Sun StorageTek T9x40-Series Tape Drives

9840, T9840B, T9840C, T9840D / T9940A, T9940B Fibre Channel Interface

Reference Manual

Part Number: 95784
Revision: N

T9x40-Series Tape Drives

9840, T9840B, T9840C, T9840D and T9940A, T9940B

Fibre Channel Interface Reference Manual

Sun Microsystems, Inc.
www.sun.com

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April 2008
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Summary of Changes

Date	Revision	Description
	A (First)	Initial release
	B (Second)	Refer to this revision for the list of changes.
	C (Third)	Refer to this revision for the list of changes.
	D (Fourth)	Refer to this revision for the list of changes.
	E (Fifth)	Refer to this revision for the list of changes.
August 2000	F (Sixth)	Refer to this revision for the list of changes (T9940A).
May 2001	G (Seventh)	Refer to this revision for the list of changes (T9840B).
November 2001	H (Eighth)	Refer to this revision for the list of changes.
November 2002	J (Ninth)	Refer to this revision for the list of changes.
December 2002	K (Tenth)	Refer to this revision for the list of changes (T9840C).
October 2003	L (Eleventh)	Refer to this revision for the list of changes.
August 2007	M (Twelfth)	Refer to this revision for the list of changes (T9840D).
April 2008	N (Thirteenth)	Updates to include: • Changed the name of Chapter 4 to "Command Reference" • Added three new commands: - "Read Attribute Command" on page 133 - "Receive Diagnostic Results" on page 141 - "Security Protocol In" on page 164 • Updated these commands - "Inquiry Data Format" on page 71 - "Vital Product Data Pages" on page 74 - "Management Network Addresses Page" on page 77 - "Sequential Access Device Capabilities Page" on page 78 - "Load/Unload Command" on page 81 - "Log Sense Page Format" on page 86 - "Log Sense Supported Pages" on page 88 - "Vendor Unique Drive Statistics Page" on page 95 - "TapeAlert Page" on page 108 - "Sense Keys" on page 154 - "Additional Sense Codes and Qualifiers" on page 155 - "Send Diagnostic Command" on page 161 • Updated document feedback locations. • Updated where to find additional information.

Note: Change bars included to indicate updates.

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Preface

The *Fibre Channel Reference Manual* is intended for solutions delivery engineers, hardware and software engineers, as well as operating system designers and developers implementing Fibre Channel on the Sun StorageTek™ T9840A, T9840B, T9840C, T9840D; T9940A and T9940B Tape Drives.

This manual contains information about the interface as well as information about the tape drive, operations, commands, hubs, cables, and connectors.

Terminology and Usage

The following terminology is used throughout this manual:

- Examples of hexadecimal notation are: x'4A', 70h, and 00 10 4F (hex).
- Examples of binary notation are: '0101' (b) or 01b.
- Examples of tape drives, or "drives" are: Sun StorageTek T9x40 Series Tape Drive, T9840A, T9840B, T9840C, T9840D; T9940A and T9940B; or T9840x and T9940x.
- The 9840 tape drives is also known as the T9840A tape drive.
- Sun StorageTek™, or just "StorageTek."
  StorageTek is a trademark of Sun Microsystems, Inc.

Organization

This reference manual contains the following information:

Chapter 1 "General Information" provides a high-level overview about Fibre Channel on the T9x40-Series Tape Drives.

Chapter 2 "Physical Interface"" describes the hubs, cables, and connectors for attaching the tape drives to the Fibre Channel interface.

Chapter 3 "Operations" describes the elements for connecting to the Fibre Channel interface.

Chapter 4 "Commands" lists and defines the SCSI commands for the tape drives and how Fibre Channel implements them.

Glossary Defines new or special terms and abbreviations used in this manual.

Index Assists in locating information in this manual.

Alert Messages

Alert messages call your attention to information that is especially important or that has a unique relationship to the main text or graphic.

Note: A note provides additional information that is of special interest. A note might point out exceptions to rules or procedures. A note usually, but not always, follows the information to which it pertains.

CAUTION:
A caution informs you of conditions that might result in damage to hardware, corruption of data, or corruption of application software. A caution always precedes the information to which it pertains.

Related Publications

The following publications provide additional information about the T9x40-Series of tape drives.

