the drive the drive will report that it is WORM media and the drive will behave like the media is WORM. It will follow all overwrite rules. This Emulate mode will be cleared after cartridge unload. There will be no emulation of the WORM tampering responses. Sense code of 300Dh is never reported in WORM Emulation mode. WTRE can be set in the Sequential Access Device Configuration Mode page (10h), this does not affect drive behavior in emulation mode.

Sense Data Behavior (Byte 5):

Table 125. Sense Data Behavior

Description	Value
Use 35-byte request Sense data (Not supported on Ultrium 3 Drives) (Default on Ultrium 2 RoHS Drives)	00h
Use 96-byte Request Sense data (Not supported on Ultrium 1 and Ultrium 2 non-RoHS Drives)	01h
Reserved for future use	02h - FFh
Note: Regardless of this setting, when the sense data is associated with an Illegal Length read, an 18-byte Request Sense data may be used.	

Reporting Behavior (Byte 6): This byte defines behaviors related to reporting conditions across the primary interface.

A Clean Check (CLNCHK) bit set to one specifies that a Check Condition, Sense Key 0h ASC/ASCQ 8282h (Drive Requires Cleaning) will be returned after a Rewind, Space, Locate, or Unload when cleaning is required. A CLNCHK bit set to zero does not specify that a Check Condition will be returned when cleaning is required. The default value of this bit is zero (i.e. No check condition is returned).

A Disable Deferred Error On Rewind (DDEOR) bit set to one specifies that no deferred error will be reported to a rewind command. A DDEOR bit set to zero does not specify that no deferred error will be reported on rewind. The default value of this bit is zero.

A Check Condition for Dead Media (CCDM) bit set to one specifies that a Check Condition, Sense Key = 1h, ASC/ASCQ 8252h (Degraded Media) will be returned after a Rewind command when the criteria are met to set the Dead Media flag in Log Page 3Ch. A CCDM bit set to zero does not specify that a Check Condition will be returned when the Dead Media criteria are met. The default value of this bit is zero.

Firmware Update Behavior (Byte 7): This byte defines behaviors related to updating drive firmware.

A Disable Field Microcode Replacement Down Level (DFMRDL) bit set to one specifies that the drive will not accept downlevel firmware via an FMR tape. A DFMRDL bit set to zero does not specify that the drive will not accept downlevel firmware via an FMR tape. This bit does not effect code downloads by means other than an FMR tape (e.g. Write Buffer over SCSI interface). The default value of this bit is zero (i.e. Firmware can be down leveled by FMR tape).

Unload On Error Behavior (Byte 8): This byte defines auto unload behaviors of different types of cartridges when the following errors occur:

- Bad Media causes a mount failure;
- FMR cartridge is loaded when it has not been requested;
- Expired cleaner cartridge is loaded; or
- An invalid or unsupported cleaner cartridge is loaded.

Settings specified over a library interface (i.e. LDI or ADI) take precedence over these settings, but do not modify these values.

Table 126 defines the Unload on Error Behavior fields. Currently the only values allowed are 00h or 15h, but we anticipate allowing more flexibility in the future.

Table 126. Unload On Error Behavior Definition

Value	Field	Behavior
00b	Unload On Error - Data (UOE-D)	No exceptional behavior specified
	Unload on Error - FMR (UOE-F)	
	Unload On Error - Cleaner (UOE-C)	
01b	Unload On Error - Data (UOE-D)	Do not auto-eject on error
	Unload on Error - FMR (UOE-F)	
	Unload On Error - Cleaner (UOE-C)	
10b	Unload On Error - Data (UOE-D)	Reserved
	Unload on Error - FMR (UOE-F)	
	Unload On Error - Cleaner (UOE-C)	
11b	Unload On Error - Data (UOE-D)	Reserved
	Unload on Error - FMR (UOE-F)	
	Unload On Error - Cleaner (UOE-C)	

Mode Page 3Dh: LEOT Mode Page (3Dh) (LTO 1 Only)

The LEOT Mode Page is used to change the capacity of the loaded volume and is defined inTable 127.

Table 127. LEOT Mode Page (Ultrium 1 Only)

Byte	Bit 7	6	5	4	3	2	1	0
0	PS (0)	SPF(0)	Page Code (3Dh)					
1	Reserved							
2								
3	MSB	Number of Wraps						
4								LSB

PERSISTENT RESERVE IN

The PERSISTENT RESERVE IN command is used for reservation management to show what types of Reservations and Reservation Keys exist.

Table 128. PERSISTENT RESERVE IN Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (5Eh)							
1	Reserved			Service Action				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Allocation Length							
9	Control							

Service Action may have one of the following values:

- 00000b (reads all registered Reservation Keys)
- 00001b (reads all current persistent reservations)
- 00010b (Returns capability information)
- 00011b (Reads complete information about all registrations and the persistent reservations, if any)

Allocation Length is set to the maximum number of bytes to be transferred.

The PERSISTENT RESERVE IN parameter data for Read Capabilities is defined in Table 129.

Table 129. PERSISTENT RESERVE IN Parameter Data for Read Capabilities

	7	6	5	4	3	2	1	0
0	MSB			Length (0008h)				
1								LSB
2	Reserved			CRH (1)	SIP_C (1)	ATP_C (1)	Reserved	PTPL_C (0)
3	TMV (1)	Reserved						PTPL_A (0)
Persistent Reservation Type Mask (bytes 4-5)								
4	WR_EX_AR (0)	EX_AC_RO (1)	WR_EX_RO (0)	Reserved	EX_AC (1)	Reserved	WR_EX (0)	Reserved
5	Reserved							EX_AC_AR (0)
6	Reserved							
7								

Compatible Reservation Handling (CRH): Set to one.
Specify Initiator Ports Capable (SIP_C): Set to one.
All Target Ports Capable (ATP_C): Set to one.
Persist Through Power Loss Capable (PTPL_C): Set to zero.
Type Mask Valid (TMV): Set to one.
Persist Through Power Loss Activated (PTPL_A): Set to zero.
Write Exclusive – All Registrants (WR_EX_AR): Set to zero.
Exclusive Access – Registrants Only (EX_AC_RO): Set to one.
Write Exclusive – Registrants Only (WR_EX_RO): Set to zero.
Exclusive Access (EX_AC): Set to one.
Write Exclusive (WR_EX): Set to zero.
Exclusive Access – All Registrants (EX_AC_AR): Set to zero.

The PERSISTENT RESERVE IN parameter data for Read Full Status is defined in Table 130.

Table 130. PERSISTENT RESERVE IN Parameter Data for Read Full Status

	7	6	5	4	3	2	1	0
0	MSB			PRGeneration				
3								LSB
4	MSB			Additional Length (n-7)				
7								LSB
Full status descriptors								
8	First full status descriptor (see Table 131 on page 139)							
	. . .							
	Last full status descriptor (see Table 131 on page 139)							
n								

The format of the full status descriptors is shown in Table 131 on page 139.

Table 131. PERSISTENT RESERVE IN Full Status descriptor format

	7	6	5	4	3	2	1	0
0	MSB			Reservation Key				
7								LSB
8	MSB			Reserved				
11								
12	Reserved						ALL_TG_PT	R_HOLDER
13	SCOPE				TYPE			
14	Reserved							
17								
18	MSB			Relative Target Port Identifier				
19								LSB
20	MSB			Additional Desscriptor Length (n-23)				
23								LSB
24	TransportID							
n								

Reservation Holder (R_HOLDER).
All Target Ports (ALL_TG_PT).

The PERSISTENT RESERVE IN parameter data for Read Keys is defined in Table 132.

Table 132. PERSISTENT RESERVE IN Parameter Data for Read Keys

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 3	Generation							
4 : 7	Additional Length							
8 : 15	First Reservation Key							
16 : n	Additional Reservation Keys							

Generation is a counter for PERSISTENT RESERVE OUT command requests.

Additional Length is a count of the number of bytes in the Reservation Key list.

For Additional Reservation Keys, a maximum of one reservation key per initiator is supported.

The PERSISTENT RESERVE IN parameter data for Read Reservations is defined in Table 133.

Table 133. PERSISTENT RESERVE IN Parameter Data for Read Reservations

Byte	Bit 7	6	5	4	3	2	1	0
0 : 3	Generation							
4 : 7	Additional Length							
8 : n	Read Reservations Descriptor							

Generation is a counter for PERSISTENT RESERVE OUT command requests.

Additional Length is a count of the number of bytes in the Reservation Key list.

Reservation Descriptors are defined in Table 134.

The PERSISTENT RESERVE IN Read Reservations Descriptor is defined in Table 134.

Table 134. PERSISTENT RESERVE IN Read Reservations Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0 : 7	Reservation Key							
8 : 11	Scope-specific address (0)							
12	Reserved							
13	Scope (0h)				Type			
14 : 15	Extent Length (0)							

A Scope value of 0h indicates that the persistent reservation applies to the entire logical unit.

Type may have one of the following values:
- 3h means Exclusive Access
- 6h means Exclusive Access, Registrants only

PERSISTENT RESERVE OUT

The PERSISTENT RESERVE OUT command is used for reservation management to allow different types of Reservations and Reservation Keys to be created or removed.

Table 135. PERSISTENT RESERVE OUT Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (5Fh)							
1	Reserved			Service Action				
2	Scope (0)				Type			
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length (18h)							
9	Control							

Table 136 contains the values for Service Action field. For additional information about the descriptions of each service action code, refer to the *SCSI Primary Commands-3 (SPC-3)* manual.

Table 136. Values for Service Action Codes in PERSISTENT RESERVE OUT Command

Code	Name	Description	PERSISTENT RESERVE Generation Field Incremented
00h	REGISTER	Registers a reservation key with the device server or unregisters a reservation key.	Yes
01h	RESERVE	Creates a persistent reservation that has a specified SCOPE and TYPE.	No
02h	RELEASE	Releases the selected persistent reservation.	No
03h	CLEAR	Clears all reservation keys (for example, registrations) and all persistent reservations.	Yes
04h	PREEMPT	Preempts persistent reservations or removes registrations.	Yes
05h	PREEMPT AND ABORT	Preempts persistent reservations or removes registrations and aborts all tasks for all preempted initiator ports.	Yes
06h	REGISTER AND IGNORE EXISTING KEY	Registers a reservation key with the device server or unregisters a reservation key.	Yes
07h	REGISTER AND MOVE	Register a reservation key for another I_T nexus with the device server and move apersistent reservation to that I_T nexus	Yes
08h - 1Fh	Reserved		

The value in the Type field specifies the characteristics of the persistent reservation that is being established for all data blocks within the logical unit. Table 137 defines the characteristics of the different type values. For each persistent reservation type, Table 137 lists the value of the code, its name, the type of drive support, and a description of the drive support.

Table 137 contains the values for the Type field.

Table 137. Persistent Reservation Type Codes

Code	Name	Drive Support (see Note 1)	Description of Drive Support (see Note 2)
0h		N/S	Not Supported
1h	Write Exclusive	N/S	Not Supported
2h		N/S	Obsolete
3h	Exclusive Access	1,2	**Reads Exclusive:** Any task from any initiator port other than the initiator port that holds the persistent reservation that requests a transfer from the storage medium or cache of the logical unit to the initiator port will be terminated with RESERVATION CONFLICT status. **Writes Exclusive:** Any task from any initiator port other than the initiator port that holds the persistent reservation that requests a transfer from the initiator port to the storage medium or cache of the logical unit will be terminated with RESERVATION CONFLICT status. **Persistent Reservation Holder:** The initiator port that delivered the PERSISTENT RESERVE OUT command with RESERVE, PREEMPT, or PREEMPT AND ABORT service action as identified by its registered reservation key.
4h		N/S	Not Supported
5h	Write Exclusive - Registrants Only	N/S	Not Supported
6h	Exclusive Access - Registrants Only	1,2	**Reads Exclusive:** A task that requests a transfer from the storage medium or cache of the logical unit to an initiator port that is not currently registered with the device server will be terminated with RESERVATION CONFLICT status. **Writes Exclusive:** A task that requests a transfer to the storage medium or cache of the logical unit from an initiator port that is not currently registered with the device server will be terminated with RESERVATION CONFLICT status. **Persistent Reservation Holder:** The initiator port that delivered the PERSISTENT RESERVE OUT command with RESERVE, PREEMPT, or PREEMPT AND ABORT service action as identified by its registered reservation key.
7h	Write Exclusive - All Registrants	N/S	Not Supported
8h	Exclusive Access - All Registrants	N/S	Not Supported
9h - Fh	Reserved		

Table 137. Persistent Reservation Type Codes (continued)

Code	Name	Drive Support (see Note 1)	Description of Drive Support (see Note 2)

Notes:

1. Drive Support is categorized as follows:
   1 = Generation 1
   2 = Generation 2
   N/S = not supported
2. The Description of Drive Support column is divided into three categories:
   A definition of the required handling for read operations.
   A definition of the required handling for write operations.
   A definition of the persistent reservation holder (for more information, refer to the *SCSI Primary Commands-3 (SPC-3)* manual.

The PERSISTENT RESERVE OUT parameter list for all service actions except REGISTER AND MOVE (07h) is defined in Table 138.

Table 138. PERSISTENT RESERVE OUT Parameter List

Byte	Bit 7	6	5	4	3	2	1	0
0 : 7	Reservation Key							
8 : 15	Service Action Reservation Key							
16 : 19	Scope-specific Address (0)							
20	Reserved							APTPL (0)
21	Reserved							
22 : 23	Obsolete (0)							

Any value is allowed for the Reservation Key and the Service Action Reservation Key.

The value for Activate Persist Through Power Loss (APTPL) will be 0.

The PERSISTENT RESERVE OUT parameter list for REGISTER AND MOVE (07h) is defined in Table 139 on page 145.

Table 139. PERSISTENT RESERVE OUT command with REGISTER AND MOVE service action parameter list

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	MSB			Reservation Key				
7								LSB
8	MSB			Service Action Reservation Key				
15								LSB
16	Reserved							
17	Reserved						UNREG	APTPL (0)
18	MSB			Relative Target Port Identifier				
19								LSB
20	MSB			Transportid Parameter Data Length (n-23)				
23								LSB
24	TransportID							
n								

PREVENT/ALLOW MEDIUM REMOVAL

The PREVENT/ALLOW MEDIUM REMOVAL command is used to prevent accidental removal of the medium while it is required by an initiator.

Table 140. PREVENT/ALLOW MEDIUM REMOVAL Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Eh)							
1	Obsolete			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							Prevent
5	Control							

If the Prevent field is set, then eject requests from the front panel are ignored and Unload commands give Check Condition status. The Sense Key is set to Illegal Request and the ASC/ASCQ to Medium Removal Prevented (5302).

All initiators that have prevented medium removal must enable it before the medium can be removed from the drive.

READ

The READ command causes data to be transferred from the tape medium to the initiator.

Table 141. READ Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (08h)							
1	Obsolete			Reserved			SILI	Fixed
2 : 4	Transfer Length							
5	Control							

If the Fixed field is set to 0 and Transfer Length is not 0, then a single block of the length in Transfer Length is to be transferred. If the next block on tape is of this length or shorter, then it is transferred to the initiator. If the next block is longer than this length, then only the length requested is returned. A Check Condition for incorrect length is returned, and the logical position is set after the block. If the length of the block was the same as the Transfer Length field, then Good status is returned.

If the Suppress Incorrect Length Indicator (SILI) field is 1 and the Fixed field is 0, the drive will do one of the following:

- Report Check Condition status for an incorrect length condition only if the overlength condition exists and the BLOCK LENGTH field in the mode parameter block descriptor is non-zero (see clause 8.3 in the *SCSI-3 Stream Commands (SSC)*).
- Not report Check Condition status if the only error is the underlength condition, or if the only error is the overlength condition and the BLOCK LENGTH field of the mode parameters block descriptor is 0.

If the SILI field is 0 and an incorrect length block is read, Check Condition status will be returned. The ILI and VALID fields must be set to 1 in the sense data and the Additional Sense Code must be set to NO ADDITIONAL SENSE INFORMATION. Upon termination, the logical position will be after the incorrect length block (end-of-partition side). If the Fixed field is 1, the INFORMATION field must be set to the requested transfer length minus the actual number of blocks read (not including the incorrect length block). If the Fixed field is 0, the INFORMATION field must be set to the requested transfer length minus the actual block length.

If the Fixed field is set to 1, the Block Length (see “Mode Block Descriptor” on page 109) is set to 0, and the Transfer Length field is not 0, Check Condition status is returned with Illegal Field in CDB (5/2400h).

If the Fixed field is set to 1, the Transfer Length field is not 0, and the Suppress Illegal Length Indicator (SILI) field is set to 0, then a sequence of blocks of the currently configured block length is to be returned, the number of blocks being indicated in the Transfer Length field. If there is a sequence of blocks of this length on the tape, they are returned to the initiator with Good status. If a block that is longer than the configured length is encountered before the sequence is complete, the blocks up to that block are returned, followed by the configured length from the record that was too long and Check Condition status. If a block that is shorter than the configured length is encountered before the sequence is complete, the blocks up to that block are returned, followed by all of that block and Check Condition status. The current position is set after the last block that was returned or partially returned.

If the Transfer Length field is 0, and if the Suppress Illegal Length Indicator and the Fixed field are not both set, then Good status is returned and no action is taken in the drive.

If Suppress Illegal Length Indicator (SILI) field is set and the Fixed field is set, then Check Condition status is returned. The Sense Key is set to Illegal Request and the ASC/ASCQ is set to Invalid Field in CDB (2400).

READ ATTRIBUTE

The READ ATTRIBUTE command allows an application client to read attribute values from medium auxiliary memory.

Table 142. READ ATTRIBUTE Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (8Ch)							
1	Reserved (0)			Service Action				
2 : 3	Reserved							
4	Reserved							
5	Volume Number (0)							
6	Reserved							
7	Partition Number (0)							
8 : 9	First Attribute ID							
10 : 13	Allocation Length							
14	Reserved							
15	Control							

If the medium auxiliary memory is not accessible because there is no medium present, the READ ATTRIBUTE command will be terminated with a Check Condition status. The Sense Key must be set to Not Ready and the Additional Sense Code must be set to Medium Not Present (3A00h).

If the medium auxiliary memory is not accessible but the medium is present, the READ ATTRIBUTE command will be terminated with a Check Condition status. The Sense Key must be set to Medium Error and the Additional Sense Code must be set to Logical Unit Not Ready, Auxiliary Memory Not Accessible (0410h).

If the medium auxiliary memory has failed, the READ ATTRIBUTE command will be terminated with a Check Condition status. The Sense Key must be set to Medium Error and the Additional Sense Code must be set to Auxiliary Memory Read Error (1112h).

The supported Service Action codes are listed in Table 143 on page 150. The sections that follow the table give the format for each supported service action.

Table 143. Supported Service Action Codes

Code	Name	Description	Format of Returned Data
00h	Attribute Values	Return attribute values	See “Format for the Attribute Values Service Action” on page 152
01h	Attribute List	Returns a list of available attribute identifiers	See “Format for the Attribute List Service Action” on page 153
02h	Volume List	Returns a list of available Volume Numbers	See “Format for the Volume List Service Action” on page 154
03h	Partition List	Returns a list of available Partition Numbers	See “Format for the Partition List Service Action” on page 155
04h	Restricted	Not applicable	Not applicable
05h - 1Fh	Reserved	Not applicable	Not applicable

The First Attribute ID field specifies the attribute identifier of the first attribute to be returned. If the specified attribute identifier is in the unsupported or nonexistent state, the READ ATTRIBUTE command will be terminated with a Check Condition status (see clause 5.10 in the *SCSI Primary Commands-3 (SPC-3)*). The Sense Key must be set to Illegal Request and the Additional Sense Code must be set to Invalid Field in CDB.

The Allocation Length field specifies how many bytes have been allocated for the returned parameter list. If the length is not sufficient to contain the entire parameter list, the first portion of the list will be returned. This is not considered an error. If the remainder of the list is required, the application client should send a new READ ATTRIBUTE command with an allocation length large enough to contain the entire parameter list or use the First Attribute ID field to restrict the attributes that are returned.

The format of parameter data that is returned by the READ ATTRIBUTE command depends on the service action that is specified.

Vendor-specific Medium Type Attributes

Table 144 describes the vendor-specific medium type attributes. Application clients may use Read Attribute to read the contents of the attributes shown in the table.

Table 144. Vendor-specific Medium Type Attributes

Attribute Identifier	Name	Attribute Length (in bytes)	Format
1000h	Unique Cartridge Identity (UCI)	28	Binary

The Unique Cartridge Identity (UCI) attribute is only supported on Ultrium 3 and follow-on drives. The Unique Cartridge Identity (UCI) attribute is read only. Any attempt to change this attribute by using the Write Attribute command will be rejected by the drive with a Sense Key 5 ASC/ASCQ 2600 Illegal Request, Invalid Field In Parameter List. If the cartridge has inconsistency between the various sources from which the components of the UCI are derived, then any command to read the UCI will be rejected with a Check Condition, and Sense Key and ASC/ASCQ of (03/1112), which is an Auxiliary Memory Read Error. This error shall also be reported if the cartridge has not been initialised.

Format for the Attribute Values Service Action

The READ ATTRIBUTE command with Attribute Values service action returns parameter data that contains the attributes that are specified by the Partition Number, Volume Number, and First Attribute ID fields in the CDB. The returned parameter data contains the requested attributes in ascending numerical order by attribute identifier value and in the format shown in Table 145.

Table 145. Parameter Data for an Attribute Values Service Action

Byte	Bit 7	6	5	4	3	2	1	0
0 : 3	Available Data (n-3)							
4 : x	Attribute #1							
m : n	Attribute #y							

The Available Data field will contain the number of bytes of attribute information in the parameter list. If the parameter list is truncated as a result of insufficient allocation length, the content of the Available Data field is not altered. The format of the attribute is described in Table 151 on page 157.

Format for the Attribute List Service Action

The READ ATTRIBUTE command with Attribute List service action returns parameter data that contains the attribute identifiers for the attributes that are not in the unsupported state and not in the nonexistent state (for information about MAM attribute states, see Table 150 on page 156). The contents of First Attribute ID field in the CDB is ignored. The returned parameter data contains the requested attribute identifiers in ascending numerical order by attribute identifier value and in the format shown in Table 146.

Table 146. Parameter Data for an Attribute List Service Action

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 3	Available Data (n-3)							
4 : 5	Attribute ID #1							
n-1 : n	Attribute ID #y							

Format for the Volume List Service Action

The READ ATTRIBUTE command with Volume List service action returns parameter data that identifies the supported number of volumes (see Table 147). The contents of Volume Number, Partition Number, and First Attribute ID fields in the CDB are ignored.

Table 147. Parameter Data for a Volume List Service Action

Byte	Bit 7	6	5	4	3	2	1	0
0 : 1	Available Data (2)							
2	First Volume Number (0)							
3	Number of Volumes Available (1)							

The Available Data field contains two.

The First Volume Number field indicates the first volume that is available and will be set to 0.

The Number of Volumes Available field indicates the number of volumes that are available and will be set to 1.

Format for the Partition List Service Action

The READ ATTRIBUTE command with Partition List service action returns parameter data that identifies the number of partitions that are supported in the specified volume number (see Table 148). The contents of the Partition Number and First Attribute ID fields in the CDB are ignored.

Table 148. Parameter Data for a Partition List Service Action

Byte	Bit 7	6	5	4	3	2	1	0
0 : 1	Available Data (2)							
2	First Partition Number (0)							
3	Number of Partitions Available (1)							

The Available Data field contains two.

The First Partition Number field indicates the first partition that is available on the specified volume number and is set to 0.

The Number of Partitions Available field indicates the number of partitions that are available on the specified volume number and is set to 1.

Medium Auxiliary Memory

Ultrium media includes a non-volatile memory that is referred to as medium auxiliary memory (MAM). MAM is used to store data that describes the media and its contents. The Ultrium drives support MAM with the READ ATTRIBUTE and WRITE ATTRIBUTE commands. The commands retrieve and store information as attributes in MAM. For more information, see "READ ATTRIBUTE" on page 149 and "WRITE ATTRIBUTE" on page 241.

A MAM attribute is composed of the following components:

- Attribute identifier
- Attribute format code
- Bit that indicates whether the attribute is read only.
- Attribute length that specifies the number of bytes in the attribute's value
- Value of the attribute

Table 149 lists the three types of MAM attributes.

Table 149. Types of MAM Attributes

Type of MAM Attribute	Attribute Source	Example	Readable with READ ATTRIBUTE	Writable with WRITE ATTRIBUTE
Medium	Permanently stored in the MAM during manufacture.	Media Serial Number	Yes	No
Device	Maintained by the tape drive.	Load Count	Yes	No
Host	Maintained by the application client.	Backup Date	Yes	Yes

Table 150 shows the states for the types of MAM attributes.

Table 150. States for the Types of MAM Attributes

Attribute Type	Attribute State	Description
Medium or Device	Read Only	An application server may read the contents of the attribute with the READ ATTRIBUTE command, but an attempt to clear or change the attribute by using the WRITE ATTRIBUTE command will result in the command being terminated with a Check Condition status. When the Read Only field of the MAM attribute is 1, the attribute is in the read only state. (For information about the Read Only field, see "Format of MAM Attribute" on page 157.)
	Unsupported	The tape drive does not support the attribute and will not return it in response to a READ ATTRIBUTE command.
Host	Nonexistent	A host attribute does not exist in the MAM until a WRITE ATTRIBUTE command creates it.
	Read/Write	The attribute has been created by using the WRITE ATTRIBUTE command. After the attribute has been created, the contents may be altered by using subsequent WRITE ATTRIBUTE commands. A read/write attribute may be returned to the nonexistent state by using a WRITE ATTRIBUTE command with the Attribute Length set to 0. When the Read Only field of the MAM attribute is 0, the attribute is in the read/write state. (For information about the Read Only field, see "Format of MAM Attribute" on page 157.)

Format of MAM Attribute

Each MAM attribute will be communicated between the application client and tape drive in the format shown in Table 151. This format will be used in the parameter data for the WRITE ATTRIBUTE and READ ATTRIBUTE commands. The attribute format implies nothing about the physical representation of an attribute in the MAM. For more information, see “READ ATTRIBUTE” on page 149 and “WRITE ATTRIBUTE” on page 241.

Table 151. Format of a MAM Attribute

Byte	Bit 7	6	5	4	3	2	1	0
0 : 1	(MSB) Attribute Identifier (LSB)							
2	Read Only	Reserved					Format	
3 : 4	(MSB) Attribute Length (n-4) (LSB)							
5 : n	(MSB) Attribute Value (LSB)							

The Attribute Identifier field contains a value that identifies the attribute. For the range of values in this field, see “Values for the Attribute Identifier Field” on page 158.

The Read Only field indicates whether the attribute is in the read only or read/write state. If the field is 1, the attribute is in the read only state; if the field is 0, the attribute is in the read/write state.

The Format field specifies the format of the data in the Attribute Value field. Table 152 describes the values and requirements for the Format field.

Table 152. Values and Requirements for the Format Field

Format	Name	Generation (see Legend)	Description
00b	Binary	1,2	The Attribute Value field will contain binary data.
01b	ASCII	1,2	The Attribute Value field will contain only graphic codes (for example, byte code values 20h through 7Eh), will be left-aligned and place any unused bytes at the highest offset in the field, and will contain 20h (for example, ASCII space) in any unused bytes.
10b	Text	1,2	The attribute contains textual data. For a description of the character set, see page 163 and Table 159 on page 163.
11b	Reserved	N/S	The Attribute Value field is reserved.

Table 152. Values and Requirements for the Format Field (continued)

Format	Name	Generation (see Legend)	Description
Legend: 1 = supported in IBM TotalStorage LTO Ultrium Tape Drive (commonly called the Ultrium 1 tape drive) 2 = supported in IBM TotalStorage LTO Ultrium 2 Tape Drive (commonly called the Ultrium 2 tape drive) N/S = not supported			

The Attribute Length field specifies the length in bytes of the Attribute Value field. The value of the Attribute Length field depends on the attribute that is returned.

The Attribute Value field contains the current (READ ATTRIBUTE) or desired (WRITE ATTRIBUTE) value of the attribute.

Values for the Attribute Identifier Field: The values in the Attribute Identifier field are assigned according to the attribute type and whether the attribute is standard or vendor unique. Table 153 lists the range of values for the each attribute type.

Table 153. Range of Values for MAM Attribute Identifiers

Range of Attribute Identifiers	Attribute Type	Standard or Vendor Unique
0000h - 03FFh	Device	Standard
0400h - 07FFh	Medium	Standard
0800h - 0BFFh	Host	Standard
0C00h - 0FFFh	Device	Vendor Unique
1000h - 13FFh	Medium	Vendor Unique
1400h - 17FFh	Host	Vendor Unique
1800h - FFFFh	Reserved	Not applicable
Note: Ultrium drives accept and process a WRITE ATTRIBUTE command that contains standard host type attribute identifier values (for example 0800h to 0BFFh) or vendor-unique host type attribute identifier values (for example 1400h to 17FFh). Standard host type attribute identifier values may be checked for conformance to the requirements described in “Standard Host Type Attributes” on page 162. Attributes may be written as long as there is sufficient available space in MAM. The Ultrium drive supports a total of 1008 bytes of Application Specific Data available for host use. Each attribute written consumes four bytes of that space for the required attribute header.		

The sections that follow describe the standard type attributes for device, medium, and host.

Standard Device Type Attributes: Device type attributes are maintained and updated by the drive when the medium and associated MAM are present. Table 154 on page 159 describes the standard device type attributes.

Table 154. Standard Device Type Attributes

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0000h	Remaining Capacity in Partition	8	Binary
0001h	Maximum Capacity in Partition	8	Binary
0002h	Restricted	N/A	N/A
0003h	Load Count	8	Binary
0004h	MAM Space Remaining	8	Binary
0005h - 0006h	Restricted	N/A	N/A
0007h	Initialization Count	2	Binary
0008h	Volume Identifier	32	ASCII
0009h - 0209h	Reserved	N/A	N/A
020Ah	Device Make/Serial Number at Last Load	40	ASCII
020Bh	Device Make/Serial Number at Load-1	40	ASCII
020Ch	Device Make/Serial Number at Load-2	40	ASCII
020Dh	Device Make/Serial Number at Load-3	40	ASCII
020Eh - 021Fh	Reserved	N/A	N/A
0220h	Total MBytes Written in Medium Life	8	Binary
0221h	Total MBytes Read in Medium Life	8	Binary
0222h	Total MBytes Written in Current/Last Load	8	Binary
0223h	Total MBytes Read in Current/Last Load	8	Binary
0224h - 033Fh	Reserved	N/A	N/A
0340h	Medium Usage History (not supported)	N/A	N/A
0341h	Partition Usage History (not supported)	N/A	N/A
0342h - 03FFh	Reserved	N/A	N/A
Note: N/A = not applicable			

Remaining Capacity in Partition and Maximum Capacity in Partition are native capacities, assuming that there is no data compression for the specified medium partition. These values are expressed in increments of 1 048 576 bytes (for example, a value of 1 means 1 048 576 bytes; a value of 2 means 2 097 152 bytes; and so forth).

Load Count indicates how many times this medium has been fully loaded. This attribute should not be reset by any action of the device server.

MAM Space Remaining indicates the space that is currently free in the medium auxiliary memory. The total MAM capacity is reported in the MAM Capacity attribute. (For a description of the MAM Capacity attribute, see page 162.) **Note:** It may not always be possible to use all of the free space that is reported.

Initialization Count indicates the number of times that a device server has logically formatted the medium. This figure is cumulative over the life of the medium and will never be reset.

On Ultrium 4 drives, the Volume Identifier indicates the volume identifier of the medium (set by the library either via the Library Drive Interface or via the ADI interface). If the volume identifier has not been set, the drive will report this attribute with an attribute length value of zero.

On Ultrium 1, 2, and 3 drives, the Volume Identifier field is not supported.

The Device Vendor Identification/Product Serial Number at Last Load, Device Vendor Identification/Product Serial Number at Load-1, Device Vendor Identification/Product Serial Number at Load-2, and Device Vendor Identification/Product Serial Number at Load-3 attributes give a rolling history of the last four device servers in which the medium has been loaded. The format for the attributes is shown in Table 155 on page 161.

Table 155. Format for Device Vendor Identification/Product Serial Number Attribute, Device Vendor Identification/Product Serial Number at Load-1 Attribute, Device Vendor Identification/Product Serial Number at Load-2 Attribute, and Device Vendor Identification/Product Serial Number at Load-3 Attribute

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB)							
:				Vendor Identification				
7								(LSB)
8	(MSB)							
:				Product Serial Number				
39								(LSB)

The Vendor Identification field will be the same value that is returned in the Standard Inquiry Data.

The Product Serial Number field contains a vendor-unique serial number. If the product serial number is not available, the Product Serial Number field will contain ASCII spaces (20h).

Total MBytes Written in Medium Life and Total MBytes Read in Medium Life indicate the number of data bytes that are transferred to or from the medium surface (after any data compression has been applied) over the entire life of the medium. These values are cumulative and will never be reset. They are expressed in increments of 1 048 576 bytes (for example, a value of 1 means 1 048 576 bytes; a value of 2 means 2 097 152 bytes; and so forth).

Total MBytes Written in Current/Last Load and Total MBytes Read in Current/Last Load indicate the total number of data bytes that are transferred to or from the medium surface (after any data compression has been applied) during the current load if the medium is currently loaded, or during the last load if the medium is currently unloaded. The device server should reset these attributes to 0 when the medium is loaded. These values are expressed in increments of 1 048 576 bytes (for example, a value of 1 means 1 048 576 bytes; a value of 2 means 2 097 152 bytes; and so forth).

Standard Medium Type Attributes: Medium type attributes are hard-coded into the MAM at the time of manufacture. All supported medium type attributes have a status of read only. Table 156 describes the standard medium type attributes.

Table 156. Standard Medium Type Attributes

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0400h	Medium Manufacturer	8	ASCII
0401h	Medium Serial Number	32	ASCII
0402h - 0405h	Restricted	N/A	N/A
0406h	Medium Manufacture Date	8	ASCII
0407h	MAM Capacity	8	Binary
0408h	Medium Type	1	Binary

Table 156. Standard Medium Type Attributes (continued)

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0409h	Medium Type Information	2	Binary
040Ah	Numeric Medium Serial Number (not supported)	N/A	N/A
040Bh - 07FFh	Reserved	N/A	N/A
Note: N/A = not applicable			

Medium Manufacturer contains 8 bytes of ASCII data that identifies the vendor of the media.

Medium Serial Number identifies the manufacturer's serial number for the medium.

Medium Manufacture Date identifies the date of manufacture of the medium. The format is `YYYYMMDD` (four numeric ASCII characters for the year, followed by two numeric ASCII characters for the month, followed by two numeric ASCII characters for the day, with no intervening spaces).

MAM Capacity is the total capacity of the medium auxiliary memory (in bytes) at the time of manufacture. It does not indicate the free space of unused MAM because some of the MAM space may be reserved for device-specific use, which makes it inaccessible to the application client.

Medium Type and Medium Type Information give information about non-data media and other types of media. The Medium Type Information attribute is interpreted according to the type of medium that is indicated by the Medium Type attribute. Table 157 give the values for the Medium Type and Medium Type Information attributes.

Table 157. Values for Medium Type and Medium Type Information Attributes

Medium Type	Description	Medium Type Information
00h	Data medium	Reserved
01h	Cleaning medium	Maximum number of cleaning cycles permitted
02h - 7Fh	Reserved	Reserved
80h	Write-once medium	Reserved
81h - FFh	Reserved	Reserved

Standard Host Type Attributes: Table 158 describes the standard host type attributes. Application clients may use the WRITE ATTRIBUTE and READ ATTRIBUTE commands to maintain the attributes shown in the table. All existing host type attributes have a status of read/write.

Table 158. Standard Host Type Attributes

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0800h	Application Vendor	8	ASCII

Table 158. Standard Host Type Attributes (continued)

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0801h	Application Name	32	ASCII
0802h	Application Version	8	ASCII
0803h	User Medium Text Label	160	Text
0804h	Date and Time Last Written	12	ASCII
0805h	Text Localization Identifier	1	Binary
0806h	Barcode	32	ASCII
0807h	Owning Host Textual Name	80	Text
0808h	Media Pool	160	Text
0809h	Partition User Text Label (not supported)	N/A	N/A
080Ah	Load/Unload at Partition (not supported)	1	Binary
080Bh - BFFh	Reserved	N/A	N/A
Note: N/A = not applicable			

Application Vendor contains 8 bytes of ASCII data that identifies the manufacturer of the application client (for example, a class driver or backup program) that most recently sent a WRITE ATTRIBUTE command to the tape drive while this MAM was accessible.

Application Name contains the name of the application client.

Application Version contains the version of the application client.

User Medium Text Label is the user-level identifier for the medium.

Date and Time Last Written contains when the application client last wrote to the MAM. The format is `YYYYMMDDHHMM` (four numeric ASCII characters for the year, followed by two numeric ASCII characters for the month, followed by two numeric ASCII characters for the day, followed by two numeric ASCII characters between 00 and 24 for the hour, followed by two numeric ASCII characters for the minute, with no intervening spaces).

Text Localization Identifier defines the character set that is used for attributes with a Text format. Table 159 gives the values for the Text Localization Identifier attribute.

Table 159. Values for the Text Localization Identifier Attribute

Value	Meaning
00h	No code specified (ASCII)
01h	ISO/IEC 8859-1 (Europe, Latin America)
02h	ISO/IEC 8859-2 (Eastern Europe)
03h	ISO/IEC 8859-3 (Southeastern Europe, miscellaneous)
04h	ISO/IEC 8859-4 (Scandinavia/Baltic)
05h	ISO/IEC 8859-5 (Cyrillic)
06h	ISO/IEC 8859-6 (Arabic)

Table 159. Values for the Text Localization Identifier Attribute (continued)

Value	Meaning
07h	ISO/IEC 8859-7 (Greek)
08h	ISO/IEC 8859-8 (Hebrew)
09h	ISO/IEC 8859-9 (Latin 5)
0Ah	ISO/IEC 8859-10 (Latin 6)
0Bh - 7Fh	Reserved
80h	ISO/IEC 10646-1 (UCS-2BE)
81h	ISO/IEC 10646-1 (UTF-8)
82h - FFh	Reserved

Barcode is the contents of a bar code that is associated with the medium in the MAM.

Owning Host Textual Name indicates the host from which the User Medium Text label originates.

Media Pool indicates the media pool to which this medium belongs.

Vendor-Specific Medium Type Attributes: Table 160 describes the vendor-specific medium type attributes. Application clients may use Read Attribute to read the contents of the attributes shown in the table.

Table 160. Vendor-Specific Medium Type Attributes

Attribute Identifier	Name	Attribute Length (in bytes)	Format
1000h	Unique Cartridge Identity (UCI)	28	Binary

The Unique Cartridge Identity (UCI) attribute is supported only on Ultrium 3 drives. The Unique Cartridge Identity (ICU) attribute is read only. Any attempt to access it using the Write Attribute command will be rejected by the drive with a Sense Key 5 ASC/ASCQ 2600 Illegal Request, Invalid Field In Parameter List. If the cartridge has inconsistency between the various sources from which the components of the UCI are derived, then any command to read the UCI will be rejected with a Check Condition, and Sense Key and ASC/ASCQ of (03/1112), which is an Auxiliary Memory Read Error. This error shall also be reported if the cartridge has not been initialized.

READ BLOCK LIMITS

The READ BLOCK LIMITS command (see Table 161) requests that the READ BLOCK LIMITS data (see Table 162) be returned. The READ BLOCK LIMITS data specifies the drive's limit on block lengths.

Table 161. READ BLOCK LIMITS Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (05h)							
1	Obsolete			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

The format of the data returned in the READ BLOCK LIMITS Descriptor is shown in Table 162.

Table 162. READ BLOCK LIMITS Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved			Granularity (0h)				
1 : 3	Maximum Block Length Limit (FFFFFFh)							
4 : 5	Minimum Block Length Limit (0001h)							

The Granularity field specifies the supported block size granularity. For Ultrium drives this is set to 0, which indicates that the drive supports all block sizes equal to n, where n is greater than or equal to the Minimum Block Length Limit and less than or equal to the Maximum Block Length Limit.

The Maximum Block Length Limit is set to 0xFFFFFF.

The Minimum Block Length Limit is set to 1.

For READ and WRITE commands with the Fixed field set to 1, block lengths are limited to multiples of four.

The Ultrium drives support fixed-block transfers or variable-block transfers, with the block length constrained between the given limits in either transfer mode. The transfer mode is controlled by the Fixed field in the WRITE or READ commands.

READ BUFFER

The READ BUFFER command reads data from the memory on the drive and sends it to the initiator. The command is used in conjunction with the WRITE BUFFER command as a diagnostic function for testing memory in the drive and the integrity of the service delivery subsystem. The READ BUFFER command is also used for retrieving data that is specified by the value of the Buffer ID. This command does not alter the medium.

Table 163. READ BUFFER Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (3Ch)							
1	Obsolete			Mode				
2	Buffer ID							
3 : 5	Buffer Offset							
6 : 8	Allocation Length							
9	Control							

The Mode field and its meaning are described in Table 164.

Table 164. Description of the Mode Field

Mode	Description	Support
00h	Combined header and data	1, 2, 3, 4
02h	Data	1, 2, 3, 4
03h	Descriptor	1, 2, 3, 4
07h	Descriptor (see Note)	1, 2, 3, 4
0Ah	Echo buffer	2, 3, 4
0Bh	Echo buffer descriptor	2, 3, 4

Legend:

1 = supported in IBM TotalStorage LTO Ultrium Tape Drive (commonly called the Ultrium 1 tape drive)

2 = supported in IBM TotalStorage LTO Ultrium 2 Tape Drive (commonly called the Ultrium 2 tape drive)

3 = supported in IBM TotalStorage LTO Ultrium 3 Tape Drive (commonly called the Ultrium 3 tape drive)

4 = supported in IBM TotalStorage LTO Ultrium 4 Tape Drive (commonly called the Ultrium 4 tape drive)

Note: The descriptor that is returned for Mode 07h has the Buffer Capacity field reported in 64-byte increments.

The Buffer ID indicates which buffer is to be read. The Buffer IDs are shown in Table 168 on page 169.

The Buffer Offset field may be set to any address in the buffer.

If the Mode is set to 07h and the Buffer ID is 0, the descriptor that is returned is for the Main Data buffer, and the Buffer Capacity field is the number of 64-byte segments that are available.

The format of the 4-byte descriptor is shown in Table 166.

Note: The Main Data buffer capacity is larger than can be represented in the Buffer Offset field of the CDB and Buffer Capacity field of the header. To compensate for this, the Buffer Offset and Buffer Capacity fields for the Main Buffer (buffer ID = 0) are interpreted and expressed in multiples of 64 bytes (for example, a value of 1 equals 64 bytes). This interpretation is for buffer modes 00h, 01h, 02h, 03h, and 07h only.

If the Mode is set to 0Ah, data from the echo buffer is returned.

In this mode, Buffer ID and Buffer Offset fields are ignored. Prior to issuing a READ BUFFER command that uses the echo buffer, a WRITE BUFFER command that uses the echo buffer must have been successfully completed (see“WRITE BUFFER” on page 242). If not, the Read Echo Buffer terminates with a Check Condition status, the Sense Key is set to Illegal Request, and ASC/ASCQ is set to Command Sequence Error (2C00h). The Read Echo Buffer returns the same number of bytes of data as was received in the prior Write Echo Buffer from the same initiator.

If the Mode is set to 0Bh, the descriptor information of the echo buffer is returned. The format of the echo buffer descriptor is shown in Table 167 on page 168. The Echo Buffer Overwritten Supported (EBOS) is set to 1 because the drive keeps the echo buffer for each initiator.

Table 165. READ BUFFER Header

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved							
1 : 3	Buffer Capacity							

Table 166. READ BUFFER Descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Offset Boundary (0h means byte boundary)							
1 : 3	Buffer Capacity							

Table 167. READ ECHO BUFFER Descriptor

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved							EBOS (1)
1	Reserved							
2	Reserved			Buffer Capacity				
3	Buffer Capacity							

Table 168. Drive Buffers

Supported Buffers	ID	Offset Boundary	Ultrium Support
Main Data	00h	4	1, 2, 3, 4
Dump Data (Read Only) (See Note)	01h	4	1, 2, 3, 4
Test	02h	4	1, 2, 3, 4
VPD	03h	4	1, 2, 3, 4
Firmware	04h	4	1, 2, 3, 4
Cartridge Memory (Read Only)	05h	4	1, 2, 3, 4
Error Log (Read Only)	06h	4	1, 2, 3, 4
SCSI Log (Read Only)	07h	4	1, 2, 3, 4
	08h	4	1, 2, 3, 4
Reserved	09h-80h	N/A	N/A
(IBM use only)	81h	N/A	N/A
(IBM use only)	83h	N/A	N/A
Reserved	84h-FFh	N/A	N/A

Legend:

1 = supported in IBM TotalStorage LTO Ultrium Tape Drive (commonly called the Ultrium 1 tape drive)

2 = supported in IBM TotalStorage LTO Ultrium 2 Tape Drive (commonly called the Ultrium 2 tape drive)

3 = supported in IBM TotalStorage LTO Ultrium 3 Tape Drive (commonly called the Ultrium 3 tape drive)

N/A = not applicable

4 = supported in IBM TotalStorage LTO Ultrium 4 Tape Drive (commonly called the Ultrium 4 tape drive)

Note: When reading dump data on a Fibre Channel drive, take care to ensure that the amount of data in each transfer does not exceed the DMA settings of the HBA. The dump data currently exceeds 1 MB in size. The default DMA setting for some HBAs is 1 MB. For this reason, it is recommended that the dump data is read in a series of smaller blocks with appropriate offsets (for example, 64 K bytes).

Note: When reading dump data the data should be read with strictly increasing offsets. If it is not read with strictly increasing offsets and a new dump is created during the readi processing, the data might be corrupted

Error Log Buffer (06h)

The error log buffer contains zero or more entries described in Table 169.

Table 169. Error Log Buffer Command

Byte	Bit 7	6	5	4	3	2	1	0
0 : 3	Time Stamp							
4	Entry Number							
5	Error Code							
6 : 7	Fsc 1st Text							
8 : 9	Fsc 1st Data							
10 : 11	Fsc 2nd Text							
12 : 13	Fsc 2nd Data							
14 : 21	Cartridge Serial Number							
22 : 27	EC Level							
28 : 31	Hardware Level							

World Wide Name Buffer (08h)

Table 170. World Wide Name Buffer

Byte	Bit 7	6	5	4	3	2	1	0
0 : 7	World Wide Node Name							
8 : 15	World Wide Port Name							

SCSI Log Buffer (07h)

The Error Log Buffer contains 10 entries, each of which has the format described in Table 171.

Table 171. Error Log Buffer Command

Byte	Bit 7	6	5	4	3	2	1	0
0 : 3	Time Stamp (seconds)							
4	Entry Number							
5	Initiator SCSI ID							
6	SCSI Status							
7	Reserved							
8 : 23	CDB							
24 : 59	Sense Data							

An Entry Number set to 0 indicates that the entry is not valid. The scheme used for setting the Entry Number is not described in this manual.

Valid entries are built for commands that are issued to LUN 0 and that get a Check Condition status for sense data that contain a Sense Key of 3 or 4.

The CDB field contains the contents of the CDB that received Check Condition status even when the check condition is a Deferred Check Condition.

READ POSITION

The READ POSITION command returns current position information to the initiator. It can be used to find the current logical position of the medium and to find information about the number of bytes or blocks in the buffer. Table 173 shows the format of the returned data.

Table 172. READ POSITION Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (34h)							
1	Obsolete			Service Action (0)				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter Length (0)							
9	Control							

Table 173. READ POSITION Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0	BOP	EOP	BCU	BYCU(1)	Rsvd	BPU(0)	PERR(0)	Rsvd
1	Partition Number (0)							
2	Reserved							
3	Reserved							
4 : 7	First Block Location							
8 : 11	Last Block Location							
12	Reserved							
13 : 15	Number of blocks in buffer							
16 : 19	Number of bytes in buffer (0)							

The First Block Location specifies the block address that is associated with the current logical position. The value indicates the block address of the next data block to be transferred between the initiator and the target if a READ or WRITE command is issued.

The Last Block Location is specified by the following procedure:

1. After a WRITE, WRITE FILEMARK, or any command failed for a deferred write error, this field specifies the block address that is associated with the next block to be transferred from the buffer to the medium.
2. After a successful read type command (for example Read, Space, Locate, non-immediate Rewind), this field is returned as 0.

The Beginning of Partition (BOP) field is set if the Block Location fields are 0.

An end-of-partition (EOP) field of 1 specifies that the logical unit is positioned between early-warning and end-of-partition. An EOP field of 0 specifies that the current logical position is not between early-warning.

The Block Position Unknown (BPU) field is always set to 0, because the position is always known.

The Partition Number is set to 0 because partitioning is not supported.

A block count unknown (BCU) field of 1 indicates that the Number of Blocks in Buffer field does not represent the actual number of blocks in the buffer. A BCU field of 0 indicates that the Number of Blocks in Buffer field is valid.

A byte count unknown (BYCU) field of 1 indicates that the Number of Bytes in Buffer field does not represent the actual number of bytes in the buffer. This field is always set to 1.

The Number of blocks in buffer field is specified by the following procedure:

1. After WRITE, WRITE FILEMARK, or any command failed for a deferred write error, this field specifies the number of unwritten data blocks and filemarks that are still in the buffer.
2. After successful read type commands this field will always return 0.

RECEIVE DIAGNOSTIC RESULTS

The RECEIVE DIAGNOSTIC RESULTS command returns the results of diagnostic tests to the initiator. The format of the data returned is specified in "SEND DIAGNOSTIC" on page 209.

Table 174. RECEIVE DIAGNOSTIC RESULTS Command

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Operation Code (1Ch)</td></tr>
<tr><td>1</td><td colspan="3">Obsolete</td><td colspan="5">Reserved</td></tr>
<tr><td>2</td><td colspan="8">Reserved</td></tr>
<tr><td>3
:
4</td><td colspan="8">Allocation Length</td></tr>
<tr><td>5</td><td colspan="8">Control</td></tr>
</table>

RELEASE UNIT

The RELEASE UNIT command removes a reservation made by a RESERVE UNIT command. If there is an existing reservation from the same initiator with the same parameters, then that reservation is removed and Good status is returned. It is not an error to attempt to release a reservation that is not currently valid or is held by another initiator. In this case, the drive returns Good status without altering any reservation.

Table 175. 6-Byte RELEASE UNIT Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (17h)							
1	Obsolete			Obsolete				
2	Obsolete							
3	Reserved							
4	Obsolete (0)							
5	Control							

Table 176. 10-Byte RELEASE UNIT Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (57h)							
1	Obsolete			3rdPty (0)		LongID (0)		Reserved
2	Reserved							
3	Third Party Device ID (0)							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length (0)							
9	Control							

REPORT DENSITY SUPPORT

The REPORT DENSITY SUPPORT command returns details about the tape formats supported by the drive. The data is returned as a header and a series of descriptor blocks. If the Media field is set, then one descriptor block is returned with the data for the currently loaded tape. If the Media field is set to 0, the density support data block descriptors are returned by ascending Primary Density Code values.