Publication	Part Number
9840 Tape Drive General Information Manual	MT 4004 *x*
9840 Tape Drive Illustrated Parts Catalog	95866
9840 Tape Drive Installation Manual	95879
9840 Tape Drive Planning and Migration Guide	MT 6004 *x*
9840 Tape Drive Product Manual	95741
9840 Tape Drive Service Reference Manual	95740
9840 Tape Drive System Assurance Guide	MT 5003 *x*
9840 Tape Drive User's Reference Manual	95739

Related Training

Sun Learning Services (SLS) has two tools that employees can use to obtain information about and for training.

- Learning Management System (LMS) enables you to sign up for classes, access training records, start e-learning courses, and much more.
- MyLearning Portal allows you can find out about the latest learning offerings, find the right learning for your job, watch training videos, and share and collaborate with peers—all from a single site.

You can access both of these tools through the SunWeb Portal at: http://sunweb.central.sun.com.

Accessing the Learning Management System

Employee Training

Employees in the US and EMEA can access the LMS by logging into myHR from the SunWeb Life and Work tabs.

Once you are logged in to myHR, click on the "My Job & Learning" tab and access the new LMS under the "Learning" channel on the page.

Employees in APAC, LATAM, and Canada have access to a light version of myHR.

Once you are logged into myHR, you can access the Learning system by clicking on the "Learning" link in the Key Links on the right side of the screen.

Note: If you have additional questions about logging on to myHR for the first time, visit the FAQs.

Partner Training

Partner-facing training resources are still available through a version of the Sun Training Access Network (SunTAN), which remains available through the remainder of FY07.

Customer Training

Customers can review the Training catalog that is available through the Sun Web site at: http://www.sun.com.

Click on the Training link at the top of the page. http://www.sun.com/training.

Additional Information

Sun Microsystems, Inc. (Sun) offers several methods for you to obtain additional information.

Sun's External Web Site

Sun's external Web site provides marketing, product, event, corporate, and service information. The external Web site is accessible to anyone with a Web browser and an Internet connection.

The URL for the Sun external Web site is: http://www.sun.com

The URL for Sun StorageTek™ brand-specific information is:
http://www.sun.com/storagetek/

Documentation Web Sites

SunSolve and the documentation Web sites enable customers and members to search for technical documentation, downloads, patches, features and articles, plus the Sun Systems Handbook. These links are available to help you locate information:

- **Documentation (customer):** http://docs.sun.com/app/docs
- **Documentation (proprietary)**: http://doc.sfbay.sun.com/app/docs
- **SunSolve External site:** http://sunwebcms.central
- **SunSolve Internal site:** http://sunsolve.central.sun.com

Hardcopy Publications

Contact a Sun sales or marketing representative to order additional paper copies of this publication or to order other StorageTek-brand product publications in paper format.

General Information

1

This chapter contains an overview about Fibre Channel specifications for the Sun StorageTek T9x40-Series of tape drives. Fibre Channel and these tape drives conform to the:

- American National Standards Institute (ANSI)
- National Committee for Information Technology Standards (NCITS) formerly X3

Table 1 lists the documents that define this implementation of Fibre Channel:

Table 1. References

Specification	Revision
Fibre Channel Physical and Signaling Interface (FC–PH)	X3.230–1994 Revision 4.3 X3.230–1996 (Amendment 1) X3.230–1997 (Amendment 2)
Fibre Channel Physical and Signaling Interface (FC–PH–2)	X3.297–1996 Revision 7.4
Fibre Channel Physical and Signaling Interface (FC–PH–3)	X3.303–199x Revision 9.3
Fibre Channel Physical INterface (FC-PI)	T11/Project 1306-0 Revision 2
Fibre Channel Framing and Signaling Interface (FC-FS)	T11/Project 1330 Revision 1.2
Fibre Channel Arbitrated Loop (FC–AL)	X3.272–1996 Revision 4.5
Fibre Channel Arbitrated Loop (FC–AL–2)	X3.272–199x Revision 6.4
Fibre Channel Protocol for SCSI (FCP)	X3.269–1996 Revision 12
Fibre Channel Protocol for SCSI (FCP–2)	T10/Project 1144D Revision 04
Fibre Channel Tape (FC–Tape)	NCITS TR–24 Revision 1.17
SCSI–3 Primary Commands (SPC)	X3.301–1997
SCSI–3 Primary Commands (SPC–2)	T10/Project 1236D Revision 11
SCSI–3 Stream Device Commands (SSC)	T10/Project 997D Revision 22
SCSI–3 Architecture Model (SAM)	X3.270–1996
SCSI Architecture Model – 2 (SAM–2)	T10/Project 1157D Revision 12