Table 177. REPORT DENSITY SUPPORT Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (44h)							
1	Obsolete			Reserved				Media
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Allocation Length							
9	Control							

The Allocation Length field specifies the maximum number of bytes that the device server may return.

The REPORT DENSITY SUPPORT command returns the REPORT DENSITY SUPPORT header (see Table 178 on page 179) followed by one or more density support data block descriptors (see Table 179 on page 179). The density support data block descriptors follow the density support header.

In an Ultrium 1 drive, the Ultrium 1 descriptor is always returned with the DEFLT field set to 1.

In an Ultrium 2 drive, if a medium is loaded in the drive and the Media field is set to 1, the descriptor of the loaded medium will be returned with the DEFLT field set to 1. If the Media bit is set to 0, the density support data block descriptors are returned with the Ultrium 1 descriptor followed by the Ultrium 2 descriptor. If there is no medium in the drive and the Media field is set to 0, both descriptors will have the DEFLT field set to 1. If a medium is loaded in the drive and the Media field is set to 0, the descriptor of the density of the loaded medium will be returned with the DEFLT field set to 1 and the descriptor of other density will be returned with the DEFLT bit set to 0.

In an Ultrium 3 drive, if a medium is loaded in the drive and the Media field is set to 1, the descriptor of the loaded medium will be returned with the DEFLT field set to 1. If the Media bit is set to 0, the density support data block descriptors are returned with the Ultrium 1 descriptor, followed by the Ultrium 2 descriptor, followed by the Ultrium 3 descriptor. If there is no medium in the drive and the Media field is set to 0, all descriptors will have the DEFLT field set to 1. If a medium is loaded in the drive and the Media field is set to 0, the descriptor of the density of the loaded medium will be returned with the DEFLT field set to 1 and the descriptor of other density will be returned with the DEFLT bit set to 0.

The format of the REPORT DENSITY SUPPORT header is as follows:

In an Ultrium 4 drive, if a medium is loaded in the drive and the Media field is set to 1, the descriptor of the loaded medium will be returned with the DEFLT field set to 1. If the Media bit is set to 0, the density support data block descriptors are returned with the Ultrium 2 descriptor, followed by the Ultrium 3 descriptor, followed by the Ultrium 4 descriptor. If there is no medium in the drive and the Media field is set to 0, all descriptors will have the DEFLT field set to 1. If a medium is loaded in the drive and the Media field is set to 0, the descriptor of the density of the loaded medium will be returned with the DEFLT field set to 1 and the descriptor of other density will be returned with the DEFLT bit set to 0.

Table 178. REPORT DENSITY SUPPORT Header

Byte	Bit 7	6	5	4	3	2	1	0
0 : 1	Available Density Descriptor Length							
2	Reserved							
3	Reserved							

The Available Density Descriptor Length gives the total amount of data that is available to be returned and does not include itself.

The header is followed by one or more REPORT DENSITY SUPPORT descriptor blocks with the format in Table 179.

Table 179. REPORT DENSITY SUPPORT Descriptor Block

Byte	Bit 7	6	5	4	3	2	1	0
0	Primary Density Code							
1	Secondary Density Code							
2	WRTOK	DUP(0)	DEFLT	Reserved				
3	Reserved							
4	Reserved							
5 : 7	Bits per mm							
8 : 9	Media Width							

Table 179. REPORT DENSITY SUPPORT Descriptor Block (continued)

Byte	Bit 7	6	5	4	3	2	1	0
10 : 11	Tracks							
12 : 15	Capacity							
16 : 23	Assigning Organization							
24 : 31	Density Name							
32 : 51	Description							

Table 180 shows the values that are reported for the Ultrium format.

Table 180. Density Information for LTO Formats

Field	Ultrium 1	Ultrium 2	Ultrium 3	Ultrium 4
Primary density code	40h	42h	44h	46h
Secondary density code	40h	42h	44h	46h
Bits per mm	4880	7398	9638	12725
Media width (in tenths of mm)	127	127	127	127
Tracks	384	512	704	896
Capacity[1]	95,367 (in 2^{20} bytes)	190,734 (in 2^{20} bytes)	381,469 (in 2^{20} bytes)	800,000 (in 10^{6} bytes)
Assigning organization	"LTO-CVE "	"LTO-CVE "	"LTO-CVE "	"LTO-CVE "
Density name	"U-18 "	"U-28 "	"U-316"	"U-416 "
Description	"Ultrium 1/8T"	"Ultrium 2/8T"	"Ultrium 3/16T"	"Ultrium 4/16T "

Notes:
1: See each generation value to see what units the capacity is expressed in. Earlier generations express Capacity in non-standard units.

The Write Okay (WRTOK) field is set to 0 if the drive does not support writing to this format, but does support reading it. This is always set to 1 for Ultrium 1 and Ultrium 2 drives. In Ultrium 3 drives, the WRTOK field is set to 0 when Generation 1 media is in the drive, and set to 1 when Generation 2 or Generation 3 media is in the drive. In Ultrium 4 drives, the WRTOK field is set to 0 when Generation 1 or Generation 2 media is in the drive, and set to 1 when Generation 3 or Generation 4 media is in the drive.

The Duplicate (DUP) field is set to 0 for every descriptor block, indicating that each density is reported only once. A DEFLT field of 0 specifies that this density is not the default density of the drive. A DEFLT field of 1 specifies that this density is the default density.

Note: The default density of the drive will vary, depending on the currently mounted media. Multiple codes may return a DEFLT field of 1 when the Media field is 0 because more than one default is possible.

If the Media field is set to 0, the maximum values possible are reported. In Ultrium 2 drives, the Ultrium 1 descriptor is returned, followed by the Ultrium 2 descriptor. In Ultrium 3 drives, the Ultrium 1 descriptor is returned, followed by the Ultrium 2 descriptor, followed by the Ultrium 3 descriptor.

If the Media field is set to 1, the Capacity field specifies the approximate capacity of the current tape, assuming that recording occurs in this density with one partition.

If the Media field is 1 and the logical unit is not in the ready state, Check Condition status will be returned. The Sense Key must be set to Not Ready and the Additional Sense Code will specify the reason for Not Ready.

The Bits per mm field specifies the number of bits per millimeter per track as recorded on the medium. See Table 180 on page 180 for the values that are returned.

The Media Width field specifies the width of the medium that is supported by this density. See Table 180 on page 180 for the values that are returned.

The Tracks field specifies the number of data tracks that are supported on the medium by this density. See Table 180 on page 180 for the values that are returned.

If the Media field is 0, the Capacity field specifies the approximate capacity of the longest supported medium for this density. If the Media field is 1, the Capacity field specifies the approximate capacity of the current medium for this density. If the approximate capacity of the current medium is not available for the mounted medium, the longest supported medium capacity for this density is used. The capacity assumes that compression is disabled. The capacity also assumes that the media is in good condition, and that normal data and block sizes are used. This value is in units of megabytes (10^6 bytes). The drive does not guarantee that this space is actually available in all cases. See Table 180 on page 180 for the values that are returned.

The Assigning Organization field contains 8 bytes of ASCII data that identifies the organization that is responsible for the specifications that define the values in this density support data block descriptor. The data is left-aligned within this field. The ASCII value for a space (20h) is used for padding. See Table 180 on page 180 for the values that are returned.

The Density Name field contains 8 bytes of ASCII data that identifies the document (or other identifying name) that is associated with this density support data block descriptor. The data is left-aligned within this field. The ASCII value for a space (20h) is used for padding. See Table 180 on page 180 for the values that are returned.

The Description field contains 20 bytes of ASCII data that describe the density. The data is left-aligned within this field. The ASCII value for a space (20h) is used for padding. See Table 180 on page 180 for the values that are returned.

REPORT LUNs

The server uses the REPORT LUNs command to retrieve information about the Logical Units that the drive supports.

Table 181. REPORT LUNs Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (A0h)							
1	Reserved							
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6 : 9	Allocation Length							
10	Reserved							
11	Control							

The allocation length is at least 16 bytes. If this is not the case, the drive returns Check Condition status, with a Sense Key of Illegal Request and an ASC/ASCQ of Invalid Field in CDB.

Table 182 shows the data that is returned:

Table 182. Logical Unit Numbers Data

Byte	Bit 7	6	5	4	3	2	1	0
0 : 3	LUN List Length							
4 : 7	Reserved							
8 : 15	First LUN (0000000000000000h)							
n : m	Additional LUN descriptor(s)							

The LUN List Length field contains the length in bytes of the LUN list that is available to be transferred. The LUN list length is the number of logical unit numbers in the logical unit inventory multiplied by eight. This value depends on drive configuration.

On drives not using the ADI interface that do not have the library control path feature enabled, this value is 8. On drives not using the ADI interface that have the library control path feature enabled, this value is 16 and an Additional LUN descriptor is returned with a value of 0001000000000000h.

On drives using the ADI interface, if the ENABLE bit of Logical Unit Index 01h in the Mode Page 0Eh subpage 03h is set, then an Additional LUN descriptor is returned with a value of 0001000000000000h.

On drives using the ADI interface:
- **If this command is received over a primary port**, and if the ENABLE bit of Logical Unit Index 02h in Mode Page 0Eh subpage 03h is set, then an Additional LUN descriptor is returned with a value of 0002000000000000h.
- **If this command is received over the ADT port** , then an Additional LUN descriptor is returned with a value of 0002000000000000h, regardless of the setting of the ENABLE bit of Logical Unit Index 02h in Mode Page 0Eh subpage 03h.

If the allocation length in the CDB is too small to transfer information about the entire logical unit inventory, the LUN list length value will not be adjusted to reflect the truncation.

REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS (Not LTO1)

The REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS command (see Table 183) requests information on task management functions supported by the drive. This command is supported on Fibre Channel drives only.

Table 183. REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS command

	7	6	5	4	3	2	1	0
0	Operation Code (A3h)							
1	Reserved			Service Action (0Dh)				
2	Reserved							
5								
6	(MSB) Allocated Length (4h or larger)							
9								(LSB)
10	Reserved							
11	Control							

The ALLOCATION LENGTH field indicates how many bytes have been allocated for the returned parameter data. If the length is not sufficient to contain all the parameter data, the first portion of the data is returned. This is not considered an error. The actual length of the parameter data is available in the TIMESTAMP PARAMETER DATA LENGTH field in the parameter data. If the remainder of the parameter data is required, the application client should send a new REPORT TIMESTAMP command with an ALLOCATION LENGTH field large enough to contain all the data.

The format of the parameter data returned by the REPORT TASK MANAGEMENT FUNCTIONS command is shown in Table 184.

Table 184. REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS parameter data

	7	6	5	4	3	2	1	0
0	ATS (1)	ATSS (1)	CACAS (0)	CTSS (1)	LURS (1)	QTS (0)	TRS (1)	WAKES (0)
1	Reserved							INTRS (0)
2	Reserved							
3								

REPORT TIMESTAMP (Not LTO 1)

The REPORT TIMESTAMP command see (see) requests that the drive return the value of the logical unit's timestamp.

Table 185. REPORT TIMESTAMP command

Byte	Bit 7	6	5	4	3	2	1	0
0	OPERATION CODE (A3h)							
1	Reserved			SERVICE ACTION (0Fh)				
2 – 5	Reserved							
6 – 9	ALLOCATION LENGTH							
10	Reserved							
11	CONTROL							

The ALLOCATION LENGTH field indicates how many bytes have been allocated for the returned parameter data. If the length is not sufficient to contain all the parameter data, the first portion of the data is returned. This is not considered an error. The actual length of the parameter data is available in the TIMESTAMP PARAMETER DATA LENGTH field in the parameter data. If the remainder of the parameter data is required, the application client should send a new REPORT TIMESTAMP command with an ALLOCATION LENGTH field large enough to contain all the data.

The format of the parameter data returned by the REPORT TIMESTAMP command is shown in Table 186.

Table 186. Timestamp Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0 – 1	TIMESTAMP PARAMETER DATA LENGTH (0Ah)							
2	Reserved					Timestamp Origin		
3	Reserved							
4	(MSB)			TIMESTAMP				
9								(LSB)
10	Reserved							
11	Reserved							

The TIMESTAMP PARAMETER DATA LENGTH field indicates the number of bytes of parameter data that follow.

The timestamp origin field indicates the origin of the timestamp returned (see "Device Clocks" on page 249). The TIMESTAMP field shall contain the current value of the timestamp (see "Device Clocks" on page 249).

REQUEST SENSE

Table 187. REQUEST SENSE Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (03h)							
1	Obsolete			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Control							

The sense data returned is described in Table 188.

Sense Data Format

Table 188. Sense Data Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Valid	Sense Error Code						
1	Segment Number (0)							
2	File Mark	EOM	ILI	Reserved	Sense Key			
3 : 6	Information							
7	Additional Sense Length							
8 : 11	Command Specific Information							
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	Field Replaceable Unit Code							
15	SKSV	C/D	Reserved		BPV	Bit Pointer		
16 : 17	SKSV (1: Field Pointer) SKSV (0: Reporting Error Fault Symptom Code)							
18 : 19	Reporting Error Flag Data							
20	Reserved (0)							
21	LowPerf				DrvSrvc	Reserved		

Table 188. Sense Data Format (continued)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>22
:
28</td><td colspan="8">Volume Label</td></tr>
<tr><td>29</td><td colspan="8">Physical Wrap</td></tr>
<tr><td>30
:
33</td><td colspan="8">Relative LPOS Value</td></tr>
<tr><td>34</td><td colspan="8">SCSI Address</td></tr>
<tr><td>35</td><td colspan="8">RS422 Information</td></tr>
<tr><td>36
:
39</td><td colspan="8">Port Identifier (Relative Target Port Address) Reporting Sense (This is the port address of the drive port through which sense is being reported.

On Fibre Channel drives, it is the Fibre Channel Fabric Port Address [for example, 011E13 or 000026] with byte 36 being reserved.

On SAS drives, it is the Hashed SAS Address of the drive port [for example, F32A94] with byte 36 being reserved.

On SCSI, bytes 36 through 38 are reserved, and byte 39 is set to the port’s SCSI address [i.e., byte 39 = byte 34].)</td></tr>
<tr><td>40</td><td>Tape Directory Valid</td><td>Reserved</td><td>Reserved</td><td>Reserved</td><td>Reserved</td><td colspan="3">Relative Tgt Port Reporting Sense

0: Reserved
1: Relative Tgt Port 1 (Port 0)
2: Relative Tgt Port 2 (Port 1)
3: Relative Tgt Port 3 (Library Port)</td></tr>
<tr><td>41</td><td colspan="8">Host Command (SCSI Opcode)</td></tr>
<tr><td>42</td><td colspan="4">Density Type

0: No media present
1: Gen1 (384 track)
2: Gen2 (512 track)
3: Gen3 (704 track)
4: Gen 4</td><td colspan="4">Media Type (Vendor Reserved)</td></tr>
<tr><td>43</td><td colspan="8" rowspan="2">Volume Label Cartridge Type</td></tr>
<tr><td>44</td></tr>
<tr><td>45
:
48</td><td colspan="8">Logical Block Number

(Current LBA that would be reported in Read Position command)</td></tr>
<tr><td>49
:
52</td><td colspan="8">Data set Number</td></tr>
<tr><td>53</td><td colspan="8" rowspan="2">1st Error FSC</td></tr>
<tr><td>54</td></tr>
</table>

Table 188. Sense Data Format (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
55	1st Error Flag Data							
56								
57	2nd Error FSC							
58								
59	2nd Error Flag Data							
60								
61	Next-to-Last Error FSC							
62								
63	Next-to-Last Error Flag Data							
64								
65	Last Error FSC							
66								
67	Last Error Flag Data							
68								
69	LPOS Region							
70 : 85	ERP Summary Information							
86 : 95	Cartridge Serial Number (This is not the Barcode value, but the value from the CM right justified)							
90 : 95	Reserved (0)							

The Valid field is set if the Information field contains valid information.

The descriptions that follow serve only as an overview of sense reporting in the tape drive. This tape drive conforms to all sense field reporting, as specified in the *SCSI Primary Commands-2 (SPC-2)*.

The Error Code field is set to 70h to indicate a current error that is associated with the most recently received command. It is set to 71h to indicate a deferred error that is not associated with the current command.

The segment number is 0, because the COPY, COMPARE, and COPY and VERIFY commands are not supported.

The File Mark field is set if a SPACE, READ, or VERIFY command did not complete because a file mark was read.

The End of Medium (EOM) field is set if a WRITE or WRITE FILE MARKS command completed in the early warning area. Spacing into BOM also causes this field to be set. It is also set on an attempt to read or space past EOD or if an attempt is made to space into Beginning of Media.

The Illegal Length Indicator (ILI) field is set if a READ or VERIFY ended because a block was read from tape that did not have the block length requested in the command.

For values of the Sense Key field see Chapter 7, "Sense Keys and Additional Sense," on page 253.

The Information Bytes are only valid if the Valid field is set. This occurs only for current errors and not for deferred errors. See the specific command for details about when Information Bytes are valid.

The Additional Sense Length is set to *n*-7, and is at least 10. When the sense data is associated with an Illegal Length read, the Additional Sense Length may be 10. In Generation 1 and Generation 2 drives, *n* can be as large as 35. In Generation 3 drives, *n* can be as large as 95. While this length in Generation 3 drives is not anticipated to change, it is recommended that the Additional Sense Length be used to parse that data.

The Command Specific Information is set to 0, because no supported commands define a use for this field.

For supported Additional Sense Codes and Additional Sense Code Qualifiers, see Chapter 7, "Sense Keys and Additional Sense," on page 253.

The Field Replaceable Unit field is set to 0 or to a non-zero, vendor-specific code that indicates the part of the drive that is suspected of causing the failure.

The only Sense Key-specific data supported is for Illegal Request (5h). For this sense key, the Sense Key Specific Valid field is set and the following fields may be set:

- The Command/Data (C/D) field is set to 1 if the illegal parameter was detected in the Command Descriptor Block, and is set to 0 if it was detected in the Data phase.
- If a bit within a byte was invalid, the Bit Pointer Valid (BPV) field is set and the Bit Pointer field is set to indicate which bit was in error.
- The Field Pointer is set to indicate which byte was in error.

The Drive Service (DrvSrvc) bit is mapped to the "Dead Drive" flag of "Log Page 3Ch: Drive Usage Information" on page "Log Page 3Ch: Drive Usage Information" on page 102. This bit is set to one by code whenever the drive determines that it has a hardware fault causing the drive to be inoperative.

1. This bit is maintained across all reset conditions, firmware downloads, and power cycles.
2. This bit does not affect drive operations.
3. The drive Power-On-Test does not test or affect this bit.

The Clean (CLN) field is set if the drive needs cleaning, and is otherwise set to 0.

In a Low Performance drive, the LowPerf bit is set to 1. In a normal, non-performance limited drive, the LowPerf bit is set to 0.

The Dump field indicates that the drive has a Dump available. The field is used to indicate when it is appropriate to read a dump.

The Volume Label Fields Valid (VolValid) field is set if the Volume Label being reported is valid.

If a cartridge is loaded in the drive and the Volume Label Fields Valid is set, the Volume Label field reports the seven characters from the left of the volume label from the CM Mechanism Related Data page (if one exists), or it reports the seven characters from the left of the volume label from the host bar code field in the CM (if it exists), or it reports all spaces (ASCII 20h).

The Current Wrap reports the physical wrap of the tape. The least significant bit reflects the current physical direction. A 0 means the current direction is away from physical beginning of tape. A 1 means the current direction is towards physical beginning of tape.

Relative LPOS reports the current physical position on tape.

SCSI Address reports the SCSI Bus Address for the drive. Values returned range from 00h to 0Fh.

The RS422 Information field may contain a value passed across the RS-422 serial interface by, for example, a tape library, if the library vendor chooses to send such a value. The value passed from across the RS-422 interface is reported persistently until a different value is sent, at which time the new value is reported persistently.

The Volume Label Cartridge Type is defined by Table 189.

Table 189. Volume Label Cartridge Type

Definition	Native Capacity	Volume Label Cartridge Type
Ultrium 1 Type A	100 GB	L1
Ultrium 1 Type B	50 GB	LA
Ultrium 1 Type C	30 GB	LB
Ultrium 1 Type D	10 GB	LC
Ultrium 2 Type A	200 GB	L2
Ultrium 3 Type A	400 GB	L3
Ultrium 3 WORM A	400 GB WORM	LT
Ultrium 4 Type A	800 GB	L4
Ultrium 4 WORM A	800 GB WORM	LU

RESERVE UNIT

The RESERVE UNIT command creates a reservation for the drive. Third-party reserves are not supported.

Table 190. 6-Byte RESERVE UNIT Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (16h)							
1	Obsolete			Obsolete (00h)				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

Table 191. 10-Byte RESERVE UNIT Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (56h)							
1	Obsolete			3rdPty(0)	Reserved		LongID (0)	Reserved
2	Reserved							
3	Third Party Device ID (0)							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length (0)							
9	Control							

REWIND

The REWIND command causes the logical position to be set to BOM.

Table 192. REWIND Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (01h)							
1	Obsolete			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

If the Immediate (Immed) field is set to 1, then the drive validates the command and waits for any previous command from any server to complete, including any immediate commands that are currently being processed. It also waits for any buffered data to be flushed to tape. It then reports a deferred error for any preceding command or buffered data, if appropriate. If there is no deferred error, the drive reports Good status and initiates the command. If the Immediate (Immed) field is set to 0, status is not returned until after the command has completed.

SECURITY PROTOCOL IN (SPIN) A2h

The SECURITY PROTOCOL IN command (see Table 193) is used to retrieve security protocol information (see xx) or the results of one or more SECURITY PROTOCOL OUT commands (see “SECURITY PROTOCOL OUT (SPOUT) B5h” on page 203).

Table 193. Security Protocol In - A2h CDB

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation code (A2h)							
1	Security Protocol							
2	Security Protocol Specific							
3								
4	INC_512 (0)	Reserved						
5	Reserved							
6	(MSB) Allocation Length							
9								(LSB)
10	Reserved							
11	Control Byte (see ″Control Byte Definition″ on page xxx)							

The following parameters apply:

- Security Protocol

Table 194. Security Protocol Definitions

Code	Description	Reference
00h	Security protocol information	“Security Protocol In Pages (00h - Security Protocol Information)”
20h	Tape Data Encryption	“Security Protocol In Pages (20h - Tape Data Encryption)” on page 196
all others	Reserved	

- Security Protocol Specific - The contents depend on the protocol specified by the Security Protocol field (see Table 194).
- Allocation Length

Security Protocol In Pages (00h - Security Protocol Information)

The Security Protocol Specific field of the SPIN CDB is defined by Table 195.

Table 195. Security Protocol Specific Definitions for Security Protocol 00h

Code	Description	Reference
0000h	Supported security protocol list	“SPIN (00h:0000h) - Supported Security Protocols List” on page 195
0001h	Certificate data	“SPIN (00h:0001h) - Certificate Data” on page 195

Table 195. Security Protocol Specific Definitions for Security Protocol 00h (continued)

Code	Description	Reference
0002h - FFFFh	Reserved	

SPIN (00h:0000h) - Supported Security Protocols List

If the SECURITY PROTOCOL field is set to 00h and the SECURITY PROTOCOL SPECIFIC field is set to 0000h in a SECURITY PROTOCOL IN command, the parameter data shall have the format shown in Table 196.

Table 196. Supported Security Protocols List Structure

Byte	Bit 7	6	5	4	3	2	1	0
0 - 5	Reserved							
6 - 7	(MSB) Supported Security Protocol List Length (m-7) (LSB)							
8	Supported Security Protocol (first) (00h)							
	. . .							
m	Supported Security Protocol (last)							

The supported Security Protocols are listed in Table 194 on page 194.

SPIN (00h:0001h) - Certificate Data

The drive certificate (if present) is provided in X.509 format via this interface (see SPC-4).

If the Security Protocol field is set to 00h and the Security Protocol Specific field is set to 0001h in a Security Protocol In command, the parameter data shall have the format shown in Table 197.

Table 197. Certificate Data Structure

Byte	Bit 7	6	5	4	3	2	1	0
0 - 1	Reserved							
2 - 3	(MSB) Certificate Length (m-3) (LSB)							
4 - m	Certificate							

The following parameters apply:

- Certificate Length - The total length, in bytes, of the certificate that follows.
- Certificate - The drive certificate set during manufacturing is returned.

Security Protocol In Pages (20h - Tape Data Encryption)

The Security Protocol Specific field (see Table 198) specifies the type of report that the application client is requesting. Table 198 shows supported Security Protocol Specific field values.

Table 198. Security Protocol Specific Definitions for Security Protocol 20h

Page Code	Description	Reference
0000h	Tape Data Encryption In Support Pages	see 196
0001h	Tape Data Encryption Out Support Pages	see 197
0010h	Data Encryption Capabilities	see 198
0011h	Supported Key Formats	see 199
0012h	Data Encryption Management Capabilities	see 199
0020h	Data Encryption Status	see 200
0021h	Next Block Encryption Status	see 201

SPIN (20h:0000h) - Tape Data Encryption In Support Pages page

Supported protocol specific in pages for protocol 20h are indicated above (see SSC-3).

Table 199. 0000h - Tape Data Encryption In Support Pages Structure

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB)			Page Code (0000h)				
1								(LSB)
2	(MSB)			Page Length (n-3)				
3								(LSB)
Tape Data Encryption In Support page code list								
4	(MSB)			Tape Data Encryption In Support page code (first)				
5								(LSB)
				...				
n-1	(MSB)			Tape Data Encryption In Support page code (last)				
n								(LSB)

Table 200 show which Tape Data Encryption In page codes are supported:

Table 200. Tape Data Encryption In page codes

Page Code	Description	Reference
0000h	Tape Data Encryption In Support Pages	"SPIN (20h:0000h) - Tape Data Encryption In Support Pages page"
0001h	Tape Data Encryption Out Support Pages	"SPIN (20h:0001h) - Tape Data Encryption Out Support Pages page" on page 197

Table 200. Tape Data Encryption In page codes (continued)

Page Code	Description	Reference
0010h	Data Encryption Capabilities	“SPIN (20h:0010h) - Data Encryption Capabilities page” on page 198
0011h	Supported Key Formats	“SPIN (20h:0011h) - Supported Key Formats page” on page 199
0012h	Data Encryption Management Capabilities	“SPIN (20h:0012h) - Data Encryption Management Capabilities” on page 199
0020h	Data Encryption Status	“SPIN (20h:0020h) - Data Encryption Status page” on page 200
0021h	Next Block Encryption Status	“SPIN (20h:0021h) - Next Block Encryption Status page” on page 201

SPIN (20h:0001h) - Tape Data Encryption Out Support Pages page

Supported protocol specific out pages for protocol 20h are indicated above (see SSC-3).

Table 201. 0001h - Tape Data Encryption Out Support Pages Structure

Byte	Bit							
	7	6	5	4	3	2	1	0
0	(MSB)			Page Code (0001h)				
1								(LSB)
2	(MSB)			Page Length (n-3)				
3								(LSB)
Tape Data Encryption Out Support page code list								
4	(MSB)			Tape Data Encryption Out Support page code (first)				
5								(LSB)
	...							
n-1	(MSB)			Tape Data Encryption Out Support page code (filastrst)				
n								(LSB)

Table 202 on page 198 shows which Tape Data Encryption Out page codes are supported:

Table 202. Tape Data Encryption Out page codes

Page Code	Description	Reference
0010h	Set Data Encryption	"SPIN (20h:0010h) - Data Encryption Capabilities page"

SPIN (20h:0010h) - Data Encryption Capabilities page

Table 203 specifies the format of the Data Encryption Capabilities page.

Table 203. 0010h - Data Encryption Capabilities page

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB)	Page Code (0010h)						
1								(LSB)
2	(MSB)	Page Length n-3)						
3								(LSB)
4	Reserved							
19								
Data Encryption Algorithm descriptor list								
20	Data Encryption Algorithm descriptor (first)							
	...							
	Data Encryption Algorithm descriptor (last)							
n								

Data Encryption Algorithm Descriptor - Standard Encryption

The Standard Encryption Algorithm Descriptor is shown in Table 204.

Table 204. Data Encryption Algorithm Descriptor - Standard Encryption Structure

Byte	Bit 7	6	5	4	3	2	1	0
0	Algorithm Index (01h)							
1	Reserved							
2	(MSB)	Descriptor Length (0014h)						
3								(LSB)
4	AVFMV	SDK_C (0)	MAC_C (1)	DED_C (1)	DECRYPT_C (2H)		ENCRYPT_C (2H)	
5	Reserved		NONCE_C (3)		Reserved			
6	(MSB)	Maximum Unauthenticated Key-Associated Data (U-KAD) Bytes (0020h)						
7								(LSB)
8	(MSB)	Maximum Authenticated Key-Associated Data (A-KAD) Bytes (000Ch)						
9								(LSB)
10	(MSB)	Key Size (0020h)						
11								(LSB)

Table 204. Data Encryption Algorithm Descriptor - Standard Encryption Structure (continued)

Byte	Bit 7	6	5	4	3	2	1	0
12 – 19	Reserved							
20 – 23	(MSB) Encryption Algorithm Identifier (00000014h) (LSB)							

SPIN (20h:0011h) - Supported Key Formats page

The structure of the Supported Key Formats page is shown in Table 205.

Table 205. Supported Key Formats page Structure

Byte	Bit 7	6	5	4	3	2	1	0
0 – 1	(MSB) Page Code (0011h) (LSB)							
2 – 3	(MSB) Page Length (n-3) (LSB)							
Supported Key Format list								
4 – 5	(MSB) Supported Key Format (first) (LSB)							
	...							
n-1 – n	(MSB) Supported Key Format (last) (LSB)							

Table 206. Supported Key Formats

Key Format	Description	Reference
00h	Plaintext Key Format	"Plaintext Key Format (00h)"

Plaintext Key Format (00h): The Plaintext Key Format structure is shown in Table 207.

Table 207. Plaintext Key Format Structure

Byte	Bit 7	6	5	4	3	2	1	0
o – n	Key							

SPIN (20h:0012h) - Data Encryption Management Capabilities

Table 208 on page 200 specifies the format of the Data Encryption Management Capabilities page.

Table 208. Data Encryption Management Capabilities

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB) Page Code (0012h)							
1								(LSB)
2	(MSB) Page Length (000Ch)							
3								(LSB)
4	Reserved							LOCK_C (1)
5	Reserved					CKOD_C (1)	CKORP_C (1)	CKORL_C (1)
6	Reserved							
7	Reserved					AITN_C (1)	LOCAL_C (1)	PUBLIC_C (1)
8 - 15	Reserved							

SPIN (20h:0020h) - Data Encryption Status page

Table 209 specifies the format of the Data Encryption Status page.

Note: This is a query of information which was set with Security Protocol Out 0010h - Set Data Encryption and does not reflect the actual state of the medium itself or of any data on medium.

Table 209. 0020h - Data Encryption Status page

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB) Page Code (0020h)							
1								(LSB)
2	(MSB) Page Length (n-3)							
3								(LSB)
4	I_T Nexus Scope			Reserved		Key Scope		
5	Encryption Mode							
6	Decryption Mode							
7	Algorithm Index							
8	(MSB) Key Instance Counter							
11								(LSB)
12 - 23	Reserved							
24 - n	Key-Associated Data Descriptors List							

The following parameters apply:

- I_T Nexus Scope
- Key Scope

- Encryption Mode
- Decryption Mode
- Algorithm Index
- Key Instance Counter
- Key-Associated Data Descriptors List (See “Key-Associated Data (KAD) Descriptors” on page 206

SPIN (20h:0021h) - Next Block Encryption Status page

Table 210 specifies the format of the Next Block Encryption Status page.

Table 210. 0021h - Next Block Encryption Status page

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB) Page Code (0021h)							
1								(LSB)
2	(MSB) Page Length (n-3)							
3								(LSB)
4	(MSB) Key Instance Counter							
11								(LSB)
12	Compression Status (0h)				Encryption Status			
13	Algorithm Index							
14	Reserved							
15								
16	Key-Associated Data Descriptors List							
n								

The following parameters apply:

- Logical Object Identifier
- Encryption Status
- Algorithm Index
- Key-Associated Data Descriptors List (See “Key-Associated Data (KAD) Descriptors” on page 206)

Note: Next block encryption status may not be available in all situations. When it is not known appropriate values are returned as per the standard. In most situations next block information is available during read operations when read ahead is being performed. This is automatically managed by the device.

The following table indicates valid combinations of record status, Decryption Mode and returned Key-Associated Descriptors reflecting the currently setup state of the device.

Table 211. SPIN (20h:0021h) - KAD Parameters by Mode

Record Information	Decryption Mode	Read Data	Status	Key-Associated Descriptors: uKAD 00h	aKAD (DKi) 01h	Nonce 02h	Meta data 03h	Notes
Unknown	any	?	1h	n/a	n/a	n/a	n/a	

Table 211. SPIN (20h:0021h) - KAD Parameters by Mode (continued)

Record Information	Decryption Mode	Read Data	Status	Key-Associated Descriptors				Notes
				uKAD 00h	aKAD (DKi) 01h	Nonce 02h	Meta data 03h	
Filemark	any	n/a	2h	n/a	n/a	n/a	n/a[2]	may be unknown
EOD	any	n/a	2h	n/a	n/a	n/a	n/a	may be unknown
Error	any	n/a	1h	n/a	n/a	n/a	n/a	may be unknown
Cleartext	0h Disable	C	3h	n/a	n/a	n/a	n/a	
Cleartext	1h Raw	E	3h	n/a	n/a	n/a	n/a	not readable
Cleartext	2h Decrypt	E	3h	n/a	n/a	n/a	n/a	not readable
Cleartext	3h Mixed	C	3h	n/a	n/a	n/a	n/a	
Encrypted	0h Disable	E	4h	Y	Y	N	N	not readable
Encrypted	1h Raw	R	5h	N	N	N	Y	
Encrypted	2h Decrypt	C[1]	or	Y	Y	N	N	
Encrypted	3h Mixed	C[1]	6h	Y	Y	N	N	

Legend:

- Y: element is required
- O: element is optional
- N: element is not present
- n/a: not applicable (element is not present)
- C: cleartext (not encrypted)
- R: raw (compressed encoded/encrypted)
- E: error condition, record cannot be read

Notes:

1. Data is decrypted
2. Value may be returned if raw mode and data set is encrypted

Key-Associated Data (KAD) Descriptors

See "Key-Associated Data (KAD) Descriptors" on page 206.

SECURITY PROTOCOL OUT (SPOUT) B5h

The SECURITY PROTOCOL OUT command (see Table 212) is used to send data to the logical unit. The data sent specifies one or more operations to be performed by the logical unit. The format and function of the operations depends on the contents of the SECURITY PROTOCOL field (see table 178). Depending on the protocol specified by the SECURITY PROTOCOL field, the application client may use the SECURITY PROTOCOL IN command (see "SECURITY PROTOCOL IN (SPIN) A2h" on page 194) to retrieve data derived from these operations.

Note: The operation code, B5h has been recovered from a seldom used media changer (i.e. LUN 1) command (Request Volume Element Address). If the device driver being used still uses the LUN field of the CDB from SCSI2 days, this command will be routed to the incorrect LUN. Because it is a DATA OUT type command, whereas the Request Volume Element Address is a DATA IN type command this can cause strange system behaviors.

Table 212. Security Protocol Out B5h CDB

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation code (B5h)							
1	Security Protocol							
2	Security Protocol Specific							
3								
4	INC_512 (0)	Reserved						
5	Reserved							
6	(MSB) Allocation Length							
9								(LSB)
10	Reserved							
11	Control Bye (see "Control Byte Definition" on page xxx)							

The following parameters apply:

- Security Protocol

  Value Description
  20h Tape Data Encryption security protocol
- Security Protocol Specific - The contents depend on the protocol specified by the Security protocol field.
- Allocation Length

Security Protocol Out Pages (20h - Tape Data Encryption security protocol)

The Security Protocol Specific field (see Table 212) specifies the type of page that the application client is sending. Table 213 on page 204 shows supported values.

Table 213. Security Protocol Specific Definitions for Security Protocol 20h

Page Code	Description	Reference
0010h	Set Data Encryption	See "SPIN (20h:0010h) - Data Encryption Capabilities page" on page 198

SPOUT (20h:0010h) - Set Data Encryption

Table 214 specifies the format of the Set Data Encryption page.

Table 214. 0010h - Set Data Encryption page

Byte	Bit 7	6	5	4	3	2	1	0
0	(MSB) Page Code (0010h)							
1								(LSB)
2	(MSB) Page Length (m-3)							
3								(LSB)
4	Scope			Reserved				LOCK
5	Reserved				SDK (0)	CKOD	CKORP	CKORL
6	Encryption Mode							
7	Decryption Mode							
8	Algorithm Index							
9	Key Format							
10	Reserved							
17								
18	(MSB) Key Length (n-19)							
19								(LSB)
20	Key							
n								
n+1	Key-Associated Data Descriptors List							
m								

The following parameters apply:

- Scope

  Value Description
  0h Public
  1h Local
  2h All I_T Nexus
- LOCK
- CKOD
- CKORP
- CKORL
- Encryption Mode

Value Description
0h Disable
1h External
2h Encrypt

- Decryption Mode

Value Description
0h Disable
1h Raw
2h Decrypt
3h Mixed

- Key Format
- Key Length

Value Description
000h When no Key is specified
0020h When Key is specified using Key Format 00h

- Key
- Key-Associated Descriptors List (See "Key-Associated Data (KAD) Descriptors" on page 206)

The following table indicates valid combinations of Encryption Mode and Decryption Mode and mandatory, optional and prohibited Key and Key-Associated Descriptors.

Table 215. SPOUT (20h:0010h) - KAD Parameters by Mode

Encryption Mode	Decryption Mode	R/W Data	Key	Key-Associated Descriptors				Notes
				uKAD 00h	aKAD (DKi) 01h	Nonce 02h	Meta data 03h	
0h Disable	0h Disable	C/C	P	P	P	P	P	
0h Disable	1h Raw	R/C	P	P	P	P	P	not recommended
0h Disable	2h Decrypt	C^4/C	M^2	P	P	P	P	not recommended
0h Disable	3h Mixed	C^6/C	M^2	P	P	P	P	
1h External	0h Disable	C/R	P	P	P	P	M^1	not recommended
1h External	1h Raw	R/R	P	P	P	P	M^1	
1h External	2h Decrypt	C^4/R	M^2	P	P	P	M^1	not recommended
1h External	3h Mixed	C^6/R	M^2	P	P	P	M^1	not recommended
2h Encrypt	0h Disable	C/C^4	M^1	O^1	O^1	$O^{1,3}$	P	
2h Encrypt	1h Raw	R/C^4	M^1	O^1	O^1	$O^{1,3}$	P	not recommended
2h Encrypt	2h Decrypt	C^5/C^4	M	O^1	O^1	$O^{1,3}$	P	
2h Encrypt	3h Mixed	C^6/C^4	M	O^1	O^1	$O^{1,3}$	P	

Table 215. SPOUT (20h:0010h) - KAD Parameters by Mode (continued)

<table>
<tr><th rowspan="2">Encryption Mode</th><th rowspan="2">Decryption Mode</th><th rowspan="2">R/W Data</th><th rowspan="2">Key</th><th colspan="4">Key-Associated Descriptors</th><th rowspan="2">Notes</th></tr>
<tr><th>uKAD 00h</th><th>aKAD (DKi) 01h</th><th>Nonce 02h</th><th>Meta data 03h</th></tr>
<tr><td colspan="4">Legend:
M: element is mandatory (required)
P: element prohibited (must not be present)
O: element is optional (may be device generated)
I: element is ignored (may be present)
C: cleartext (not encrypted)
R: raw (compressed encoded/encrypted)</td><td colspan="5">Notes:
1: Only used for writing
2: Only used for reading
3: May be partially ignored
4: Data is encrypted
5: Data is decrypted
6: Data is decrypted (if needed)</td></tr>
</table>

Key-Associated Data (KAD) Descriptors

KAD 00h - Unauthenticated KAD

The Unauthenticated KAD field is available for application use and is recorded when writing with each key change.

Note: If this field is not present an identifier of all zeroes is used.

Table 216. KAD 00h - Unauthenticated KAD

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7 msb</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Key Descriptor Type (00h)</td></tr>
<tr><td>1</td><td colspan="5">Reserved</td><td colspan="3">Authenticated</td></tr>
<tr><td>2</td><td colspan="8" rowspan="2">(MSB)
Key Descriptor Length (n-3)
(LSB)</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td colspan="8" rowspan="2">Unauthenticated Data</td></tr>
<tr><td>n</td></tr>
</table>

The following parameters apply:

- Authenticated

  Value Description
  0h Reserved (must be set for Security Protocol Out - 0010h)
  1h Not Covered by Authentication (only Security Protocol In)
- Key Descriptor Length: may be up to 0020h bytes
- Unauthenticated Data

KAD 01h - DKi (Data Key Identifier)

The DKi KAD field is an optional field which is used when writing and is recorded with each record.

Note: If this field is not present an identifier of all zeroes is used.

Table 217. KAD 01h - DKi (Data Key Identifier)

Byte	Bit 7 msb	6	5	4	3	2	1	0 lsb
0	Key Descriptor Type (01h)							
1	Reserved					Authenticated		
2	(MSB) Key Descriptor Length (n-3)							
3								(LSB)
4	DKi							
n								

The following parameters apply:

- Authenticated

  Value **Description**
  0h Reserved (must be set for Security Protocol Out)
  2h No attempt has been made to authenticate (only Security Protocol In)
- Key Descriptor Length: may be up to 000Ch bytes
- DKi

KAD 02h - Nonce

The Nonce/Initialization Vector (IV) is not technically key-associated data. The Nonce may be set to provide the initial value for IV generation for write operations. This field is optional and the device is capable of generating high quality random IV values. When an application specifies nonce values, it is possible that a systemic cryptographic weakness may be introduced into the system. It is strongly recommended that nonce values are not supplied by the application.

Note: The Nonce KAD is only reported by the device in Security Protocol In 0020h - Data Encryption Status, and the value returned is the exact value specified in 0010h - Set Data Encryption. This may not reflect the actual nonce or IV used for writing encrypted data.

Note: IV values start at the specified Nonce value and are incremented for each record written.

Table 218. KAD 02h - Nonce

Byte	Bit 7 msb	6	5	4	3	2	1	0 lsb
0	Key Descriptor Type (02h)							
1	Reserved					Authenticated		
2	(MSB) Key Descriptor Length (n-3) (000Ch)							
3								(LSB)
4	Nonce/IV							
n								

The following parameters apply:

- Authenticated

  Value Description
  0h Reserved (must be set for Security Protocol Out)
  1h Not Covered by Authentication (only Security Protocol In)
- Key Descriptor Length: the only supported length is 000Ch
- Nonce/IV

KAD 03h - Metadata (Raw)

The Metadata KAD is the combination of the full DKi and DKv fields. This information is available during raw decryption mode reads and must be propogated during external encryption mode write operations (keyless copy) of tape.

Table 219. KAD 03h - Metadata (Raw)

Byte	Bit 7 msb	6	5	4	3	2	1	0 lsb
0	Key Descriptor Type (03h)							
1	Reserved					Authenticated		
2	(MSB) Key Descriptor Length (n-3)							
3								(LSB)
4	Metadata							
n								

The following parameters apply:

- Authenticated

  Value Description
  0h Reserved (must be set for Security Protocol Out)
  1h Not Covered by Authentication (only Security Protocol In)
- Key Descriptor Length: the only supported length is 0040h
- Metadata

SEND DIAGNOSTIC

Table 220. SEND DIAGNOSTIC Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Dh)							
1	Self-Test Code (000b)			PF	Reserved	SelfTest	DevOfL	UnitOfL
2	Reserved							
3 : 4	Parameter List Length							
5	Control							

The SEND DIAGNOSTIC command requests the drive to perform diagnostic operations. When the SelfTest field is 0 and the Self-Test Code field contains 000b, this command is usually followed by a RECEIVE DIAGNOSTIC RESULTS command.

Table 221 lists the supported diagnostics.

Table 221. Supported Diagnostics

Name	Diagnostic ID	Go To Page...
Self-Test	N/A	216
Post A Self Test Diagnostic	0100h	217
Post B Performance Diagnostic	0101h	218
Post C Media Test Diagnostic	0102h	219
Post D Head Test Diagnostic	0103h	221
Primary Port Wrap Test	0090h	222
Force Dump	0160h	223
Write Dump to Cartridge	0161h	224
Write Dump to FLASH (EEPROM)	0162h	227
Clear FLASH Dump (EEPROM)	016Fh	227
Set Traps	0190h	228
Remove Traps	0191h	229
Reset Drive	2002h	231
Read Thermal Sensor	1002h	"Read Thermal Sensor" on page 231
Note: N/A = not applicable		

SIM Data Structure

The following data structure is used in several of the diagnostics. Its purpose is to give detailed error information about drive problems:

Table 222. SIM Data Structure

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (31h)							
1	Reserved							
2 : 3	Page Length (0044h)							
4 : 5	Parameter Code (0000h)							
6	Parameter Control (061h)							
7	Parameter Length (040h)							
8	Indicator (01h)							
9 : 15	Reserved							
16 : 19	Microcode Level							
20 : 21	SIM Message Code							
22 : 23	Reserved							
24	Exception Message							
25	Service Message							
26	Severity Code							
27	Reserved							
28 : 29	Exception Data (00h)							

Table 222. SIM Data Structure (continued)

Byte	Bit 7	6	5	4	3	2	1	0
30 : 33	Error Code							
34 : 37	First FSC							
38 : 41	Last FSC							
42 : 45	Product ID (8000h)							
46 : 48	Vendor ID "IBM"							
49 : 50	Plant of Manufacture							
51	Product ID3 '-'							
52 : 63	Serial Number							
64 : 71	Device Type/Dev SIM_MESSAGE_TYPE							

The SIM Message Code may be one of six values:
- '00'=No Message
- '41'=Device Degraded
- '42'=Device Hardware Failure
- '43'=Service Circuit Failed
- '55'=Drive Needs Cleaning
- '57'=Drive Has Been Cleaned

The Exception Message may be one of eight values:
- '1'=Effect of Failure is Unknown

- ′2′=Device Exception No Performance Impact
- ′3′=Exception on SCSI Interface xx
- ′4′=Device Exception on Operator Panel
- ′5′=Device Exception on Tape Path
- ′6′=Device Exception in Drive
- ′7′=Cleaning Required
- ′8′=Cleaning Done

The Service Message may be one of four values:
- ′1′=Repair Impact is Unknown
- ′7′=Repair will Disable Access to Device Servo
- ′9′=Clean Device
- ′A′=Device Cleaned

The Severity Code may be one of four values:
- ′0′=Service
- ′1′=Moderate
- ′2′=Serious
- ′3′=Acute

MIM Data Structure

The following data structure is used in several of the diagnostics. Its purpose is to give detailed error information about media problems:

Table 223. MIM Data Structure

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (31h)							
1	Reserved							
2 : 3	Page Length (0044h)							
4 : 5	Parameter Code (0000h)							
6	Parameter Control (061h)							
7	Parameter Length (040h)							
8	Indicator (02h)							
9 : 15	Reserved							
16 : 19	Engineering Data Microcode Level							
20 : 21	MIM Message Code							
22 : 23	SARS Data							
24	Exception Message							
25	Reserved							
26	Severity Code							
27 : 29	Reserved							
30 : 33	Error Code							

Table 223. MIM Data Structure (continued)

Byte	Bit 7	6	5	4	3	2	1	0
34 : 39	Volume ID Volume Serial Number							
40	Volume ID Flag							
41	Reserved							
42 : 45	Product ID (8000h)							
46 : 48	Vendor ID “IBM”							
49 : 50	Plant of Manufacture							
51	Product ID3 ’-’							
52 : 63	Serial Number							
64 : 71	Device Type							

The MIM Message Code may be one of four values:
- ’00’=No Message
- ’60’=Bad Media Read Only Permitted
- ’61’=Rewrite Media if Possible
- ’72’=Replace Cleaning Cartridge

The Exception Message may be one of four values:
- ’2’=Data Degraded
- ’4’=Medium Degraded
- ’6’=CM Error
- ’7’=Medium Exception

The Severity Code may be one of four values:
- ’0’=Service
- ’1’=Moderate - Temporary Read/Write Errors
- ’2’=Serious - Permanent Read/Write Errors

- ′3′=Acute - CM Error

The Volume ID Flag may be one of four values:

- ′0′=VOLID not valid
- ′1′=VOLID valid - obtained from tape (CM)
- ′3′=VOLID valid - obtained from cartridge label (server data)
- ′5′=VOLID valid - obtained from cartridge level (library)

Self-Test

For the Self-Test Diagnostic, the CDB values must be set as follows:

- PF - Any value allowed and ignored
- SelfTest - 1
- DevOfl - Any value allowed and ignored
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 0000h

Receive Diagnostics Results: There are no diagnostic results for the Self-Test diagnostic.

Post A Self Test Diagnostic

Table 224. Post A Self Test Send Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0100h)							
6	Flags (0000000b)							Cartridge Required (bx)
7	Reserved							

Table 225. Post A Self Test Receive Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004Dh)							
4 : 5	Diagnostic ID (0100h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9 : 80	SIM/MIM Message or All Zeros							

Post B Performance Diagnostic

The Performance Diagnostic performs a test to determine how well the tape drive writes data. If the percentage degradation exceeds the threshold, the **Send Diagnostic** command will return a Check Condition. The Sense Key will be set to 1h and the ASC/ASCQ set to 0000h. The FSC field of sense data will be set to 52E5, if the degradation is in the forward direction, or 52E6, if the degradation was in the backward direction. The Flag field of the sense data will be set to the percentage. TapeAlert2 (Write Warning) will be set and the SCD will display the character ’A.’ The **Receive Diagnostic** command will return SIM data related to the failure.

Table 226. Post B Performance Send Diagnostic Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0101h)							
6	Flags (0000000b)							Cartridge Required (1b)
7	Reserved							

Table 227. Post B Performance Receive Diagnostic Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004Dh)							
4 : 5	Diagnostic ID (0101h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error

Table 227. Post B Performance Receive Diagnostic Parameter Data (continued)

Byte	Bit 7	6	5	4	3	2	1	0
9 : 80	SIM/MIM Message or All Zeros							

Post C Media Test Diagnostic

Table 228. Post C Media Test Send Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0102h)							
6	Flags (0000000b)							Cartridge Required (1b)
7	Reserved							

Table 229. Post C Media Test Receive Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (004Dh)							
4 : 5	Diagnostic ID (0102h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error

Table 229. Post C Media Test Receive Diagnostic Parameter Data (continued)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
9 : 80	SIM/MIM Message or All Zeros							

Post D Head Test Diagnostic

Table 230. Post D Head Test Send Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0103h)							
6	Flags (0000000b)							Cartridge Required (1b)
7	Reserved							

Table 231. Post D Head Test Receive Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (004Dh)							
4 : 5	Diagnostic ID (0103h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9 : 80	SIM/MIM Message or All Zeros							

Primary Port Wrap Test Diagnostic

This test will perform a wrap test on the specified primary port. A wrap tool must be attached prior to running this command.

See Table 232.