4FC*	Fibre Channel Physical Interface	FC-PI T11/Project 1306-0, Rev. 2
4FC*	Fibre Channel Framing and Signaling Interface	FC-FS T11/Project 1330, Rev. 1.2

Overview

Fibre Channel (FC) is a serial interface standard that represents a revolution in input/output (I/O) interfaces. FC began as an extension of the IPI–3 industry standard conforming to the following:

- Serial connection
- Copper (electrical) or fiber (optical) transmissions
- Multiple protocols (such as SCSI, IP, HIPPI, IPI-3)
- Information transparent
- 100 MByte data transfer rates (and higher)
- Scalable for data rates, distance, media, and protocols

In 1994, the Fibre Channel Physical and Signaling Interface (FC–PH), or ANSI X3.230–1994, was completed, differing from every other architecture at the time. This specification married the strengths of channels, including high throughput and low overhead, with the strengths of networks, including flexibility, long distance capability, and high connectivity.

History

In 1988, Fibre Channel began as an extension of work done on the Intelligent Peripheral Interface Level 3 (IPI–3) Enhanced Physical Standard. In October of that year, the scope widened when ANSI X3T11 was chartered. The standard included the High Performance Parallel Interface (HIPPI), Small Computer System Interface (SCSI–3) along with other interface types. Other standards adopted to implement Fibre Channel were:

- IBM's 8B/10B coding scheme, which does not embed error correction
- A low cost copper cable variant

Work began in earnest in late 1989 to develop the FC-PH standard. This standard uses characteristics similar to IBM's Enterprise System Connection (ESCON) in the following ways:

- 8B/10B coding scheme
- A D-shell type connector with a laser safety shutter
- Two sets of transceivers:
  - A standard 200 Mbaud LED transmitter in multimode up to 3 km
  - An Extended Distance Facility laser transmitter in single mode to 20 km
  - Transfer rates up to 18 MB/sec
  - The ESCON Directors that operate similar to the FC–PH–1 Class 1 Dedicated Connections in Fibre Channel Switches

Development continued through 1990 into 1991, when the following occurred:

- The first draft of the FC–PH–1 appeared in March 1991, and was forwarded to X3T9 for peer review in August of that year
- The SC connector was adopted in October 1991

By 1992, the FC–PH standard was:

- Forwarded to X3T9 for standardization in February
- Released for first public review in June

In 1993, X3T9 incorporated public comments for the final ANSI review process in 1994. The official FC–PH–1 (X3.230–1994) was finished in October 1994.

Table 2. Fibre Channel Hierarchy

ULPs	SCSI	IPI	IP	SBCCS	HIPPI
FC-4	**Upper Level Protocol Mapping** Mapping of ULP functions and constructs				
FC-3	**Common Services**				
FC-2	**Link Service** • Login and Logout services • Basic and Extended Link Services				
	Signaling Protocol • Frames, Sequences, and Exchanges • N_Ports, F_Ports, and Topologies • Classes of Service (1, 2, and 3) • Buffer-to-Buffer/end-to-end flow control				
FC-AL	**Arbitrated Loop Functions** • Ordered sets for loop arbitration • Loop Initialization • Physical address assignments				
FC-1	**Transmission Protocol** • Encoding and Decoding • Link management • Error monitoring				
FC-0	**Physical Interface** • Transmitters, receivers, and Bandwidth				
	Media • Cables and Connectors				

Implementation

StorageTek uses the following physical hardware and software features to implement Fibre Channel on the T9840A, T9840B, T9840C, T9840D, T9940A, and T9940B Tape Drives:

Tape Drive:

- NL_Port Arbitrated loop (conforming to the FC–Tape)
- FCP (SCSI-3) command set for tape (serial) devices
- Class 3 level of service
- Class 2 level of service (*future*)
- Private Loop NL_Port attach operation
- Public Loop FL_Port attach operation
- Fabric F_Port attach operation on T9840A, B, C, and D; T9940A and B.
- Point to Point attachment on T9840A, B, C, and D; T9940A and B.
- Hard assigned port addresses (AL-PA)
- Basic and extended link services
- Connections to an external hub
- Data transfer rate (Burst) of 100 megabytes per second (MB/s)
- Data transfer rate (Burst) of 200 MB/s on T9840B, C, and D, plus the T9940B
- Standard approved length shortwave fibre optic cables
- Multimode laser operating at **850** nanometers (shortwave) non–OFC
- Replaceable small form-factor pluggable (SFP) modules on the T9840D
- Dual port connections

Hub:

- Multiple ports
- Standard approved length fibre optic and copper cables
- Multimode laser operating at **850** nanometers (shortwave) non–OFC
- Single mode laser operating at 1300 nanometers (longwave) connecting other devices
- Cascading hub attachments
- Gigabit Interface Converter (GBIC) connections in the hub

Note: See Chapter 2, "Physical Interface" for more information about the hubs, cables, and connectors.

Switch:

- Attachment to FL_Ports (public loop) is supported
- Attachment to F_Port is supported on T9840B, C, and D, plus the T9940B

Product Specifications

Product specifications provide information about StorageTek's Nearline Cartridge Subsystems that support Fibre Channel attachments.

T9x40-Series Tape Drives

The T9x40-Series Tape Drives–including the T9840A, T9840B, T9840C, T9840D, and the T9940A and T9940B—are small, modular, high-performance tape drives designed for both the enterprise and open-system environment.

These tape drives are self-contained units with all the electrical and mechanical components required for the tape drive to function including external power supplies that mount with or attach to the drives.

T-Series drives consist of two types:

- **Capacity-centric** drives are designed to hold large amounts of data on one tape cartridge.
- **Access-centric** drives are designed to read and write data far more quickly and serve as a cost-effective alternative—not a replacement—to high-speed disk (with access times in milliseconds).

The tape drive can be installed as a desktop unit, rackmount, with optional cartridge scratch loader (CSL) on the T9840 only or attached to one of a Sun StorageTek automated library.

T9840 Tape Drives

Description

StorageTek's T9840—models A, B, C and D—are **access-centric** tape drives that have an average access time of just 12 seconds.

These drives obtain their high-performance by using a unique *dual-hub* cartridge design with midpoint load technology. This enables fast access and reduces latency by positioning the read/write head in the middle of the tape.

Read/Write Technology

The T9840C uses a variable rate randomizer, with partial response, maximum likelihood circuitry and LZ1—an Adaptive Lossless Data Compression technique—as the data recording method.

The T9840 models A and B use a StorageTek proprietary recording format.

A 16-channel head reduces the required number of tape passes to record data to tape and also extends media life (few passes).

Media

With the T9840A unique dual-hub design, the entire tape path is contained within the cartridge, which reduces contamination and enables the drives fast access.

Connectivity

Host interfaces to the T9840 tape drives include: Fibre Channel (FC), IBM's Enterprise Systems Connection (ESCON) and Fibre Connection (FICON), or small computer system interface (SCSI).
However, not all interfaces are available for all configurations:

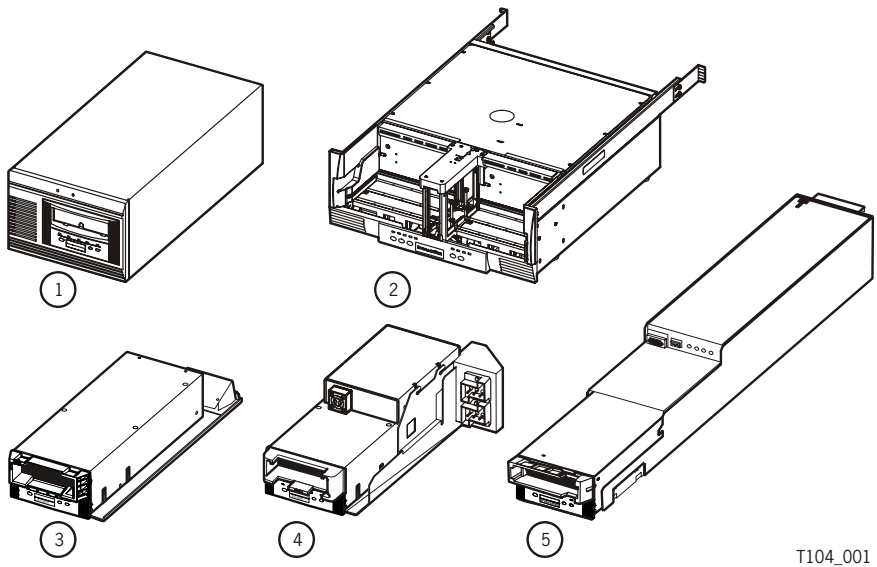
Interface	T9840A	T9840B	T9840C	T9840D
Fibre Channel	1 Gb	2 Gb	2 Gb	2 Gb
Ultra-SCSI HVD	10 MB/s	19 MB/s	N/A	N/A
ESCON	19 MB/s	19 MB/s	19 MB/s	19 MB/s
FICON	N/A	2 Gb	2 Gb	2 Gb

Operating Systems

Versions of both enterprise and open system platforms, such as:
Windows: NT, 2000; UNIX: Solaris, HP-UX, AIX; Linux; MVS, VM, and OS/390

Configurations

The T9840 tape drives support four configurations: library-attach, rack-mount, cartridge scratch-loader (CSL), and desktop.



1. Desktop
2. Cartridge scratch loader
3. 9310/9360/9740 and L5510 library-attach
4. L-Series library-attach
5. SL8500 library-attach

T9840 Specifications

Table 3. T9840 Tape Drive Specifications

Physical Specifications	T9840A	T9840B	T9840C	T9840D*
Height	8.25 cm (3.25 in.)	8.25 cm (3.25 in.)	8.25 cm (3.25 in.)	8.25 cm (3.25 in.)
Width	14.6 cm (5.75 in.)	14.6 cm (5.75 in.)	14.6 cm (5.75 in.)	14.6 cm (5.75 in.)
Length (depth)	38.1 cm (15 in.)	38.1 cm (15 in.)	38.1 cm (15 in.)	38.1 cm (15 in.)
Weight	3.9 kg (8.5 lb)	3.9 kg (8.5 lb)	3.9 kg (8.5 lb)	3.9 kg (8.5 lb)
Performance Specifications				
Capacity (native)	20 GB	20 GB	40 GB	75 GB
Transfer rate (native)	10 MB/s	19 MB/s	30 MB/s	30 MB/s
Data Buffer size	8 MB	32 MB	64 MB	64 MB
Number of tracks	288	288	288	576
Tape Load to ready	7 sec	7 sec	6.5 sec	8.5 sec
Access time-average (to first file)	8 sec	8 sec	8 sec	8 sec
Tape speed (meters per second)	2 m/s	4 m/s	3.295 m/s	3.4 m/s
Rewind time (maximum/average)	16/8 sec	16/8 sec	16/8 sec	16/8 sec
Tape Unload time	8 sec	8 sec	11.5 sec	12 sec
Emulation Modes	Native, 3490E, 3590, Standard	Native, 3490E, 3590, Standard	Native, 3490E, 3590, Standard, T9840B	Native, 3490E, 3590H
Interface Support	FC1, ESCON, Ultra-SCSI (HVD)	FC2, FICON, ESCON	FC2, FICON, ESCON	FC2, FICON, ESCON
MTBF (100% duty cycle)	290,000 hrs	290,000 hrs	290,000 hrs	290,000 hrs
Media/Format Compatibility				
Read/Write	Proprietary Format—9840 Tape Cartridge			
Power				
Auto-ranging / Amperage	100–240 VAC at 50–60 Hz			
Consumption	82 W			TBD
Operating Heat Output	280 Btu/hrs	280 Btu/hrs	280 Btu/hrs	TBD

Note: The T9840D is the next generation, access-centric, encryption-capable, tape drive from Sun StorageTek, which is expected to release in 2008. These specifications are subject to change.