Table 232. Primary Port Wrap Test Send Diagnostic Parameter Data

Byte	7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2	(MSB) Page Length (0004h)							
3								(LSB)
4	Diagnostic ID (0090h)							
5								
6	Flags (0000000b)							Cartridge Required (0b)
7	Port Identifier							

Port Identifier

This field is synonymous with the Port Identifier field described in the Device Identification Inquiry page. If the value of the Port Identifier is zero, then the wrap test will be performed on all primary ports. If the value is a valid Port Identifier, the wrap test is performed on the port indicated by the Port Identifier. If an invalid Port Identifier value is used, the drive will respond with a Check Condition for Invalid Field in Parameter List.

The Primary Port Wrap Test Receive Diagnostic returns information about the attempted Primary Port Wrap Test Send Diagnostic.

Table 233. Primary Port Wrap Test Receive Diagnostic Parameter Data

Byte	7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2	(MSB) Page Length (004Dh)							
3								(LSB)
4	Diagnostic ID (0090h)							
5								
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9	SIM/MIM Message or All Zeros							
80								

Force Dump

The Force Dump Diagnostic causes the drive to capture into a reserved space in memory a log of data that is used to assist field and development engineers in determining the root cause of drive behavior. This log is called a drive dump. This diagnostic copies the dump to memory, but does not save it for later use. The save operation must be done by using a READ BUFFER command or a Write Dump To Cartridge Diagnostic.

Note: Because forcing a drive dump will overwrite any previously stored dump, before forcing the dump it may be desirable to check the Dump field of the sense data to determine if a drive dump exists.

For the Force Dump Diagnostic, the CDB values should be set as follows:

- PF - 1
- SelfTest - 0
- DevOfl - Any value allowed and ignored
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 0008h

Table 234 shows the parameter data to be sent with the Force Dump diagnostic.

Table 234. Force Dump Diagnostic Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0160h)							
6	Flags (0000000b)							Cartridge Required (0)
7	Reserved							

Receive Diagnostics Results: There are no diagnostic results for the Force Dump diagnostic.

Write Dump To Cartridge

The Write Dump To Cartridge Send Diagnostic causes the drive to write a dump from memory to the cartridge that is loaded in the drive. The dump might exist because of a previous Force Dump diagnostic command or it might exist because of other scenarios where the drive code automatically creates a dump. To determine if a drive dump exists before forcing a dump, the application client can look at the Dump field of the sense data.

Table 235. Write Dump to Cartridge Send Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0161h)							
6	Flags (0000000b)							Cartridge Required (1b)
7	Reserved							

The Write Dump To Cartridge Receive Diagnostic returns information about the attempted Write Dump To Cartridge Send Diagnostic.

Table 236. Write Dump to Cartridge Receive Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (004Dh)							
4 : 5	Diagnostic ID (0161h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9 : 80	SIM/MIM Message or All Zeros							

Write Dump to Flash (EEPROM)

The Write Dump To FLASH Send Diagnostic causes the drive to write a dump from memory to non-volatile memory in the drive. If a dump exists before receipt of this command that dump is written to non-volatile memory. If a dump does not exist before receipt of this command, a dump will be forced then written to non-volatile memory. The intent of this function is to help the factory in diagnostics of a failed drive in the field. This dump will be returned to a series of read buffer commands as any normal dump will be read. This dump will only be returned if no other dump exists in the drive.

See Table 237.

Table 237. Write Dump To FLASH Send Diagnostic Parameter Data

Byte	7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2	(MSB) Page Length (0004h)							
3								(LSB)
4	Diagnostic ID (0162h)							
5								
6	Flags (0000000b)							Cartridge Required (0b)
7	Reserved							

The Write Dump To FLASH Receive Diagnostic returns information about the attempted Write Dump To FLASH Send Diagnostic.

See Table 238.

Table 238. Write Dump To FLASH Receive

Byte	7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2	(MSB) Page Length (004Dh)							
3								(LSB)
4	Diagnostic ID (162hh)							
5								
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9	SIM/MIM Message or All Zeros							
80								

Clear FLASH Dump (EEPROM)

The Clear FLASH Dump Send Diagnostic causes the drive to clear the dump that was saved to non-volatile memory in the drive. The intent of this function is to clear a dump in non-volatile memory that is no longer needed for factory diagnostics.

See Table 239

Table 239. Clear Dump to FLASH Send Diagnostic Parameter Data

Byte	7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2	(MSB) Page Length (0004h)							
3								(LSB)
4	Diagnostic ID (016Fh)							
5								
6	Flags (0000000b)							Cartridge Required (0b)
7	Reserved							

Set Traps

The Set Traps diagnostic is used to cause the drive to force a Panic when the specified Fault Symptom Code (FSC) is created in the drive. A Panic will cause the drive to capture a drive dump, then reboot. The drive dump will be available for retrieval after the reboot.

In Ultrium 2 and Ultrium 3 drives, a list of traps can be created. When the list is full, the next trap that is set will automatically clear the least recently set trap. Currently, the maximum number of traps that can be set is 10, but may be modified at any time.

In Ultrium 1 drives only one trap is allowed to be set at a time.

For the Set Traps Diagnostic, the CDB values should be set as follows:
- PF - 1
- SelfTest - 0
- DevOfl - Any value allowed and ignored
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 000Ah

Table 240 shows the parameter data to be sent with the Set Traps diagnostic.

Table 240. Set Traps Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0006h)							
4 : 5	Diagnostic ID (0190h)							
6	Flags (0000000b)							Cartridge Required (0)
7	Reserved							
8 : 9	Fault Symptom Code							

Receive Diagnostics Results: There are no diagnostic results for the Set Traps diagnostic.

Remove Traps

The Remove Traps diagnostic is used to remove a trap that has been previously set by a Set Traps diagnostic. The Fault Symptom Code (FSC) that is specified is cleared from the trap list.

For the Remove Traps Diagnostic, the CDB values should be set as follows:

- PF - 1
- SelfTest - 0
- DevOfl - Any value allowed and ignored
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 000Ah

Table 241 shows the parameter data to be sent with the Remove Traps diagnostic.

If all that is desired is to inspect which Traps have been set, sending down Remove Traps with the Fault Symptom Code set to 0000h will set up diagnostic results that show which traps are currently set without changing the state of any traps.

Table 241. Remove Traps Diagnostic Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0006h)							
4 : 5	Diagnostic ID (0191h)							
6	Flags (0000000b)							Cartridge Required (0)
7	Reserved							
8 : 9	Fault Symptom Code							

Receive Diagnostics Results - Table 242 on page 230 shows the diagnostic results data returned for the Remove Traps diagnostic.

Table 242. Reset Drive Diagnostic Results Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (*n* - 4)							
4 : 5	Diagnostic ID (0191h)							
6	Flags (0)							
7	Reserved							
8	Reserved					Diag Blocked	Reserved	Error
9-10 : (*n*-1)-*n*	First Fault Symptom Code with Trap Still Set Last Fault Symptom Code with Trap Still Set							

Reset Drive

The Reset Drive diagnostic causes the drive to reboot. All data in the drive is lost.

For the Reset Drive Diagnostic, the CDB values should be set as follows:

- PF - 1
- SelfTest - 0
- DevOfl - 1
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 0008h

Table 243 shows the parameter data to be sent with the Reset Drive.

Table 243. Reset Drive Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (2002h)							
6	Flags (0000000b)							Cartridge Required (0)
7	ReservedXRE							

Receive Diagnostics Results: There are no diagnostic results for the Reset Drive diagnostic.

Read Thermal Sensor

The Read Thermal Sensor diagnostic is used to read the digital thermal sensor on the drive. For the Read Thermal Sensor, the CDB values should be set as follows:

- PF - 1
- SelfTest - 0
- DevOfl - Any value allowed and ignored
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 0008h

Table 244 on page 232 shows the parameter data to be sent with the Read Thermal Sensor diagnostic.

Table 244. Read Thermal Sensor Diagnostic parameter data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2	(MSB)	Page Length (0004h)						
3								(LSB)
4	(MSB)	Diagnostic ID (1002h)						
5								(LSB)
6	Flags (0000000b)							Cartridge Required (0b)
7	Reserved							

Receive Diagnostics Results - Table 245 shows the diagnostic results data returned for the Read Thermal Sensor diagnostic.

Table 245. Read Thermal Sensor Receive Diagnostic parameter data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2	(MSB)	Page Length (000Eh)						
3								(LSB)
4	(MSB)	Diagnostic ID (1002h)						
5								(LSB)
6	Flags (0000000b)							Cartridge Required (0b)
7	Reserved							
8	Flags (00000b)					Diag. Blocked	Reserved	Error
9	Reserved							
10	Thermal Reading (units of ºC) (Value read by sensor)							
11	Reserved							
12	Thermal Warning Threshold (units of ºC) (Full-Height Drives raise an alert at this temperature)							
13	Reserved							
14	Thermal Fencing Threshold (units of ºC) (Half-Height Drives fence operations at this temperature)							
15	Reserved							
16	Thermal Restart Threshold (units of ºC) (Half-Height Drives remove the temperature fence at this temperature)							
17	Reserved							

Table 245. Read Thermal Sensor Receive Diagnostic parameter data (continued)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Note: A value of 00h in any of the Thermal value fields indicates the value is not applicable.								

SET CAPACITY (not Ultrium 1)

The SET CAPACITY command is supported in Ultrium 2 and Ultrium 3 drives only and and sets the available medium for the currently mounted tape to a proportion of the total capacity of that tape. Any excess space will be unavailable on the tape after successful completion of this command until changed by a new SET CAPACITY command. This change will persist through power cycles, logical unit resets, and the unloading or reloading of the tape.

Table 246. SET CAPACITY Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (0Bh)							
1	Reserved							Immed
2	Reserved							
3	(MSB)							
:	Capacity Proportion Value							
4								(LSB)
5	Control							

If the tape drive does not contain a tape, then the command will be terminated with Check Condition status. The Sense Key must be set to Not Ready, and the Additional Sense Code must be set to Medium Not Present.

The SET CAPACITY command will be accepted only when the tape is at beginning-of-tape (BOT). If the tape is logically at any other position, the command will be rejected with Check Condition status. The Sense Key will be Illegal Request, and the Additional Sense Code set to Position Past Beginning Of Medium (5/3B0Ch).

A valid SET CAPACITY command will cause all data on the entire physical tape to be lost.

Buffered write data may be discarded by the tape drive upon successful validation of the SET CAPACITY command.

An Immediate (Immed) field of 0 specifies that the device server will not return status until the set capacity operation has completed. An Immed field of 1 specifies that the device server will return status as soon as the command descriptor block of the SET CAPACITY command has been validated. If Check Condition status is returned for a SET CAPACITY command with an Immed field set to 1, the set capacity operation has not been performed.

The Capacity Proportion Value field specifies the portion of the total unscaled tape capacity to be made available for use. This field is the numerator to a fraction that has a denominator of 65 535 (FFFFh). The resulting available capacity on the tape is equal to the total unscaled tape capacity multiplied by this fraction.

```
((Capacity Proportion Value) / 65 535) * (Total Unscaled Tape Capacity) =
(Resulting Available Capacity)
```

The tape drive may round up the capacity to the next highest supported value. This rounding is not considered an error and will not be reported. On Ultrium 2 RoHS, Ultrium 3 and later drives, if the Capacity Proportion Value does not meet the ranges specified in Table 194 then Check Condition status is returned with Illegal Field in CDB (5/2400h).

On Ultrium 2 non-RoHS drives, if the Capacity Proportion Value does not meet the ranges specified in Table 194 or it attempts to increase the available capacity to a value higher than it is currently set then Check Condition status is returned with Illegal Field in CDB (5/2400h).

WARNING: If the Capacity Proportion is increased it is possible that a debris dump may exist at the previous logical end of medium. This may cause a defect when attempting to write through that area.

Table 247. Minimum Capacity Proportion Values

Drive Generation	Cartridge	Minimum Capacity Proportion Value	Resultant Approximate Minimum Capacity	Maximum Capacity
2	Ultrium 2	1605h	17.2 GB	200 GB
	Ultrium 3	N/A	N/A	N/A
3	Ultrium 2	1605h	17.2 GB	200 GB
	Ultrium 3	151Ah	33 GB	400 GB
4	Ultrium 4	123Dh	52 GB	800 GB
Note: Available and total tape capacities are approximate values that may be affected by defects which reduce the actual available capacity of the tape. Other factors, such as compression and block packing, may also affect available capacity.				

SPACE

The SPACE (6) command instructs the drive to set a new logical position relative to the current logical position. How this is done depends on the value of the Code field and the Count field. The Count field is a signed value that indicates the distance to move. A negative value indicates movement towards BOM; a positive value indicates movement towards EOM.

Table 248. SPACE (6) Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (11h)							
1	Obsolete			Reserved		Code		
2 : 4	Count							
5	Control							

Table 249. SPACE (16) command

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (91 h)							
1	Reserved				Code			
2	Reserved							
3	Reserved							
4	(MSB)							
5								
6								
7								
8	Count							
9								
10								
11								(LSB)
12	(MSB)							
13	Parameter Length (0000h)							(LSB)
14	Reserved							
15	Control							

If the Code field is 000b, then the logical position is moved the number of blocks that is indicated by the Count field. If a filemark is encountered while spacing over blocks, the command is terminated. Check Condition status is returned, and the Filemark and Valid fields are set to 1 in the sense data. The Sense Key is set to No Sense and the Additional Sense Code is set to Filemark Detected. The Information field is set to the requested count minus the actual number of blocks spaced over (not including the filemark). The new logical position is set immediately after the file mark in the direction of the space operation. If BOM or EOD is detected before the requested logical position, then the logical position is set to that position.

If the Code field is 001b, then the logical position is moved the number of file marks indicated by the Count field. If BOM or EOD is detected before the requested logical position, then the logical position is set to that position.

If end-of-data is encountered while spacing over blocks or filemarks, Check Condition status is returned, the Sense Key is set to Blank Check, and the sense data Valid field is set to 1 in the sense data. The Additional Sense Code is set to End-Of-Data Detected. The sense data EOM field is set to 1 if end-of-data is encountered at or after early-warning. The Information field is set to the requested count minus the actual number of blocks or filemarks spaced over as defined by the Code value. The medium is positioned such that a subsequent write operation would append to the last record or filemark.

If the end-of-tape is encountered while spacing forward over blocks or filemarks, Check Condition status is returned, and the Sense Key is set to Medium Error. The Additional Sense Code is set to End-Of-Partition/Medium Detected, and the sense data EOM and Valid fields are set to 1. The Information field is set to the requested count minus the actual number of blocks or filemarks spaced over, as defined by the Code value.

If beginning-of-tape is encountered while spacing over blocks or filemarks in the reverse direction, the drive returns Check Condition status and sets the Sense Key to No Sense. The Additional Sense Code is set to Beginning-Of-Partition/Medium Detected. The sense data EOM and Valid fields are set to 1, and the Information field is set to the total number of blocks or filemarks not spaced over (the requested number of blocks or filemarks minus the actual number of blocks or filemarks spaced over). A successfully completed SPACE command does not set EOM to 1 at beginning-of-tape.

If the Code field is 011b, then the logical position is set to after the last valid block on tape. In this case the Count field is ignored.

Any other value of the Code field causes Check Condition status to be returned. Spacing to sequential file marks is not supported. Set marks are not supported. The Sense Key is set to Illegal Request and the ASC/ASCQ is set to Invalid Field in CDB (2400).

The explicit command set is not supported. The Parameter Length field of the SPACE (16) command is set to 0. If the Parameter Length field is set to any other value, the command is terminated with a Check Condition status. The sense key is set to Illegal Request and the additional sense code is set to Invalid Field In Cdb (5/2400h)

TEST UNIT READY

The TEST UNIT READY command reports when there is a medium in the drive that is ready to accept medium access commands. If a medium is loaded and a problem is detected that does not force the automatic ejection of the medium, GOOD status will still be returned to the TEST UNIT READY command. Whatever error is detected will be returned in response to the next medium access command.

Table 250. TEST UNIT READY Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (00h)							
1	Obsolete			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

VERIFY

The VERIFY command causes data to be read from the tape and passed through the drive's error detection and correction hardware to determine whether it can be recovered from the tape. The amount of data to be read is indicated by the Verification Length field and the Fixed field in the same manner as is used in a READ command. (See "READ" on page 147.)

Table 251. VERIFY Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (13h)							
1	Obsolete			Reserved		Immed(0)	BCmp(0)	Fixed
2 : 4	Verification Length							
5	Control							

The VERIFY command is supported by all drives.

The Immed and BCmp fields are not supported and must be set to 0.

WRITE

The WRITE command causes data to be transferred to the drive in a Data Out and written to tape.

Table 252. WRITE Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (0Ah)							
1	Obsolete			Reserved				Fixed
2 : 4	Transfer Length							
5	Control							

If the Fixed field is set to 1, the Block Length (see "Mode Block Descriptor" on page 109) is set to 0, and the Transfer Length field is not 0, Check Condition status is returned with Illegal Field in CDB (5/2400h).

If the Fixed field is set to 0, the initiator transfers a single block of the length indicated in Transfer Length.

If the Fixed field is set to 1, the initiator transfers a sequence of blocks. The number of blocks is given by the Transfer Length field. The length of the blocks is given by the current fixed block length (see "Mode Block Descriptor" on page 109).

If the current logical block number is greater than FFFFFF00h and less than FFFFFFF0h, rules for Logical EOM processing are applied. If the current logical block number is greater than or equal to FFFFFFF0h, rules for physical end of tape processing are applied.

WRITE ATTRIBUTE

Table 253. WRITE ATTRIBUTE Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (8Dh)							
1 : 4	Reserved							
5	Volume Number (0)							
6	Reserved							
7	Partition Number (0)							
8 : 9	Reserved							
10 : 13	Allocation Length							
14	Reserved							
15	Control							

Refer to *SCSI Primary Commands-3 (SPC-3)* for support for the WRITE ATTRIBUTE command.

For information about attributes that are supported, see "READ ATTRIBUTE" on page 149.

Table 254 gives the format of the data that is returned for an Attribute Values service action request.

Table 254. Parameter Data for Attribute Values Service Action Request

Byte	Bit 7	6	5	4	3	2	1	0
0 : 3	Parameter Data Length (n-3)							
4 : x	Attribute #1							
m : n	Attribute #y							

WRITE BUFFER

The WRITE BUFFER command transfers data into the memory on the drive for the purpose of diagnostics, tests, or firmware upgrade.

Table 255. WRITE BUFFER Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (3Bh)							
1	Obsolete			Mode				
2	Buffer ID							
3 : 5	Buffer Offset							
6 : 8	Parameter List Length							
9	Control							

Values for the Mode field and their meaning are described in Table 256.

Table 256. Description of Mode Field

Mode	Description	Support
00h	Write combined header and data	1, 2, 3, 4
02h	Write data	1, 2, 3, 4
04h	Download microcode	1, 2, 3, 4
05h	Download microcode and save	1, 2, 3, 4
06h	Download microcode with offsets	1, 2, 3, 4
07h	Download microcode with offsets and save	1, 2, 3, 4
0Ah	Echo buffer	2, 3, 4

Legend:
1 = supported in IBM TotalStorage LTO Ultrium Tape Drive (commonly called the Ultrium 1 tape drive)
2 = supported in IBM TotalStorage LTO Ultrium 2 Tape Drive (commonly called the Ultrium 2 tape drive)
3 = supported in IBM TotalStorage LTO Ultrium 3 Tape Drive (commonly called the Ultrium 3 tape drive)
4 = supported in IBM TotalStorage LTO Ultrium 4 Tape Drive (commonly called the Ultrium 4 tape drive)

If the Mode field is 00h, the data to be written is sent with a 4-byte header, which must be set to all zeroes.

The Buffer ID field indicates which buffer is to be written.

To download firmware, Modes 04h, 05h, 06h, and 07h are accepted and handled in the same fashion. Any Buffer ID value in these modes is allowed and ignored. The code must be downloaded with strictly increasing offsets. If it is not, no data is written and Check Condition status is generated. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400). Ending status is given when the code has been successfully saved to flash, but before the drive has initiated its reset.

If Mode is set to 0Ah, the data is stored in the echo buffer. The Buffer ID and Buffer Offset fields are ignored in this mode.

The Buffer Offset field indicates where in the buffer the data should be written. This must be smaller than the size of the buffer.

The Parameter List Length field holds the amount of data. This must be smaller than the difference between the Buffer Offset field and the size of the buffer. If it is not, no data is written and Check Condition status is generated. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400).

Buffers that may be written to are Test, Firmware, and VPD (see “READ BUFFER” on page 166).

WRITE FILE MARKS

The WRITE FILE MARKS command causes a sequence of file marks to be written at the current logical position. The number of file marks to be written is indicated in the Count field. If the Immed field is set, status is returned immediately, before the file marks are written to tape. If the Immed field is set to 0, the file marks and any buffered data is written to tape before status is returned.

The Write Set Mark (WSmk) field must be 0. Set marks are not supported.

Table 257. WRITE FILE MARKS Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (10h)							
1	Obsolete			Reserved			WSmk(0)	Immed
2 : 4	Count							
5	Control							

If the Immed field is set to 0 and the Count field is 0, then all buffered data is flushed to tape before the status is reported.

If the current logical block number is greater than FFFFFF00h and less than FFFFFFF0h, rules for Logical EOM processing are applied. If the current logical block number is greater than or equal to FFFFFFF0h, rules for physical end of tape processing are applied.

A Write Filemark with Count set to 0 when there is no data in the buffer to be synchronized to media will always return Good Status. Good Status is returned even if the media is WORM media and the media is not at a writable location or the WORM media has been tampered with.

A Write Filemark with Count set to 0 when there is data in the buffer to be synchronized with media will return sense data as expected for a Write.

Chapter 4. Error Sense Information

Sense Data

For a description of Sense data, see "Sense Data Format" on page 187.

Sense Data Management

The drive maintains three types of Sense data:

Current Sense
: The Sense data associated with the last command received from the initiator.

Deferred Sense
: The Sense data from a command that has been reported as Good, but has generated sense data after being reported. This may be a command with the Immediate flag set or may be a buffered write. A command with the Immediate flag set generates sense for the server that sent the command. A buffered write may generate sense for all servers.

Unit Attention Sense
: The Sense data generated by a Unit Attention condition. (See "Unit Attention Conditions" on page 245.) This is generated for all servers. When a Unit Attention condition has been driven by a command (for example, when mode parameters have changed), a Unit Attention is posted for all initiators except the one that caused the change.

Commands generate Check Condition status if there is Deferred Sense data or Unit Attention data available, depending on Table 8 on page 17. All commands generate Check Condition status if the command itself generates sense data. If the next command after the Check Condition status is not a REQUEST SENSE command, then all sense data for that initiator is cleared.

When a REQUEST SENSE command is received, the Current Sense is returned. If there is no Current Sense, the Deferred Sense is returned. If there is no Deferred Sense, the Unit Attention Sense is returned. If there is no Unit Attention Sense, default sense data is returned. Once a particular set of sense data has been returned, that sense data is cleared. Any other sense data that is still pending may still cause Check Condition status for subsequent commands.

Unit Attention Conditions

The drive generates a Unit Attention condition under the following circumstances:

- Reset condition (for example, power-on, SCSI reset, bus device reset)
- Tape Loaded condition (for example, media inserted, LOAD command from another initiator)
- Mode parameters changed by another initiator
- Drive firmware has been upgraded

The drive only maintains one Unit Attention condition at any one time for any one initiator. If a subsequent Unit Attention condition is generated, it replaces the existing one if it is of higher priority. If it is of lower priority, it is ignored. The priorities are in the order listed above, with a reset being highest priority and a firmware upgrade being lowest priority.

Persistent Errors

When errors occur that prevent tape operation, they are reported persistently until the problem is cleared. For medium-related errors (usually reported with a Sense Key of 3), the error is reported until the cartridge is successfully unloaded. For hardware-related errors (usually reported with a Sense Key of 4), the error is reported until the drive successfully performs a power-on self test. These persistent errors are only reported on those commands that are eligible for deferred Check Condition reporting (see Table 4 on page 8). The error may or may not be reported as Deferred.

Fencing Behavior

The Ultrium 2 and Ultrium 3 drives will fence the drive (prevent certain operations) when errors are detected that could endanger customer data if further usage is allowed. The operations that are prevented depend on the nature of the error encountered and the current drive state. The drive will post an FSC for the original error that caused the fence condition. Then, fencing FSCs will be reported as status to the attempted host commands that are not allowed due to fence.

The following Fence states are defined and used:

1. ALLOW_NO_OPERATION
   a. All medium access commands (Read/Write/Motion) are rejected.
   b. (SCSI/Panel/LDI) Unload is accepted.
   c. After the cartridge is ejected:
      - When load is attempted, the cartridge stays at mount position and Good status is returned for TUR.
      - From the above state, the cartridge can be ejected normally.
      - Other medium access commands are rejected.
2. ALLOW_UNLOAD
   a. All medium access commands (Read/Write/Motion) are rejected.
   b. (SCSI/Panel/LDI) Unload is accepted.
   c. Once a cartridge is ejected, Fence state is cleared. You can load a new cartridge and perform all medium access commands.
3. ALLOW_ALLOCATE
   a. All medium access commands (Read/Write/Motion) are rejected.
   b. (SCSI/Panel/LDI) Unload is accepted.
   c. Once a cartridge is ejected, Fence state is cleared. You can load a new cartridge and perform all medium access commands.
   d. Space command is rejected while in Fence state.
4. MID-TAPE RECOVERY

   See the “Mode Page 2Fh: Behavior Configuration Mode Page” on page 131 for a description of this behavior.

See Table 258 on page 247 for the errors that trigger the fence states.

Table 258. Fence State to Error Mapping

Description	Fence State
ALLOW_NO_OPERATION	• Severe Drive Hardware problem • Severe Media Hardware problem • Temperature Overrange • Load or Unload Hardware problem • Severe Firmware Problem
ALLOW_LOCATE	• Hardware Problem detected that could affect Writing • Hardware Problem detected that could affect Reading
ALLOW_UNLOAD	• Serious Drive Hardware problem — May be recovered on a different mount • Serious Media problem — Drive may be recovered on different mount • Serious Firmware problem — May be recovered on different mount
MID-TAPE RECOVERY	See "Mode Page 2Fh: Behavior Configuration Mode Page" on page 131

Chapter 5. Implementation Considerations

Device Clocks

The drive supports a Device Clock that maintains a timestamp for various items. This timestamp gets recorded in drive error logs.

The timestamp origin (TORIG) is one of those specified in Table 259.

Table 259. Timestamp Origin

Value	Definition
000b	Timestamp initialized to zero at power-on
001b	Reserved
010b	Timestamp initialized by the SET TIMESTAMP command
011b	Timestamp initialized by the Library over the Library Drive Interface (i.e. RS-422)
100b - 111b	Reserved

Once a timestamp is initialized it begins counting from that time forward. Once the timestamp is initialized it remains in effect until one of the following occurs:

- A SET TIMESTAMP command is processed;
- An LDI command is processed that modified the timestamp; or
- A Hard reset.

The method used is indicated in the extended control mode page.

The Timestamp is not affected by an I_T nexus loss or a Logical Unit reset.

The TIMESTAMP is specified in table Table 260.

Table 260. TIMESTAMP Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0	(MSB)	TIMESTAMP						
5								(LSB)

The TIMESTAMP field contains the value established at the last action that set the timestamp incremented by one for every millisecond that has elapsed since the timestamp was set.

Chapter 6. WORM BEHAVIORS

Conditions for Writing

If the following condition is met, writing is allowed:
- the cartridge is uninitialized

If all the following conditions are met, writing is allowed:
- the current logical position is at BOT
- there are only filemarks between here and EOD

If all of the following conditions are met, writing is allowed:
- if the current logical position is at BOT
- there are exactly 1 or 2 data records, followed by 0 to infinite number of filemarks, followed by no data records, followed by EOD

If all of the following conditions are met, writing is allowed:
- the current logical position is BETWEEN BOT and EOD:
- there are only filemarks from the current logical position to EOD
- there is at least one filemark **immediately** before the current logical position

If the following condition is met, writing is allowed:
- the current logical position is AT® EOD

Command Behavior When WORM Medium Has Been Tampered With

Table 261 specifies the behavior of the drive when it has detected the WORM medium that is loaded in the drive has been tampered with (See Sequential Access Drive Configuration page).

Table 261. Behavior when the loaded medium has suspect integrity

Command	WTRE=01b	WTRE=00b or 10b
Write	0x7/300D	0x7/300D
Write Filemark n (n !=0)	0x7/300D	0x7/300D
Write Filemark 0 (buffered data)	0x7/300D	0x7/300D
Write Filemark 0 (no buffered data)	Good	Good
Erase	0x7/300D	0x7/300D
Read	Good	0x3/300D
Verify	Good	0x3/300D
Space	Good	0x3/300D
Locate to (block !=0)	Good	0x3/300D
Locate to 0	Good	Good
Rewind	Good	Good
Unload	Good	Good
Load	Good	Good

Chapter 7. Sense Keys and Additional Sense

This chapter lists all possible combinations of Sense Keys, Additional Sense Codes (ASC), and Additional Sense Code Qualifiers (ASCQ) that are reported by this device.

Notes:

1. ASCs of X'EE' and X'EF' are used for encryption related features and are only supported by encryption capable devices.
2. When using encryption enabled devices in an in-band configuration (System method or key path), ASCs of X'EF' are used to initiate a key management session via a system proxy.

Sense Key 0 (No Sense)

Table 262. ASC and ASQ Summary for Sense Key 0 (No Sense)

ASC ASCQ	Description
00 00	No Additional Sense Information - (unsolicited, no CA/CC)
00 00	No Additional Sense Information - EOM=B'1' (Early Warning)
00 00	No Additional Sense Information - ILI=B'1'
00 00	No Additional Sense Information - FM=B'1'
00 01	Filemark Detected
00 02	End-of-Partition/Medium Detected (Early Warning)
00 04	Beginning-of-Partition/Medium Detected
00 16	Operation in Progress
82 82	Drive Requires Clearing
Note: ASCs of EEh and EFh are used for encryption related features and are only supported by encryption capable devices. **Note:** When using encryption enabled devices in an in-band configuration (System method or key path), ASCs of X'EF' are used to initiate a key management session via a system proxy.	

Sense Key 1 (Recovered Error)

Table 263. ASC and ASQ Summary for Sense Key 1 (Recovered Error)

ASC ASCQ	Description
00 00	No Additional Sense Information
0C 00	Write Error: A write error occurred, but was recovered. Data was successfully written to tape.
11 00	Read Error: A read error occurred, but was recovered. Data was successfully read from tape.
17 01	Recovered Data with Retries
17 01	Recovered Data with Retries
37 00	Mode Parameters Rounded
5D 00	Failure Prediction Threshold Exceeded

Table 263. ASC and ASQ Summary for Sense Key 1 (Recovered Error) (continued)

ASC **ASCQ**	**Description**
5D FF	Failure Prediction Threshold Exceeded (FALSE)
EF 13	Encryption - Key Translate

Sense Key 2 (Not Ready)

Table 264. ASC and ASQ Summary for Sense Key 2 (Not Ready)

ASC ASCQ	Description
04 00	Logical Unit Not Ready, Cause Not Reportable: A tape is present in the drive, but it is in the process of being unloaded.
04 01	Logical Unit Is in Process of Becoming Ready
04 02	Initializing Command Required: A tape is present in the drive, but it is not logically loaded.
04 12	Logical Unit Not Ready, Offline
30 03	Cleaning Cartridge Installed
30 07	Cleaning Failure
3A 00	Medium Not Present
3E 00	Logical Unit Has Not Self-configured

Sense Key 3 (Medium Error)

Table 265. ASC and ASQ Summary for Sense Key 3 (Medium Error)

ASC ASCQ	Description
04 10	Logical Unit Not Ready, Auxiliary Memory Not Accessible
09 00	Track Following Error (Servo)
0C 00	Write Error
11 00	Unrecovered Read Error
11 12	Auxiliary Memory Read Error
14 00	Recorded Entity Not Found
30 00	Incompatible Medium Installed
30 01	Cannot Read Medium, Unknown Format
30 02	Cannot Read Medium, Incompatible Format
30 0D	Medium Error/WORM Medium - Integrity Check: Set when the drive rejects a Read operation because the current cartridge is a Suspicious WORM cartridge, and the WTRE bit is set to 0.
31 00	Medium Format Corrupted
3B 00	Sequential Positioning Error
50 00	Write Append Error
51 00	Erase Failure
52 00	Cartridge Fault
53 00	Media Load or Eject Failed
53 04	Medium Thread or Unthread Failure
EE 60	Encryption - Proxy Command Error
EE D0	Encryption - Data Read Decryption Failure
EE D1	Encryption - Data Read after Write Decryption Failure
EE E0	Encryption - Key Translation Failure

Table 265. ASC and ASQ Summary for Sense Key 3 (Medium Error) (continued)

ASC ASCQ	Description
EE E1	Encryption - Key Translation Ambiguous
EE F0	Encryption - Decryption Fenced (Read)
EE F1	Encryption - Encryption Fenced (Write)
Note: ASCs of EEh and EFh are used for encryption related features and are only supported by encryption capable devices. **Note:** When using encryption enabled devices in an in-band configuration (System method or key path), ASCs of EFh are used to initiate a key management session via a system proxy.	

Sense Key 4 (Hardware or Firmware Error)

Table 266. ASC and ASQ Summary for Sense Key 4 (Hardware or Firmware Error)

ASC ASCQ	Description
04 03	Manual Intervention Required: A tape is present in the drive but could not be loaded or unloaded without manual intervention.
08 01	Logical Unit Communication Failure
40 XX	Diagnostic Failure: The Additional Sense Code Qualifier indicates the failing component.
41 00	Data Path Failure
44 00	Internal Target Failure
51 00	Erase Failure
53 00	Media Load or Eject Failed
53 04	Medium Thread or Unthread Failure
EE 0E	Encryption - Key Service Timeout
EE 0F	Encryption - Key Service Failure
Note: ASCs of EEh and EFh are used for encryption related features and are only supported by encryption capable devices. **Note:** When using encryption enabled devices in an in-band configuration (System method or key path), ASCs of EFh are used to initiate a key management session via a system proxy.	

Sense Key 5 (Illegal Request)

Table 267. ASC and ASQ Summary for Sense Key 5 (Illegal Request)

ASC ASCQ	Description
1A 00	Parameter List Length Error
20 00	Invalid Command Operation Code
24 00	Invalid Field in CDB
25 00	Logical Unit Not Supported
26 00	Invalid Field in Parameter List
26 11	Encryption - Incomplete Key-Associate Data Set
29 04	Device Internal Reset
2C 00	Command Sequence Error
2C 0B	Not Reserved - The OIR bit of the Sequential Access Device page is set and the I_T nexus attempting to communicate with the drive does not hold a reservation
3B 0C	Position Past Beginning of Medium: A command that required the medium to be at BOP was attempted when the medium was not at BOP (for example, Set Capacity).
53 02	Medium Removal Prevented
82 83	Bad Microcode Detected: The data transferred to the drive during a firmware upgrade is corrupted or incompatible with the drive hardware.
A3 01	OEM Vendor-Specific
EE 00	Encryption - Key Service Not Enabled
EE 01	Encryption - Key Service Not Configured

Table 267. ASC and ASQ Summary for Sense Key 5 (Illegal Request) (continued)

ASC ASCQ	Description
EE 02	Encryption - Key Service Not Available
EE 10	Encryption - Key Required
EE 20	Encryption - Key Count Exceeded
EE 21	Encryption - Key Alias Exceeded
EE 22	Encryption - Key Reserved
EE 23	Encryption - Key Conflict
EE 24	Encryption - Key Method Change
EE 25	Encryption - Key Format Not Supported
EE 26	Encryption - Unauthorized Request - dAK
EE 27	Encryption - Unauthorized Request - dAK
EE 28	Encryption - Unauthorized Request - eAK
EE 29	Encryption - Authentication Failure
EE 2A	Encryption - Invalid RDKi
EE 2B	Encryption - Key Incorrect
EE 2C	Encryption - Key Wrapping Failure
EE 2D	Encryption - Sequencing Failure
EE 2E	Encryption - Unsupported Type
EE 2F	Encryption - New Key Encrypted Write Pending
EE 30	Encryption - Prohibited Request
EE 2D	Encryption - Sequencing Failure
EE 30	Encryption - Prohibited Request
EE 31	Encryption - Key Unknown
EE 42	Encryption - EKM Challenge Pending
EE E2	Encryption - Key Translation Disallowed
EE FF	Encryption - Security Prohibited Function
EF 01	Encryption - Key Service Not Configured
Note: ASCs of EEh and EFh are used for encryption related features and are only supported by encryption capable devices. **Note:** When using encryption enabled devices in an in-band configuration (System method or key path), ASCs of X'EF' are used to initiate a key management session via a system proxy.	

Sense Key 6 (Unit Attention)

Table 268. ASC and ASQ Summary for Sense Key 6 (Unit Attention)

ASC ASCQ	Description
28 00	Not Ready to Ready Transition, Medium May Have Changed
28 01	Import or Export Element Accessed
29 00	Power On, Reset, or Bus Device Reset Occurred: This also occurs on Fibre Channel drives when a host logs in (PLOGI).
29 05	Transceiver Mode Changed To Single-ended: The drive detected a transceiver mode change from LVD mode to MSE mode
29 06	Transceiver Mode Changed To LVD: The drive detected a transceiver mode change from MSE mode to LVD mode
2A 01	Mode Parameters Changed
2A 11	Encryption - Data Encryption Parameters Changed by Another I_T Nexus
2A 12	Encryption - Data Encryption Parameters Changed by Vendor Specific Event
2F 00	Commands Cleared by Another Initiator
3F 03	Inquiry Data Has Changed
3F 0E	Reported LUNs Data Has Changed
5D FF	Failure Prediction False: A MODE SELECT command has been used to test the Failure Prediction System.
5A 01	Operator Medium Removal Request
EE 12	Encryption - Key Change Detected
EE 18	Encryption - Changed (Read)
EE 19	Encryption - Changed (Write)
EE 40	Encryption - EKM Identifier Changed
EE 41	Encryption - EKM Challenge Changed
EE 50	Encryption - Initiator Identifier Changed
EE 51	Encryption - Initiator Response Changed
Note: ASCs of EEh and EFh are used for encryption related features and are only supported by encryption capable devices. **Note:** ASCs of EEh and EFh are used for encryption related features and are only supported by encryption capable devices.	

Sense Key 7 (Data Protect)

Table 269. ASC and ASQ Summary for Sense Key 7 (Data Protect)

ASC ASCQ	Description
26 10	Encryption - Data Decryption Key Fail Limit
27 00	Write Protected
2A 13	Encryption - Data Encryption Key Instance Counter Has Changed
30 05	Cannot Write Medium, Incompatible Format

Table 269. ASC and ASQ Summary for Sense Key 7 (Data Protect) (continued)

ASC ASCQ	Description
30 0D	Data Protect/WORM Medium - Integrity Check: Set when the drive rejects a Write operation because the current cartridge is a Suspicious WORM cartridge.
30 0C	Data Protect/WORM Medium - Overwrite Attempted: Set when the drive rejects a Write operation because the rules for allowing WORM writes have not been met.
52 00	Cartridge Fault
74 00	Security Error
74 01	Encryption - Unable to Decrypt Data
74 02	Encryption - Unencrypted Data Encountered While Decrypting
74 03	Encryption - Incorrect Data Encryption Key
74 04	Encryption - Cryptographic Integrity Validation Failed
74 05	Encryption - Error Decrypting Data
EF 10	Encryption - Key Required
EF 11	Encryption - Key Generation
EF 13	Encryption - Key Translate
EF 1A	Encryption - Key Optional
EF C0	Encryption - No Operation
Note: ASCs of EEh and EFh are used for encryption related features and are only supported by encryption capable devices. **Note:** ASCs of EEh and EFh are used for encryption related features and are only supported by encryption capable devices.	

Sense Key 8 (Blank Check)

Table 270. ASC and ASQ Summary for Sense Key 8 (Blank Check)

ASC ASCQ	Description
00 05	End-of-Data (EOD) Detected
0B 01	The drive detected an overtemperature condition. The currently loaded medium has been ejected.
14 03	End-of-Data (EOD) not Found

Sense Key B (Aborted Command)

Table 271. ASC and ASQ Summary for Sense Key B (Aborted Command)

ASC ASCQ	Description
00 02	End-of-Partition/Medium Detected
3D 00	Invalid Bits in Identify Message
3F 0F	Echo Buffer Overwritten
43 00	Message Error
45 00	Select/Reselect Failure
48 00	Initiator Detected Error Message Received
49 00	Invalid Message Error
4A 00	Command Phase Error
4B 00	Data Phase Error
4E 00	Overlapped Commands

Sense Key D (Volume Overflow)

Table 272. ASC and ASQ Summary for Sense Key D (Volume Overflow)

ASC ASCQ	Description
00 02	End-of-Partition/Medium Detected

Chapter 8. Device Hardware Encryption (Ultrium 4)

Ultrium 4 devices contain hardware which performs user data write encryption and read decryption, protecting all user data written to the medium from unauthorized use [provided it is integrated into a secure system design].

Chapter 9. Attachment Features

Types of Interface Attachments

The Ultrium Tape Drive communicates with servers that use SCSI parallel, Fibre Channel, or SAS interfaces. The interfaces share certain tape LUN behaviors, but also possess unique features. This chapter describes the common and unique features of these interfaces.

Common Tape LUN Behaviors

Parallel SCSI and Fibre Channel and SAS interfaces share the following tape LUN behaviors:

- Power-on procedure
- Reset strategy
- Abort handling
- Multi-initiator support
- Status codes

The sections that follow describe each behavior.

Power-On

The drive responds to INQUIRY, REPORT LUNs, REQUEST SENSE, and TEST UNIT READY commands within 5 seconds of power-on. The first command (other than INQUIRY or REQUEST SENSE) from any initiator gets a Check Condition status with Unit Attention sense data for the power-on. After this, any medium access command is reported with a Sense Key of Not Ready and an ASC/ASCQ of LUN Has Not Self-Configured Yet (3E00). Once the drive has completed its self test and setup procedures, the drive attempts to load any tape that is present. Medium access commands are reported with an ASC/ASCQ of Drive in Process of Becoming Ready (0401).

Reset Strategy

The drive supports the hard reset option as is required by SCSI-3. On receiving a reset, the following actions are taken:

- The current I/O process is aborted, as in “Abort Handling” on page 266.
- Any queued I/O processes from other initiators are removed.
- All reservations are cleared.
- All mode values are reset to their defaults.
- Synchronous/Wide negotiations are cleared (applies only to SCSI parallel attach).
- A unit attention condition is set.
- A logical position is established that may or may not be the same as the position prior to the reset. Where possible, the logical position prior to reset is maintained.

For drives that use he Fibre Channel or SAS interface, the next command that is eligible for the Unit Attention Check Condition from each initiator gets a Check

Condition status, with Unit Attention sense data for the reset. However, other commands may not be processed until the internal state of the drive has been reset.

Drives that use a SCSI interface are able to respond to the INQUIRY, REPORT LUNs, REQUEST SENSE, and TEST UNIT READY commands within 250 ms of the reset line being released. The next command that is eligible for the Unit Attention Check Condition from each initiator gets a Check Condition status, with Unit Attention sense data for the reset. However, other commands may not be processed until the internal state of the drive has been reset. Any commands that allow Disconnects and cannot be processed are accepted and queued until the drive is ready to process them. Those commands that do not allow Disconnects receive Busy status response.

Abort Handling

If a command is aborted on a drive with a Fibre Channel or SAS interface, see Table 273 for abort processing.

If a command is aborted on a drive with a SCSI interface, one of the following conditions will occur:

- If an abort condition is detected before a command phase completes, the bus is set to Bus Free and the command is not executed.
- If an abort condition is detected during status phase, the bus is set to bus free.
- If an abort condition is detected between the end of the command phase and the start of the status phase, then the bus is set to Bus Free and the processing in Table 273 on page 266 is carried out.

Table 273. Abort Condition Handling

Command	Abort Processing
ERASE	Long erase is aborted as quickly as possible without corrupting tape format. Short erase completes.
INQUIRY	None.
LOAD/UNLOAD	Load completes and logically positions tape at BOM. Unload is aborted, leaving logical position at BOM unless operation is past the ‘point of no return’, in which case the tape is ejected.
LOCATE	The logical position is set back to that at the start of the operation unless the operation is past its ‘point of no return’, in which case the operation completes.
LOG SELECT	If data transfer is completed, command is completed; otherwise, no action is taken.
LOG SENSE	None.
MODE SELECT	If data transfer is completed, command is completed; otherwise, no action is taken.
MODE SENSE	None.
PERSISTENT RESERVE IN	None.
PERSISTENT RESERVE OUT	If data transfer is completed, the command is completed; otherwise, no action is taken.
PREVENT/ALLOW MEDIUM REMOVAL	The command completes.
READ	The current position is set to the first record boundary at or after the start of the current data burst.

Table 273. Abort Condition Handling (continued)

Command	Abort Processing
READ ATTRIBUTE	None.
READ BLOCK LIMITS	None.
READ BUFFER	None.
READ POSITION	None.
RECEIVE DIAGNOSTIC RESULTS	None.
RELEASE UNIT	The command completes.
REPORT DENSITY SUPPORT	None.
REPORT LUNs	None.
REQUEST SENSE	Sense data is discarded.
RESERVE UNIT	The command completes.
REWIND	The command completes.
SEND DIAGNOSTIC	Vendor unique.
SPACE	The logical position is set back to that at the start of the operation unless the operation is past its 'point of no return', in which case the operation completes.
TEST UNIT READY	None.
VERIFY	The logical position is set to the next record boundary after the point where the verify was aborted.
WRITE	The data up to first record boundary in the current burst is written to buffer or tape, depending on Buffered Mode. Any subsequent data is discarded. If there is no record boundary in the current burst, the record is truncated to the amount of data transferred and written to buffer or tape, again depending on Buffered Mode.
WRITE BUFFER	If data transfer is completed, the command is completed; otherwise, no action is taken.
WRITE FILE MARKS	The command completes.

For drives with a SCSI interface, if a command other than INQUIRY, REPORT LUNs, REQUEST SENSE, or TEST UNIT READY is received after the abort but before the drive is ready to process the command, the drive attempts to disconnect and wait until the abort processing has completed before executing the command. If disconnects are not allowed, Busy status is returned. A TEST UNIT READY command reports with status immediately.

For drives with a Fibre Channel or SAS interface, an INQUIRY command returns the required data and gives Good status. A REQUEST SENSE command gives no sense. A TEST UNIT READY command reports with status immediately.

Multi-initiator Support

SCSI-attached drives support a maximum of two initiators on the same bus. Fibre-Channel-attached drives and Serial Attached SCSI drives support an infinite number of initiators, but have a limit on how many initiators can be logged in processing commands concurrently. When this limit is exceeded, the least recently used (LRU) initiator that is not reserved or does not have an outstanding command will be implicitly logged out.

The drive supports untagged queuing when operating with multiple initiators. If a command from one initiator is being processed when a command other than INQUIRY, REPORT LUNs, REQUEST SENSE, and TEST UNIT READY is received from a second initiator, the new command is queued. Media access commands (for example, Write, Write Filemarks, Read, Verify, Rewind, Mode Select that changes block size) are always executed in strict order of receipt. For drives with a SCSI interface, if the queue is full or disconnect privilege is not granted in the new command, the drive reports busy status.

The INQUIRY, REPORT LUNs, REQUEST SENSE, and TEST UNIT READY commands are always processed immediately, irrespective of whether a command from another initiator is being processed.

The drive maintains sense data for the supported number of initiators. On Fibre-Channel-attached drives and Serial Attached SCSI drives, if an additional initiator connects to the drive and causes an initiator to be implicitly logged out, the drive erases all sense data for that initiator before processing the command for the new initiator. See “Sense Data Management” on page 245 for more details of sense data management.

Features of the Serial Attached SCSI (SAS) Interface

The World Wide Node Name and Port Name that are used by an Ultrium Tape Drive follow the format of the Institute of Electrical and Electronics Engineers (IEEE).

The IBM Ultrium Tape Drive is compliant with the American National Standard, Project T10/1601-D, Information technology - Serial Attached SCSI - 1.1 (SAS-1.1), Revision 10, 21 September 2005.

Status Codes

Table 274. Status Codes

Status Code	Value	Circumstance
Good	00h	The command completed without problems.
Check Condition	02h	A problem occurred during command execution. The sense data should be examined to determine the nature of the problem.
Busy	08h	The drive is unable to accept the command at this time. This status is returned during the power-on sequence or if there are commands from too many initiators outstanding. (See “Multi-initiator Support” on page 268.) It is also returned when commands are issued without Disconnect Privilege and when another command is in progress.
Reservation Conflict	18h	This status is returned if the drive is reserved for an initiator other than the one sending the command.
Queue Full	28h	Not normally returned.

Features of the SCSI Interface

The Ultrium Tape Drive's SCSI parallel interface features the following:

- LUN identification
- Bus parity errors
- Disconnect strategy
- Messages

LUN Identification

Identify messages are used to identify the LUN to which an initiator is connecting and to identify which LUN is reconnecting to an initiator. These are required. The LUN field in SCSI-2 commands is not used.

SPI Information Unit (Ultra 320 Attached drives only)

The following TASK MANAGEMENT FUNCTIONs are supported in SPI Command Information Unit:

01h - ABORT TASK (see "Abort Handling" on page 266)
02h - ABORT TASK SET (see "Abort Handling" on page 266)
04h - CLEAR TASK SET (see "Abort Handling" on page 266)
08h - LOGICAL UNIT RESET (see "Abort Handling" on page 266)
20h - TARGET RESET (see "Abort Handling" on page 266)

The following TASK ATTRIBUTE CODEs are supported in SPI Command Information Unit:

20h - SIMPLE

Bus Parity Errors (when using Data group transfers)

On detecting a bus parity error during a Command or Data Out phase or receiving an Initiator Detected Error message during a Data In or Status phase, the drive attempts to retry the Bus phase. A Restore Pointers message is sent to the initiator and the transfer is repeated. Only one retry is attempted for any given burst. If the retry fails or the Restore Pointers message is rejected by an Initiator Detected Error, Message Reject, or Message Parity message, then the drive goes to the Status phase and attempts to report Check Condition status. If this fails with an Initiator Detected Error message, the drive goes to Bus Free. The Sense Key is set to Aborted Command and the ASC/ASCQ is set to Command Phase Error (4A00) (if the error was in the Command phase) or to Data Phase Error (4B00) (if the error was in the Data phase). If the error was in the Status phase, the sense data remains as that from the command.

If an Initiator Detected Error or Message Parity Error message is received during the Message In phase, the initiator has detected an error in the message. The drive goes to Message In and resends the message that was in error. If the subsequent message is rejected with an Initiator Detected Error, then the drive goes to the Status phase and sends Check Condition status. The Sense Key is set to Aborted Command and the ASC/ASCQ is set to Initiator Detected Error (4800). If the subsequent message is rejected with a Message Parity Error, then the drive goes to the Status phase and sends Check Condition status. The Sense Key is set to Aborted Command and the ASC/ASCQ is set to Message Error (4300).

On detecting a bus parity error during a Message Out phase, the drive handshakes in all message bytes until ATN is deserted. It then stays in the Message Out phase to indicate to the initiator that the whole Message Out phase should be resent.