Interface Codes:
Fibre Channel: FC1 = Gb support, FC2 = 2-Gb support, FC4 = 4 Gb support
FICON is IBM's Fibre Connection
ESCON is IBM's Enterprise System Connectivity

T9940 Tape Drives

Description

StorageTek's T9940 tape drives—models A and B—are "**capacity-centric**" tape drives that offer exceptional storage capacity.

Read/Write Technology

The T9940B use a variable rate randomizer, with partial response, maximum likelihood circuitry and LZ1—an Adaptive Lossless Data Compression technique—as the data recording method.

The T9940A use a StorageTek proprietary recording format.

A 16-channel head reduces the required number of tape passes to record data to tape and also extends media life (few passes).

Media

The tape cartridge for this drive uses a single-reel hub design—the supply reel is inside the cartridge and the take-up reel is inside the tape drive.

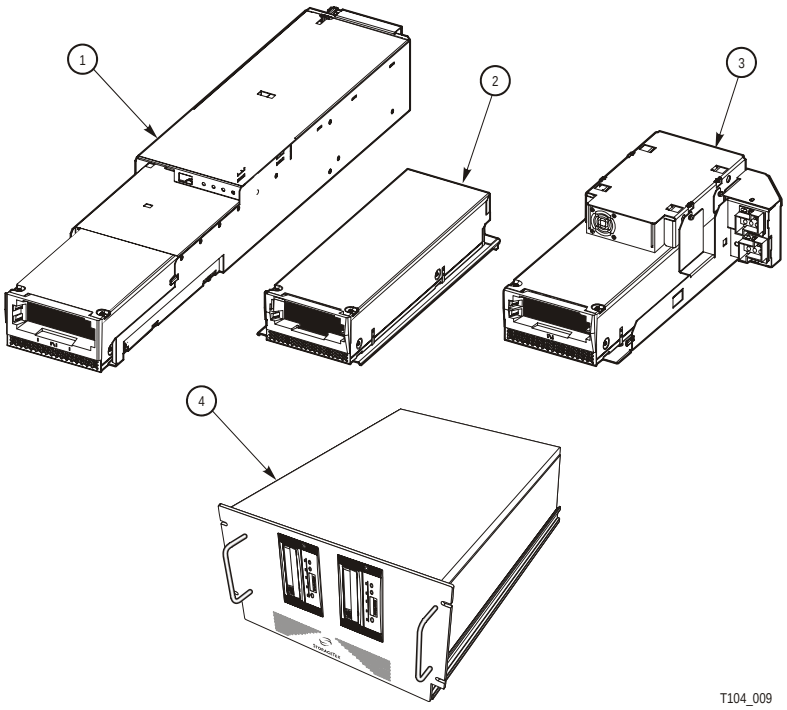
Connectivity

Host interfaces to the T9940 tape drives include: Fibre Channel (FC), IBM's Enterprise Systems Connection (ESCON) and Fibre Connection (FICON), or small computer system interface (SCSI).
However, not all interfaces are available for all configurations:

Interface	T9940A	T9940B
Fibre Channel	1 Gb	2 Gb
Ultra-SCSI HVD	40 MB/sec	N/A
ESCON	20 MB/sec	20 MB/sec
FICON	N/A	2 Gb

Configurations

The T9940 tape drives support two configurations: library-attach and rack mount.