Bus Parity Errors (when using Information unit transfers)

On detecting an iuCRC error in a SPI L_Q information unit, the drive goes bus free. If the retry fails, then the drive goes to the SPI Status information unit and attempts to report Check Condition status. If this fails with an Initiator Detected Error message, the drive goes Bus Free. The Sense Key is set to Aborted Command and the ASC/ASCQ is set to INFORMATION UNIT iuCRC ERROR DETECTED error (4703h) (if the error was in the SPI Command information unit, SPI Data information unit or Data Stream information unit). If the error was in the Status information unit, the sense data from the command remains.

Disconnect Strategy

The disconnect strategy used by the drive is based on the assumption of maximizing bus utilization for large sequential data transfers from a large data buffer. The drive disconnects whenever it believes that it can provide better bus utilization. This may be between Command and Data phases, between bursts of data, or before sending status. However, the drive guarantees that it sends the configured maximum burst size or the remaining data in the transfer in any single Data phase burst if the maximum burst size has been set to a value other than 0.

Messages

Message Out

Table 275. Supported Outbound Messages

Support[1]	Name	Code	Support
D	Abort	06h	An abort condition is generated (see “Abort Handling” on page 266).
D	Bus Device Reset	0Ch	A reset condition is generated (see “Abort Handling” on page 266).
E	Abort Test (Tag)	0Eh	An abort condition is generated (see “Abort Handling” on page 266
E	Clear Task Set	0Eh	An abort condition is generated (see “Abort Handling” on page 266 for each task in the task set.
E	Simple (queue tag)	20h/Tag(00h - FFh)	The task is to use Simple tagged queueing using the queue tag as a qualifier on the task.
D	Identify	80h+	The Identify Out message is sent by the initiator to identify the Logical Unit to be accessed and to set Disconnect Privilege. The LUNTAR flag must be 0. The Identify Out message must be sent as the first thing after selection. If it is sent at any other time, the drive responds with a Message Reject message and goes to Bus Free.
D, E	Initiator Detected Error	05h	The initiator has detected an error in the data being sent in a Message Command, Data, or Status phase. The drive retries the data burst or message (see “Bus Parity Errors (when using Data group transfers)” on page 269). If the message is received immediately after an Identify message or after the Command Complete message has been sent, the drive goes to Bus Free.
D, E	Message Parity Error	09h	The initiator has detected a parity error in a message. The drive retries the message (see “Bus Parity Errors (when using Data group transfers)” on page 269). If the message is received during a Command, Data, or Status phase, immediately after an Identify message, or after the Command Complete message has been sent, the drive goes to Bus Free.
D, E	Message Reject	07h	This message is sent when the initiator does not support a message sent by the drive or considers the message inappropriate. If the message being rejected is Disconnect, Synchronous Data Transfer Request, or Wide Data Transfer Request, the operation continues without those features. For all other messages except Restore Pointers, the message is treated as an Abort message. If the message is received during a Command, Data, or Status phase, immediately after an Identify message, or after the Command Complete message has been sent, the drive goes to Bus Free.
D, E	No Operation	08h	This message has no effect and is ignored.

Table 275. Supported Outbound Messages (continued)

Support[1]	Name	Code	Support
D, E	Wide Data Transfer Request	01h,02h,03h	transfer negotiation. The initiator is expected to do so. Since this mode is most important at power-on, no SCSI method of changing this mode is provided. Instead, an internal method of changing this mode is provided (VPD or jumper setting). If the message is received after selection and before the Command phase, it then goes to the Message In phase and responds with a valid response to complete the negotiation. If the message is received at any other time, a Message Reject is sent in response, placing the Bus Width to 1 byte wide and data transfer mode to asynchronous for that initiator.
D, E	Synchronous Data Transfer Request	01h,03h,01h	The default mode is for the drive to never initiate a Synchronous data transfer negotiation. The initiator is expected to do so. Since this mode is most important at power-on, no SCSI method of changing this mode is provided. Instead, an internal method of changing this mode is provided (VPD or jumper setting). If the message is received after selection and before the Command phase, it then goes to the Message In phase and responds with a valid response to complete the negotiation. If the message is received at any other time, a Message Reject is sent in response, placing the drive data transfer mode for that initiator to asynchronous
D,E	Parallel Protocol Request	01h,06h,04h	Parallel Protocol Request messages are used to negotiate a synchronous transfer agreement, a wide data transfer agreement, and set the protocol options between the initiator and the target.
[1]D - IU Transfers Disables E - IU Transfers Enabled			

Message In

Table 276. Supported Inbound Messages

Support[1]	Name	Code	Support
D	Command Complete (Task Complete)	00h	This message is sent by the drive at the end of the Status phase to indicate that a command is complete. Once the message is sent, the drive releases the bus and goes to Bus Free.
D	Disconnect	04h	This message is sent by the drive to indicate that it is about to disconnect from the bus and go to Bus Free. During a Data phase, it is always preceded by a Save Data Pointers message. If a Message Reject message is received in response to this message, then the disconnect is prevented.
D	Identify	80h+	The Identify In message is sent to the initiator during reconnect to indicate which Logical Unit is reconnecting. The Disconnect Privilege and LUNTAR flags are both clear.
D	Ignore Wide Residue	23h	This message is sent by the drive to the initiator to indicate that a byte on a wide bus is not valid. This is supported whenever a wide transfer is active.
D, E	Message Reject	07h	This message is sent when the initiator does not support a message sent by the drive or considers the message inappropriate. If the message being rejected is Disconnect, Synchronous Data Transfer Request, or Wide Data Transfer Request, the operation continues without those features. For all other messages except Restore Pointers, the message is treated as an Abort message. If the message is received during a Command, Data, or Status phase, immediately after an Identify message, or after the Command Complete message has been sent, the drive goes to Bus Free.
D, E	Parallel Protocol Request	01h,06h,04h	Parallel Protocol Request messages are used to negotiate a synchronous transfer agreement, a wide data transfer agreement, and set the protocol options between the initiator and the target.
D	Restore Pointers	03h	This message causes the initiator to reset its data transfer pointers to the values they held when the last Save Data Pointers message was sent. It is sent when a parity error is detected on the bus or when an Initiator Detected Error message is received in order to retry the Data phase.
D	Save Data Pointers	02h	This message instructs the initiator to save its current data transfer pointers for use with a subsequent Restore pointers message. This message is always sent before a Disconnect message during Data phases.

Table 276. Supported Inbound Messages (continued)

Support[1]	Name	Code	Support
D, E	Synchronous Data Transfer Request	01h,03h,01h	The default mode is for the drive to never initiate a Synchronous data transfer negotiation. The initiator is expected to do so. Since this mode is most important at power-on, no SCSI method of changing this mode is provided. Instead, an internal method of changing this mode is provided (VPD or jumper setting). If the message is received after selection and before the Command phase, it then goes to the Message In phase and responds with a valid response to complete the negotiation. If the message is received at any other time, a Message Reject is sent in response, placing the drive data transfer mode for that initiator to asynchronous
D, E	Wide Data Transfer Request	01h,02h,03h	The default mode is for the drive to never initiate a Wide data transfer negotiation. The initiator is expected to do so. Since this mode is most important at power-on, no SCSI method of changing this mode is provided. Instead, an internal method of changing this mode is provided (VPD or jumper setting). If the message is received after selection and before the Command phase, it then goes to the Message In phase and responds with a valid response to complete the negotiation. If the message is received at any other time, a Message Reject is sent in response, placing the Bus Width to 1 byte wide and data transfer mode to asynchronous for that initiator.
[1]D - IU Transfers Disables E - IU Transfers Enabled			

Features of the Fibre Channel Interface

The Ultrium Internal Tape Drive Model T200F (the Fibre Channel Generation 1 drive) is an Arbitrated-Loop-only device (also known as an NL port). The drive supports Fibre Channel Arbitrated Loop (FC-AL) protocol, and uses Class 3 Service frames. The drive also supports both public (switch-attached) and private loops.

Like the Ultrium Internal Tape Drive, the Ultrium 2 Tape Drive Model T400F (the Fibre Channel Generation 2 drive) and the IBM TotalStorage Ultrium 3 Tape Drive Model T800F (the Fibre Channel Generation 3 drive) can attach as an FC-AL device (that is, L-Port). The drives also support operating as a public (switch-attached) or private device (that is, L-Port to FL-Port; or L-Port to L-Port). The Ultrium 2 and Ultrium 3 drives can also attach using the point-to-point protocol (also known as an N-Port). When operating in the point-to-point protocol, the Ultrium 2 and Ultrium 3 drives can attach in a Fabric topology (that is, N-Port to F-Port).

The World Wide Node Name and Port Name that are used by an Ultrium Tape Drive follow the format of the Institute of Electrical and Electronics Engineers (IEEE).

The IBM Ultrium Tape Drive is compliant with the FC-Tape Technical Report of the Accredited Standard Committee NCITS. IBM recommends that your server's device driver and host bus adapter (HBA) use the Class 3 Error Recovery procedures that are specified in the Fibre Channel Protocol for SCSI, Second Version (FCP-2).

Chapter 10. Firmware Download

This chapter describes Firmware download.

Identifying Level Hardware of Drive (Not Ultrium 1)

The firmware that is loaded in the drive will report a Load ID and RU Name in Inquiry page 03h. The Load ID and RU Name are used to designate the Level Hardware. The following table defines the Load ID and RU Name values for each Level Hardware.

Table 277. Load ID and RU Name Designation

Product (Level Hardware)	Load ID	RU Name (EBCDIC string) (Hex representation)	F/W (Min Level)	Product ID (Left-Aligned) (IBM)	Product ID (Left-Aligned) (OEM)
Ultrium 2 Ultra 160	A1700299	″AJEFGP99″ 0xC1D1C5C6C7D7F9F9	-	ULT3580-TD2	ULTRIUM-TD2
Ultrium 2 FC 2G	A170029A	″AJEFGP9A″ 0xC1D1C5C6C7D7F9C1	-		
Ultrium 2 Ultra 160 RoHS	A1700D67	″AJEFAX67″ 0xC1D1C5C6C1E7F6F7	-		
Ultrium 2 FC 2G RoHS	A1700D68	″AJEFAX68″ 0xC1D1C5C6C1E7F6F8	-		
Ultrium 3					
Ultrium 3 Ultra 160	A1700D50	″AJEFAX50″ 0xC1D1C5C6C1E7F5F0	-	ULT3580-TD3	ULTRIUM-TD3
Ultrium 3 Ultra 160 RoHS			5BG2		
Ultrium 3 FC2	A1700D52	″AJEFAX52″ 0xC1D1C5C6C1E7F5F2	-		
Ultrium 3 FC4 RoHS			5BG2		
Ultrium 3 Half-High SAS	A1700D64	″AJEFAX64″ 0xC1D1C5C6C1E7F6F4	-	ULT3580-HH3	ULTRIUM-HH3
	A1700D53	″AJEFAX53″ 0xC1D1C5C6C1E7F5F3			
Ultrium 3 Half-High Ultra 160	A1700D63	AJEFAX69			
	A1700D69	″AJEFAX69″ 0xC1D1C5C6C1E7F6F9			
Ultrium 4					
Ultrium 4 U160	A1700D6A	″AJEFAX6A″ 0xC1D1C5C6C1E7F6C1	-	ULT3580-TD4	ULTRIUM-TD4
Ultirum 4 FC4	A1700D6B	″AJEFAX6B″ 0xC1D1C5C6C1E7F6C2			
Ultrium 4 SAS	A1700D6C	″AJEFAX6C″ 0xC1D1C5C6C1E7F6C3			
Ultrium 4 U320	A1700D70	″AJEFAX70″ 0xC1D1C5C6C1E7F7F0			

Table 277. Load ID and RU Name Designation (continued)

Product (Level Hardware)	Load ID	RU Name (EBCDIC string) (Hex representation)	F/W (Min Level)	Product ID (Left-Aligned) (IBM)	Product ID (Left-Aligned) (OEM)
- Not Applicable					

Identifying the Level Hardware for which the Firmware image is intended (Not Ultrium 1)

The Firmware Image is defined in Table 278.

Table 278. Firmware Image

Bit Byte	7	6	5	4	3	2	1	0
0	MSB			Not Specified				
3								LSB
4	MSB			Firmware Length + Header Length (m)				
7								LSB
8	Load ID (See Inquiry Page 03h)							
11								
12	Firmware Revision Level (See Standard Inquiry bytes 32 - 35)							
15								
16	Reserved							
23								
24	RU Name (See Inquiry Page 03h)							
31								
32	Not Specified							
m								

The Load ID and RU Name fields in the Firmware Image are used to define the Level Hardware for which the Firmware Image is intended.

Download Process

1. Check the Level Hardware of the drive whose firmware is to be updated. See "Firmware Designation Page (03h)" on page 26.
2. Confirm the Level Hardware of the Firmware Image to be loaded matches the Level Hardware of the drive. (See Table 278.)
3. Download the Firmware Image. See "WRITE BUFFER" on page 242.

Appendix A. ASN.1 Information (Used for Encryption)

ASN.1 [DER] Encoding Implementation

See the appendix for an overview on ASN.1 with DER encoding. Within this construct there are certain fields and layouts which are expected by the device. These are detailed as follows:

SEDK ASN.1 Format

The SEDK structure must be understood by both the tape device and the EKM and is the method for transferring the DK from the EKM to the drive.

```
MediaEncryptionStandardData ::= SEQUENCE {
   version    INTEGER,          -- Always set to 0
   mesInfo    TbsMesInfo,           -- Signed portion
   mesSigAlgIDAlgorithmIdentifier OPTIONAL,-- No sig if clear key
      OID= 1 3 14 3 2 11RSA signature
      OID= 1 3 14 3 2 29RSA w/SHA1 signature
      OID= 1 2 840 113549 1 1 5sha1withRSAEncryption

   mesSignatureOCTET STRING OPTIONAL

}

TbsMesInfo ::= SEQUENCE {
   version    INTEGER,        -- Always set to 0
   driveDK    [2] MesKeyInfo OPTIONAL-- Key blob for drive

}

MesKeyInfo ::= SEQUENCE {
   xedkDataMesKeyData     -- actual key information

}

MesKeyData ::= CHOICE {
   kedkInfo[0] KeyEncryptedDKInfo,    -- KEK/dSK/dAK encrypted DK
NOTE: SEDK(s) cannot use the PasswordEncryptedDKInfo (drive does not understand)
   cdkInfo    [2] ClearDK      -- Clear DK (driveDK [SEDK ONLY])
   redkInfo[3] KeyEncryptedDKInfo,    -- KEK/dSK/dSK encrypted raw key
                        (does not use ClearKey)
NOTE: The "redkInfo" format does not contain any DK meta information [this could be changed
 by using a different structure than KeyEncryptedDKInfo (or altered format)] and is
 intended for environments where the DK generation and wrapping are performed entirely in
 hardware. In some instances the key size may be unusual (i.e., a 192 bit odd parity 3DES
 key [168 bits of entropy]) which the drive must expand to 256 in a common manner for use
 as an AES key.

}

KeyEncryptedDKInfo ::= SEQUENCE {
   version    INTEGER,        -- Always set to 0
   kekid     KEKeyIdentifier,    -- Identifies KEK used by EKM
   kekAlg    AlgorithmIdentifier,
      OID= 1 2 840 113549 1 1 1RSA
      OID= 1 2 840 113549 1 1 7RSAES-OAEP
      OID= TBD (ANY (for EEDK), used by EKM only)
   kedk     OCTET STRING,      -- Encrypted ClearDK (if kedkInfo)
                  -- Encrypted raw key (if redkInfo)
   dkUUID    OCTET STRING OPTIONAL  -- DKi
```



```
}

KEKeyIdentifier ::= CHOICE {
   kekPublicDigest[0] DigestInfo-- Digest of public key,
      OID= 1 3 14 3 2 26SHA-1
      OID= 1 2 840 113549 2 7Legacy format
   kekIssuerSNDigest[1] DigestInfo,    -- Digest of DER encoded IssuerAndSerialNumber
   kekLabel [2] IA5String(1::64)

}

ClearDK ::= SEQUENCE {
   version   INTEGER,         -- Always set to 0
   dataKeyAlg AlgorithmIdentifier,    -- Algorithm used for data encryption
      OID= 2 16 840 1 101 3 4 1AES (TBD 256-GCM specific?)
   dataKey    OCTET STRING      -- The DK
   dkUUID    OCTET STRING OPTIONAL   -- DKi

}
```

ASN.1 Standalone SEDK (SEDK only, clear, signed) - Example

```
ASN1  Data
Ofs  Ofs  Len:  ASN.1          Field Name
 0   4  356:  SEQUENCE {
        :   <30 82 01 64>
  4   6   1 :   INTEGER 0         version
         :   <02 01 00>
  7   9  76 :   SEQUENCE {mesInfo:
          <30 4B>
  9   11   1 :   INTEGER 0         version
        :   <02 01 00>
  12  14   53 :   [2] SEQUENCE {       driveDK:
          <A2 35>
  14  16   69 :   [2] SEQUENCE {       cdkInfo
        :   <A2 45>
  16  18    1 :   INTEGER 0         version
        :   <02 01 00>
  19  21   12 :   SEQUENCE {        dataKeyAlg
        :   <30 0C>
  21  23    8 :   OID 2 16 840 1 101 3 4 1:
          <06 08 60 86 48 01 65 03 04 01>
  31  33    0 :   NULL
        :   <05 00>
        :   }
  33  35   32 :   OCTET STRING        dataKey:
        :  ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
        :  ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
  67   69   16 :   OCTET STRING        dkUUID (OPTIONAL)
        :   <04 10>
        :    }
        :   }
        : }
 85   87   13 :   SEQUENCE {mesSigAlgID
        :   <30 0D>
 87   89    9 :   OID 1 2 840 113549 1 1 5
        :   <06 09 2A 86 48 86 F7 0D 01 01 05>
 98   100    0 :   NULL
        :   <05 00>
        :   }
 100  104    256:   OCTET STRING        mesSignature
        :   <04 82 01 00>
        :  ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
        :  ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
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           :  ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
           :  }
```

ASN.1 Standalone SEDK (SEDK only, dSK encrypted, signed) - Example

```
ASN1  Data
  Ofs  Ofs  Len:  ASN.1            Field Name
    0   4    627 :  SEQUENCE {
           :    <30 82 02 73>
    4   6   1 :     INTEGER           version
           :      <02 01 00>
    7   11   345 :       SEQUENCE {mesInfo
           :        <30 82 01 59>
    11  13   1 :         INTEGER 0        version
           :          <02 01 00>
    14  18  338 :          [2] SEQUENCE       {driveDK
           :          <A2 82 01 52>
    18  22  334 :           [0] SEQUENCE       {kedkInfo
           :            <A0 82 01 4E>
    22   24    1 :      INTEGER 0       version
           :        <02 01 00>
    25   27   33 :        [0] SEQUENCE {    kekid:
                  <A0 21>       (kekPublicDigest)
    27   29   31 :         SEQUENCE {     digestAlgorithm
           :         <30 1F>
    29   31    5 :         OID 1 3 14 3 2 26
           :          <05 2B 0E 03 02 1A>
    36   38    0 :           NULL
           :          <05 00>
    38   40   20 :           OCTET STRING  digest (of dSK)
           :           <04 14>
           :           <?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
           :            ?? ?? ?? ??>
           :          }
           :         }
    60   62   13 :         SEQUENCE {    kekAlg
           :         <30 0D>
    62   64    9 :          OID 1 2 840 113549 1 1 1
           :           <06 09 2A 86 48 86 F7 0D 01 01 01>
    73   75    0 :          NULL
           :          <05 00>
           :         }
    75   79  256 :         OCTET STRING    kedk
           :          <04 82 01 00>
           :          < ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
           :          < ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
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      :         < ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
      :         < ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
 335  337   16 :         OCTET STRING    dkUUID (OPTIONAL)
      :         <04 10>
      :         < ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
      :       }
      :      }
      :     }
353 355  13  :       SEQUENCE {mesSigAlgID
      :       <30 0D>
355 357   9  :        OID 1 2 840 113549 1 1 5
      :       <06 09 2A 86 48 86 F7 0D 01 01 05>
366 368   0  :        NULL
      :        <05 00>
      :       }
368 372  256  :          OCTET STRING       mesSignature
      :          <04 82 01 00>
      :        < ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
      :         ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
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      :   }
```

EEDK ASN.1 Format

(raw) DRV <-> EKM

The EEDK structure is the recorded protected format of the DK on medium. It is used by the tape drive to request access from the EKM to the DK for further [future] processing of data recorded to the medium. The EEDK structure is owned and used by the EKM and does not need understood by the tape device. However, there are certain advantages when the tape drive can understand the EEDK. Since the information content requirements of the EEDK are fairly similar to the SEDK, a nearly identical structure is recommended [see the SEDK ASN.1 definition above].

If an aggregate SEDK is used, the EEDK structure may start at the MesKeyInfo layer of the ASN.1 structure defined above.

The tape drive format specification has an allotted maximum size of each EEDK which limits the maximum EEDK size to 380 bytes.

The following ASN.1 EEDK structure is used by the IBM EKM.

```
MediaEncryptionStandardData ::= SEQUENCE {
   mesInfo    TbsMesInfo,
   mesSigAlgID  AlgorithmIndentifierOPTIONAL,
   mesSignature  OCTET STRING
```

```
}

TbsMesInfo ::= SEQUENCE {
   version    INTEGER,  - Always 0
   mesKeyInfo  MesKeyInfo

}

MesKeyInfo ::= CHOICE {
   eedkInfo   [0] ExternalEncryptedDKInfo
}

ExternalEncryptedDKInfo ::= SEQUENCE {
   version    INTEGER,  - Always 0
   kekid    KEKeyIdentifier,
   kekAlg    AlgorithmIdentifier,
      OID= 1 2 840 113549 1 1 1RSA
   eedk     OCTET STRING
}

KEKeyIdentifier ::= CHOICE {
   kekPublicDigest[0] DigestInfo,
      OID= 1 3 14 3 2 26SHA-1
   kekLabel[2] IA5String(1::64)

}

DigestInfo ::= SEQUENCE {
   digestAlgorithm  AlgorithmIdentifier,
   digest      OCTET STRING

}

AlgorithmIdentifier ::= SEQUENCE {
   algorithm   OBJECT IDENTIFIER,
   parameters  NULL
- Always NULL

}
```

xAK/xSK ASN.1 Format

The dAK/eAK/dSK are public keys which are sent between the tape drive and EKM in various messages. The dAK and eAK do not need to be protected in any fashion. The dSK is pseudo secret and is used to protect the DK in the SEDK - this effectively provides another layer of authentication.

```
KeyExchangeData ::= SEQUENCE {
   version    INTEGER,         -- Always set to 0
   kedInfo    SubjectPublicKeyInfo,    -- Signed portion
   kedSigAlgID  AlgorithmIdentifier OPTIONAL, -- No sig if clear key
      OID= 1 3 14 3 2 11     RSA signature
      OID= 1 3 14 3 2 29     RSA w/SHA1 signature
      OID= 1 2 840 113549 1 1 5  sha1withRSAEncryption (from device)
   kedSignature  OCTET STRING OPTIONAL
```

The following is the PKCS #1 ASN.1 definition.

```
SubjectPublicKeyInfo ::= SEQUENCE {
   algorithm      AlgorithmIdentifier,    -- (we intend to use RSA)
      OID= 1 2 840 113549 1 1 1  RSA
   subjectPublicKey     BIT STRING

}

Where subjectPublicKey is:
```

```
RSAPublicKey ::= SEQUENCE {
   modulus        INTEGER,      -- n
   publicExponent     INTEGER         -- e

}
```

ASN.1 xAK/xSK Structure (clear, signed) - Example

```
ASN1 Data
Ofs  Ofs   Len:  ASN.1           Field Name
0   4    572 :    SEQUENCE {
      :    <30 82 02 73>
4   6     1 :   INTEGER 0          version
      :    <02 01 00>
7  11   290-:        SEQUENCE {     kedInfo
      :   <30 82 01 22> (may be 21)
11   13   13 :   SEQUENCE {          algorithm
      :   <30 0B>
13   15    9 :   OID 1 2 840 113549 1 1 1
      :    <06 09 2A 86 48 86 F7 0D 01 01 01>
24   26    0 :   NULL
      :    <05 00>
      :   }
26  30   271-:       BIT STRING (0 unused bits) {subjectPublicKey
      :   <03 82 01 0F>
      :   <00>
31  35   266-:       SEQUENCE {      RSA key
      :   <30 82 01 0A> (may be 09)
35  39   257-:       INTEGER        modulus
      :   <02 82 01 01> (may be 00 [need to add 00 if msb=1])
      :   <[00]
      :    ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
      :    ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
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296-  298-   3 :       INTEGER        publicExponent
      :       <02 03>
      :       <01 00 01>
      :      }
      :     }
      :    }
301-  303-  13 :  SEQUENCE {kedSigAlgID
      :   <30 0D>
303-  305-   9 :   OID 1 2 840 113549 1 1 5
      :   <06 09 2A 86 48 86 F7 0D 01 01 05>
314-  316-   0 :   NULL
      :   <05 00>
      :   }
316-  318-  256 :   OCTET STRING          kedSignature
      :   <04 82 01 00>
      :    ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
      :    ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
      :    ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
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: }
```

Signing ASN.1 Format

The following structure is used to specify or negotiate the HMAC.

```
SigningInfo ::= SEQUENCE {
   version    INTEGER,          -- Always set to 0
   hmacMethod  MethodHMAC        -- specify/select HMAC method
   siSigAlgID  AlgorithmIdentifier OPTIONAL,
      OID= 1 3 14 3 2 11     RSA signature
      OID= 1 2 840 113549 1 1 5  sha1withRSAEncryption
      siSignature OCTET STRING OPTIONAL

}

MethodHMAC ::= CHOICE {
   hmacSelection[0] EXPLICIT SelectHMAC-- used by EKM to select method
   hmacEncrypted[1] EXPLICIT ProtHMAC-- eAK encrypted ClearHMAC
   hmacClear[2] EXPLICIT ClearHMAC-- only used when no eAK

}

SelectHMAC ::= SEQUENCE {
   version    INTEGER,        -- Always set to 0
   hmacAlg AlgorithmIdentifier,     -- Algorithm used for message hashing
      OID= 1 3 14 3 2 18            SHA
      OID= 1 3 14 3 2 26            SHA1
      OID= 1 3 14 3 2 11            RSA signature (not recommended)
   hmacLen   INTEGER         -- length in bytes of HASH

}

ProtHMAC ::= SEQUENCE {
   version   INTEGER,         -- Always set to 0
   hmacEncAlg AlgorithmIdentifier,    -- eAK method (RSA)
      OID= 1 2 840 113549 1 1 1   RSA
      OID= 1 2 840 113549 1 1 7   RSAES-OAEP
   hmacEncOCTET STRING         -- eAK encrypted ClearHMAC

}

ClearHMAC ::= SEQUENCE {
   version   INTEGER,         -- Always set to 0
   hmacAlg AlgorithmIdentifier,     -- Algorithm used for message hashing
      OID= 1 3 14 3 2 18      SHA
      OID= 1 3 14 3 2 26      SHA1
      OID= 1 3 14 3 2 11      RSA signature (not recommended)
   hmacLen   INTEGER         -- length in bytes of HASH
   hmacKey   OCTET STRING       -- The HMAC key (seed data)
}
```

ASN.1 Signing Information (clear, unsigned) - Example

```
ASN1 Data
    Ofs  Ofs   Len:  ASN.1            Field Name
    0   2    56 :    SEQUENCE {
          :      <30 38>
    2   4    1 :     INTEGER 0         version
          :     <02 01 00>
    5   7   51 :     [2] SEQUENCE {       hmacClear
          :     <A2 33>
    7   9    1 :     INTEGER 0         version
           :     <02 01 00>
    10  12    9 :     SEQUENCE          {hmacAlg
          :     <30 09>
    12  14    5 :     OID 1 3 14 3 2 18
          :     <06 05 2B 0E 03 02 12>
    19  21    0 :     NULL
          :     <05 00>
          :    }
    21   23    1 :    INTEGER 32         hmacLen
          :     <05 01 20>
    24   26   32 :    OCTET STRING         hmacKey
          :     <04 20>
          :    <?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
          :     ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??>
          :  }
          :  }
```

ASN.1 Signing Information (eAK encrypted, dAK signed) - Example

```
ASN1 Data
    Ofs  Ofs   Len:  ASN.1            Field Name
    0   4    560:    SEQUENCE {
          :      <30 82 02 30>       version
    4   6    1 :     INTEGER 0
          :     <02 01 00>
    7  11    278:     [1] SEQUENCE {       hmacEncrypted
          :     <A1 82 01 16>
    11  13    1 :     INTEGER 0         version
          :     <02 01 00>
    14  16   13 :     SEQUENCE {        hmacEncAlg
          :     <30 0D>
    16  18    9 :     OID 1 2 840 113549 1 1 1
          :     <06 09 2A 86 48 86 F7 0D 01 01 01>
    27  29    0 :     NULL
          :     <05 00>
          :     }
    29  33    256:     OCTET STRING        hmacEnc (w/eAK)
          :     <04 82 01 00>
          :      <?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
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          :   }
```

```
   289  291   13 :    SEQUENCE {siSigAlgID
          :     <30 0D>
   291  293    9 :     OID 1 2 840 113549 1 1 5
          :     <06 09 2A 86 48 86 F7 0D 01 01 05>
    302  304    0 :     NULL
          :     <05 00>
          :    }
    304  308    256:    OCTET STRING         siSignature
          :    <04 82 01 00>
          :      <?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
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          :       ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??>
          :   }
```

HMAC ASN.1 Format

The following is taken from PKCS #1.

```
ClearHMAC ::= SEQUENCE {
   version   INTEGER,         -- Always set to 0
   hmacAlg AlgorithmIdentifier,     -- Algorithm used for message hashing
      OID= 1 3 14 3 2 18      SHA
      OID= 1 3 14 3 2 26      SHA1
      OID= 1 3 14 3 2 11      RSA signature (not recommended)


DigestInfo ::= SEQUENCE {
   version   INTEGER,         -- Always set to 0
   digestAlgorithmDigestAlgorithmIdentifier,
   OID= 1 3 14 3 2 18         SHA
   OID= 1 3 14 3 2 26         SHA1
   OID= 1 3 14 3 2 11         RSA signature (not recommended)
   digest               Digest

}

DigestAlgorithmIdentifier ::= AlgorithmIdentifier

Digest ::= OCTET STRING
```

ASN.1 HMAC Structure - Example

```
ASN1 Data
    Ofs  Ofs   Len:  ASN.1            Field Name
    0   4     47 :    SEQUENCE {
          :     <30 2F>
    2   4    1 :     INTEGER 0         version
          :     <02 01 00>
    5   7    9 :     SEQUENCE {digestAlgorithm
          :     <30 09>
    7   8    5 :     OID 1 3 14 3 2 18
          :     <06 05 2B 0E 03 02 12>
    13  15    0 :     NULL
```

```
       :      <05 00>
       :    }
15  17   32 :     OCTET STRING        digest
       :      <04 20>
       :       ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??
       :       ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ?? ??>
       :   }
```

Appendix B. Notices

Trademarks

The following terms are trademarks of International Business Machines Corporation in the United States or other countries (or regions) or both:

AIX	OS/400	pSeries
AS/400	pSeries	RAA
eServer	SP	zSeries
IBM	RS/6000	NetBackup (NBU)
iSeries	TotalStorage	

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Linear Tape-Open
LTO
Ultrium

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Linux is a register traefmark of Linus Torvalds.

NetBackup is a trademark of Symantec

Microsoft®, Windows®, Windows NT, and the Windows logo are registered trademarks of Microsoft Corporation in the United States, or other countries (or regions), or both.

Other company, product, and service names may be trademarks or service marks of others.

Glossary

This glossary defines the special terms, abbreviations, and acronyms that are used in this publication.

Numbers and Symbols

2:1 compression. The relationship between the quantity of data that can be stored with compression as compared to the quantity of data that can be stored without compression. In 2:1 compression, twice as much data can be stored with compression as can be stored without compression.

A

adapter. See *adapter card*.

adapter card. A circuit board that adds function to a computer.

AL_PA. See *Arbitrated Loop Physical Address*.

Arbitrated Loop Physical Address (AL_PA). An 8-bit value that identifies a device in an arbitrated loop. All Fibre Channel ports communicate by using AL_PAs.

B

backups. The short-term retention of records used for restoring essential business and server files when vital data has been lost because of program or server errors or malfunctions.

bezel. The removable frame that fits over the front of the Ultrium Tape Drives.

bit. The smallest unit of data in a computer. A bit (short for binary digit) has a single binary value (either 0 or 1). Computers store data and execute instructions in bit multiples called bytes. In most computer systems, there are eight bits in a byte.

bus. See *SCSI bus*.

byte. A string that consists of a certain number of bits (usually 8) which are treated as a unit and represent a character. A byte is a fundamental unit of data.

C

capacity. The amount of data that can be contained on storage media and expressed in bytes.

cartridge. See *tape cartridge*.

cartridge memory. See *LTO cartridge memory*.

circuit board. A thin sheet on which chips and other electronic components are placed. Computers consist of one or more boards, often called cards or adapters.

cleaning cartridge. A tape cartridge that is used to clean the heads of a tape drive. Contrast with *data cartridge*.

command timeout. Following the issuance of a command, a period of time during which it is determined that there is a bad connection between the server and the drive.

compression. The process of eliminating gaps, empty fields, redundancies, and unnecessary data to shorten the length of records or blocks.

configure. To describe to a server the devices, optional features, and programs installed on the system.

D

data. Any representations such as characters or analog quantities to which meaning is, or might be, assigned.

data cartridge. A tape cartridge that is dedicated to storing data. Contrast with *cleaning cartridge*.

data compression. See *compression*.

data transfer rate. The average number of bits, characters, or blocks per unit of time that pass between corresponding equipment in a data transmission system. The rate is expressed in bits, characters, or blocks per second, minute, or hour.

device. Any hardware component or peripheral, such as a tape drive or tape library, that can receive and send data.

device driver. A binary file that is installed on a host system and enables the host system to access a device.

diagnostic. A software program that is designed to recognize, locate, and explain faults in equipment or errors in programs.

diagnostic cartridge. A tape cartridge that enables the detection and isolation of errors in programs and faults in equipment.

drive. See *IBM Ultrium Internal Tape Drive Models T200 and T200F* or *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F*.

drive dump. The recording, at a particular instant, of the contents of all or part of one storage device into another storage device, usually as a safeguard against faults or errors, or in connection with debugging.

drive head. The component that records an electrical signal onto magnetic tape, or reads a signal from tape into an electrical signal.

drive sense data. See *SCSI drive sense data*.

dump. See *drive dump*.

duplex. See *duplex transmission*.

duplex adapter. A mechanism that allows a device to send and receive communication at the same time.

duplex transmission. Transmission in both directions, either one direction at a time (half-duplex) or both directions simultaneously (full-duplex).

E

eject. To remove or force out from within.

electronic mail. Correspondence in the form of messages transmitted between user terminals over a computer network.

e-mail. See *electronic mail*.

enclosure. A device, such as a desktop unit, tape cartridge autoloader, or tape library, into which you can install an Ultrium Tape Drive.

error log. Maintained by an Ultrium Tape Drive, a list that contains the ten most recent error codes. The codes identify errors that pertain to the drive.

F

Fibre Channel. A 100-MB-per-second, full-duplex, serial communications technology that is capable of interconnecting Ultrium Tape Drives and servers which are separated by as much as 11 kilometers (7 miles). Fibre Channel technology combines features of the input/output (I/O) and networking interfaces.

Fibre Channel cable. The cable that connects a Fibre Channel tape drive to another device. The conductive element within the cable is constructed of either copper wires or optical fibers. Generally, copper wires are used for short distances (up to 30 meters or 98 feet); optical fibers are used for longer distances. Fiber-optic cabling is referred to by mode or the frequencies of light waves that are carried by a particular cable type. Multimode fiber cables are generally used for distances up to 500 meters (1640 feet) and with short-wave (780 nanometer) laser light. Single-mode fiber cables are used for distances greater than 500 m (1640 feet) and with long-wave (1300 nanometer) laser light.

file. A named set of records that are stored or processed as a unit.

filemark. Located on the magnetic tape within a tape cartridge, a recorded element that typically marks the organizational boundaries in a serial file structure (such as directory boundaries) and that is requested to be written or read by the server.

firmware. Proprietary code that is usually delivered as part of an operating system. Firmware is more efficient than software that is loaded from an alterable medium, and is more adaptable to change than pure hardware circuitry. An example of firmware is the Basic Input/Output System (BIOS) in read-only memory (ROM) on a PC motherboard.

G

Gb. See *gigabit*.

GB. See *gigabyte*.

gigabit (Gb). 1 000 000 000 bits.

gigabyte (GB). 1 000 000 000 bytes.

H

hard addressing. Pertaining to the Fibre Channel drives (Models T200F and T400F), a method that identifies the drive's LID and, consequently, its AL_PA (the AL_PA enables the drive to communicate with other devices).

hardware. The physical equipment or devices that form a computer.

head. See *drive head*.

host. The controlling or highest-level system in a data communication configuration. Synonymous with *server*.

I

IBM Ultrium Internal Tape Drive Models T200 and T200F. A data-storage device that controls the movement of the magnetic tape in an IBM LTO Ultrium Tape Cartridge. The drive houses the mechanism (drive head) that reads and writes data to the tape. Its native data capacity is 100 GB per cartridge and up to 200 GB at 2:1 compression. Its native data transfer rate is 15 MB per second and 30 MB per second at 2:1 compression.

IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F. A data-storage device that controls the movement of the magnetic tape in an IBM LTO Ultrium Tape Cartridge. The drive houses the mechanism (drive head) that reads and writes data to the tape. Its native data capacity is 200 GB per cartridge and up to 400 GB at 2:1 compression. Its native data transfer rate is 35 MB per second and 70 MB per second at 2:1 compression.

ID. Identifier.

initiator. In SCSI terms, a SCSI device that requests an I/O process to be performed by another SCSI device (a target). In many cases, an initiator can also be a target.

input/output (I/O). Data that is provided to a computer or data that results from computer processing.

install. (1) To set up for use or service. (2) The act of adding a product, feature, or function to a server or device either by a singular change or by the addition of multiple components or devices.

Internet. The worldwide collection of interconnected networks that use the Internet suite of protocols and permit public access.

I/O. See *input/output*.

J

jumper. (1) A tiny connector that fits over a pair of protruding pins in a connector. A jumper can be moved to change electrical connectors. When in place, the jumper connects the pins electrically. (2) To place a jumper on a connector pin.

L

Linear Tape-Open (LTO). A type of tape storage technology developed by the IBM Corporation, Hewlett-Packard, and Seagate. LTO technology is an "open format" technology, which means that its users have multiple sources of product and media. The "open" nature of LTO technology enables compatibility between different vendors' offerings by ensuring that vendors comply with verification standards.

load. Following the insertion of a tape cartridge into the tape load compartment, the act of positioning the tape (performed by the tape drive) for reading or writing by the drive's head.

load and unload cycle. The act of inserting a cartridge into a tape drive, loading the tape to load point, rewinding the tape into the cartridge, and ejecting the cartridge from the drive.

log sense data. See *SCSI log sense data*.

Low Voltage Differential (LVD). A low-noise, low-power, and low-amplitude electrical signaling system that enables data communication between a supported server and the Ultrium Tape Drive. LVD signaling uses two wires to drive one signal over copper wire. The use of wire pairs reduces electrical noise and crosstalk.

LTO. See *Linear Tape-Open*.

LTO cartridge memory (LTO-CM). Within each LTO Ultrium Data Cartridge, an embedded electronics and interface module that can store and retrieve a cartridge's historical usage and other information.

LTO-CM. See *LTO cartridge memory*.

LTO-DC. See *LTO Data Compression*.

LTO Data Compression (LTO-DC). A method that compresses a server's data before the drive writes it to tape. LTO-DC detects but does not recompress or test record boundaries and file markers (which are encoded as control symbols). It also allows switching between compression and no compression within the data stream, which prevents data from expanding when the drive compresses random or encrypted data.

LVD. See *Low Voltage Differential*.

M

magnetic tape. A tape with a magnetizable surface layer on which data can be stored by magnetic recording.

MB. See *megabyte*.

media. The plural of *medium*.

media capacity. See *capacity*.

medium. A physical material in or on which data may be represented, such as magnetic tape.

megabyte (MB). 1 000 000 bytes.

micrometer. One millionth of a meter (.000001 m). Synonymous with *micron*. Abbreviated as µm.

micron. One millionth of a meter (.000001 m). Synonymous with *micrometer*. Abbreviated as µm.

microsecond. One millionth of a second (.000001 s). Abbreviated as µs.

millimeter (mm). One thousandth of a meter (.001 m).

millisecond (ms). One thousandth of a second (.001 s).

mm. See *millimeter*.

ms. See *millisecond*.

Model T200. The version of the IBM Ultrium Internal Tape Drive that uses the SCSI interface, has a native storage capacity of 100 GB, and a native data transfer rate of 15 MB per second.

Model T200F. The version of the IBM Ultrium Internal Tape Drive that uses the Fibre Channel interface, has a native storage capacity of 100 GB, and a native data transfer rate of 15 MB per second.

Model T400. The version of the IBM TotalStorage LTO Ultrium 2 Tape Drive that uses the SCSI interface, has a native storage capacity of 200 GB, and a native data transfer rate of 35 MB per second.

Model T400F. The version of the IBM TotalStorage LTO Ultrium 2 Tape Drive that uses the Fibre Channel interface, has a native storage capacity of 200 GB, and a native data transfer rate of 35 MB per second.

N

N/A. Not applicable.

native storage capacity. The amount of data that can be stored without compression on a tape cartridge.

native sustained data transfer rate. See *data transfer rate*.

network. A configuration of data processing devices and software that is connected for information interchange.

network server. In a local area network, a personal computer that provides access to files for all of the workstations in the network.

node. In Fibre Channel technology, a communicating device.

ntutil. Created by IBM, a utility program for LTO devices that connect to Windows NT and Windows 2000. *ntutil* provides problem determination for hardware or connections, assists with device and medium changer recognition, forces dumps, loads new firmware, sends and receives SCSI commands to and from the hardware, and obtains SCSI sense data to use in resolving errors.

O

offline. The operating condition that the Ultrium Tape Drives are in when the server's applications cannot interact with it.

online. The operating condition that the Ultrium Tape Drives are in when the server's applications can interact with it.

Open Systems. Computer systems whose standards are not proprietary.

operating system. The master computer control program that translates the user's commands and allows software application programs to interact with the computer's hardware.

P

parity. The state of being even-numbered or odd-numbered. A parity bit is a binary number that is added to a group of binary numbers to make the sum of that group always odd (odd parity) or even (even parity).

parity error. A transmission error that occurs when the received data does not have the parity that is expected by the receiving system. This usually occurs when the sending and receiving systems have different parity settings.

port. (1) A system or network access point for data entry or exit. (2) A connector on a device to which cables for other devices such as display stations and printers are attached. (3) The representation of a physical connection to hardware. A port is sometimes referred to as an adapter; however, there can be more than one port on an adapter.

power-off. To remove electrical power from a device.

power-on, powered-on. (1) To apply electrical power to a device. (2) The state of a device when power has been applied to it.

protocol. The meanings of, and the sequencing rules for, requests and responses that are used to manage a network, transfer data, and synchronize the states of network components.

Q

quiesce. To put a device into a temporarily inactive or inhibited state, but not remove it from the server.

R

read. To acquire or interpret data from a storage device, from a data medium, or from another source.

reboot. To reinitialize the execution of a program by repeating the initial program load (IPL) operation.

record. The smallest distinct set of data bytes that is supplied from a server for processing and recording by a tape drive, and the smallest distinct set of data to be read from tape, reprocessed, and made available to a server by a tape drive.

record boundaries. The fixed limits of a record.

repeater. A device that regenerates signals to extend the range of transmission between data stations or to interconnect two branches. A repeater is a node of a local area network.

reset. To return a device or circuit to a clear state.

RS-422 connector. Located at the rear of the Ultrium Tape Drive, the connector to which the internal RS-422 cable of an enclosure connects. The connection enables serial devices to communicate with the drive.

RS-422 interface. An electrical interface standard that is approved by the Electronic Industries Association (EIA) for connecting serial devices. The RS-422 standard, which supports higher data rates and greater immunity to electrical interference, is an alternative to the older RS-232 interface, and uses individual differential signal pairs for data transmission. Depending on data transmission rates, RS-422 can be used at distances up to 1,275 m (4,000 ft). The RS-422 interface also supports multi-point connections.

S

s. See *second*.

SAN. See *Storage Area Network*.

SAN Data Gateway. A device that provides Fibre Channel attachment between Open Systems servers and SCSI disk and tape storage systems.

SC. See *subscription channel connector*.

SCSI. See *Small Computer Systems Interface*.

SCSI bus. (1) A collection of wires through which data is transmitted from one part of a computer to another. (2) A generic term that refers to the complete set of signals that define the activity of the Small Computer Systems Interface (SCSI).

SCSI connector. Located at the rear of the Ultrium Tape Drive, the connector that facilitates commands to and from the server, and to which the internal SCSI cable of an enclosure connects.

SCSI device. Anything that can connect into the SCSI bus and actively participate in bus activity.

SCSI drive sense data. In response to inquiry from the server about an error condition, a packet of SCSI sense bytes that contains information about the error and that is sent back to the server by the drive.

SCSI ID. The unique address (from 1 to 15) that you assign to an Ultrium Tape Drive that uses a SCSI interface.

SCSI ID connector. Located at the rear of the Ultrium Tape Drive, the connector that enables the drive's SCSI address to be set. Addresses are determined by the placement of jumpers on the pins.

SCSI ID switch. Located on an enclosure that contains a Ultrium Tape Drive, a mechanism that connects to the drive and allows you to change the drive's SCSI ID without using jumpers.

SCSI log sense data. In response to inquiry from the server about the Ultrium Tape Drive's error logs and counters, a packet of SCSI sense bytes which contains that information and which is sent back to the server by the drive. Log sense data is used to diagnose problems, especially if the problems are intermittent.

second. One sixtieth of a minute.

selection timeout. Following the selection of an option (for example, a data transfer), the period of time during which it is determined that there is a bad connection between the server and the drive.

sense data. Data that describes an I/O error. Sense data is presented to a server in response to a Sense I/O command.

serial interface. An interface that sequentially or consecutively executes two or more operations in a single device, such as an arithmetic and logic operation.

server. A functional unit that provides services to one or more clients over a network. Examples include a file server, a print server, or a mail server. The IBM @server pSeries, IBM @server iSeries, HP, and Sun are servers. Synonymous with *host*.

short-wave cable. In Fibre Channel technology, a laser cable that uses a wavelength of 780 nanometers and is only compatible with multimode fiber.

Small Computer Systems Interface (SCSI). A standard used by computer manufacturers for attaching peripheral devices (such as tape drives, hard disks, CD-ROM players, printers, and scanners) to computers (servers). Pronounced "scuzzy." Variations of the SCSI interface provide for faster data transmission rates than standard serial and parallel ports (up to 160 megabytes per second). The variations include:

- Fast/Wide SCSI: Uses a 16-bit bus, and supports data rates of up to 20 MBps.
- SCSI-1: Uses an 8-bit bus, and supports data rates of 4 MBps.
- SCSI-2: Same as SCSI-1, but uses a 50-pin connector instead of a 25-pin connector, and supports multiple devices.
- Ultra SCSI: Uses an 8- or 16-bit bus, and supports data rates of 20 or 40 MBps.
- Ultra2 SCSI: Uses an 8- or 16-bit bus and supports data rates of 40 or 80 MBps.
- Ultra3 SCSI: Uses a 16-bit bus and supports data rates of 80 or 160 MBps.
- Ultra160 SCSI: Uses a 16-bit bus and supports data rates of 160 MBps.

soft addressing. Pertaining to the Fibre Channel drive, a method that enables the drive to dynamically arbitrate its AL_PA with other Fibre Channel devices on the loop. The AL_PA enables the drive to communicate with other devices.

software. Programs, procedures, rules, and any associated documentation pertaining to the operation of a computer system.

Storage Area Network (SAN). A high-speed subnetwork of shared storage devices. A SAN's architecture makes all storage devices available to all servers on a LAN or WAN. As more storage devices are added to a SAN, they too will be accessible from any server in the larger network. Because stored data does not reside directly on any of a network's servers, server power is used for business applications, and network capacity is released to the end user.

subscription channel connector (SC). A push-pull type of optical connector that features high density, low loss, low backreflection, and low cost.

switch. A network infrastructure component to which multiple nodes attach. Unlike hubs, switches typically have the ability to switch node connections from one to another. A typical switch can facilitate several simultaneous bandwidth transmissions between different pairs of nodes.

T

TapeAlert. A patented technology and ANSI standard that defines conditions and problems that are experienced by tape drives.

TapeAlert flags. Status and error messages that are generated by the TapeAlert utility and display on the server's console.

tape cartridge. A removable storage case that houses belt-driven magnetic tape that is wound on a supply reel and a takeup reel.

tape drive. See *IBM Ultrium Internal Tape Drive Models T200 and T200F* or *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F*.

tape path. Within a tape drive, the channel in which the media moves.

tapeutil. Created by IBM, a utility program for LTO devices that connect to all supported servers except Windows NT and Windows 2000. *tapeutil* provides service aids for tape subsystems, offers a menu-driven tool for exercising or testing IBM tape and medium changer devices, and includes a command-line interface that is convenient for use in shell scripts.

terminate. To prevent unwanted electrical signal reflections by applying a device (known as a terminator) that absorbs the energy from the transmission line.

topology. In communications, the physical or logical arrangement of nodes in a network, especially the relationships among nodes and the links between them.

TotalStorage LTO Ultrium Tape Drive Models T400 and T400F. See *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F*.

transfer rate. See *data transfer rate*.

U

Ultrium Tape Drive. See *IBM Ultrium Internal Tape Drive Models T200 and T200F* or *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F*.

Ultrium 2 Tape Drive. See *IBM TotalStorage LTO Ultrium 2 Tape Drive*.

uniform resource locator (URL). The address of an item on the World Wide Web. It includes the protocol followed by the fully qualified domain name (sometimes called the host name) and the request. The web server typically maps the request portion of the URL to a path and file name. For example, if the URL is `http://www.networking.ibm.com/nsg/nsgmain.htm`, the protocol is `http`; the fully qualified domain name is `www.networking.ibm.com`; and the request is `/nsg/nsgmain.htm`.

unload. The act (performed by the drive) of unthreading tape from the drive's internal tape path and returning it (with the leader block) to the tape cartridge.

URL. See *uniform resource locator*.

utility. See *utility program*.

universal time (UT). The time at longitude zero, colloquially known as Greenwich Mean Time. See `http://aa.usno.navy.mil/faq/docs/UT.html`.

utility program. A computer program that supports computer processes. For example, a diagnostic program, a trace program, or a sort program.

V

vital product data (VPD). Information about a product. Among other details, the VPD may include a model number, serial number, part number, or level of firmware.

W

web. See *World Wide Web*.

World Wide Name. A unique, 8-byte identifier that is assigned by IBM Manufacturing to each Ultrium Tape Drive and used to identify a drive.

World Wide Web. A network of servers that contain programs and files. Many of the files contain hypertext links to other documents that are available through the network.

write. To make a permanent or transient recording of data in a storage device or on a data medium.

write protected. Applicable to a tape cartridge, the condition that exists when some logical or physical mechanism prevents a device from writing on the tape in that cartridge.

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Special characters

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