1. SL8500 library-attach
2. 9310/9360/9740/L5500 library-attach
3. L-Series library-attach
4. Rack mount

T9940 Specifications

Table 4. T9940 Tape Drive Specifications

Physical Specifications	T9940A	T9940B
Height	8.25 cm (3.25 in.)	8.25 cm (3.25 in.)
Width	14.6 cm (5.75 in.)	14.6 cm (5.75 in.)
Length (depth)	52.1 cm (20.5 in.)	52.1 cm (20.5 in.)
Weight	6.8 kg (15.0 lb)	6.8 kg (15.0 lb)
Performance Specifications		
Capacity (native)	60 GB	200 GB
Transfer rate (native)	10 MB/s	30 MB/s
Data Buffer size	32 MB	64 MB
Number of tracks	288	576
Load to ready	18 sec	18 sec
Access time-average (to first file)	59 sec	59 sec
Tape speed (meters per second)	2.0 m/s	2.4 m/s
Rewind time (maximum/average)	90/45 sec	90/45 sec
Unload time	18 sec	18 sec
Emulation Modes	Native, 3490E, 3590, Standard	Native, 3490E, 3590, Standard, T9940A
Interface Support	FC1, ESCON, Ultra-SCSI (HVD)	FC2, FICON, ESCON for VSM
MTBF (100% duty cycle)	290,000 hrs	290,000 hrs
Media/Format Compatibility		
Read/Write	Proprietary Format—9940 Tape Cartridge	
Power		
Auto-ranging / Amperage	100–240 VAC at 50–60 Hz	
Consumption	82 VA	82 VA
Operating Heat Output	280 Btu/hrs	280 Btu/hrs
Interface Codes: Fibre Channel: FC1 = Fibre Channel Gb support, FC2 = Fibre Channel 2-Gb support FICON is IBM's Fibre Connection ESCON is IBM's Enterprise System Connectivity		

Physical Interface

2

This chapter describes how the Sun StorageTek tape drives attach to a Fibre Channel (FC) interface and includes recommendations for hubs, cables, and connectors.

Topologies

Sun StorageTek tape drives support the following topologies with either single or dual port attachments:

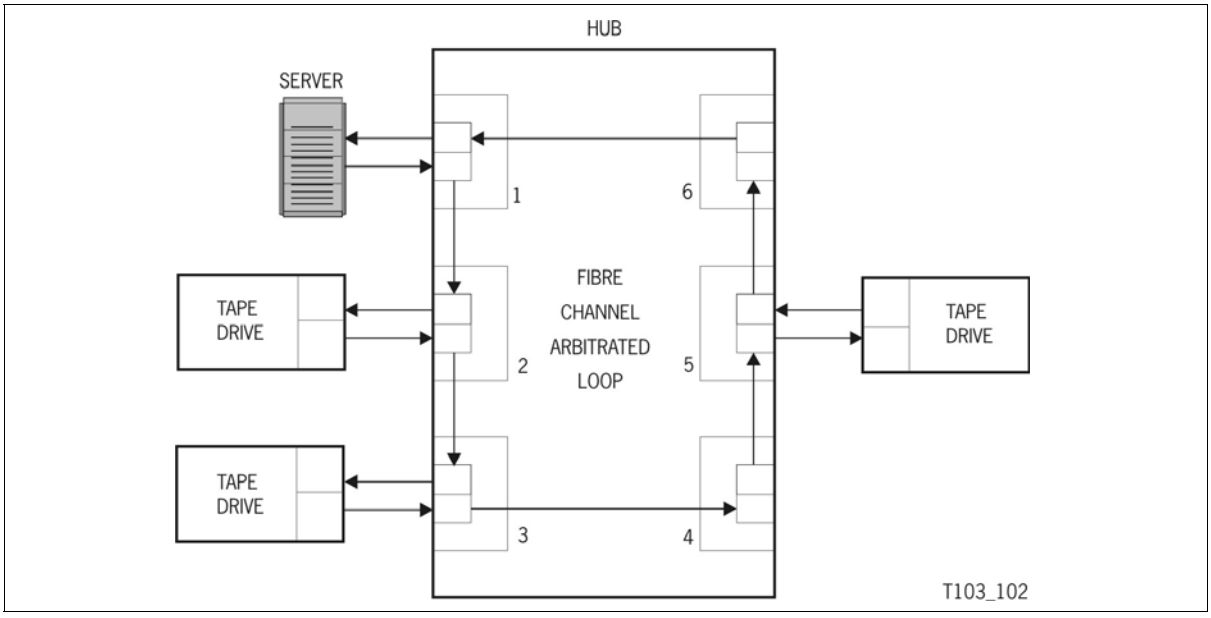
- Arbitrated Loop—private loop, NL_Port to NL_Ports
- Arbitrated Loop—public loop, NL_Port to NL_Ports, and one FL_Port
- Fabric F_Port attachment
- Point to Point attachment

Note: Dual port technology provides a redundant path and allows connections to two ports, which increases the flexibility of the drive. Only one port on a drive may be active for data transfer at a time.

Arbitrated Loop

Figure 1 is an example of a hub producing an arbitrated loop.

Figure 1. Arbitrated Loop



Hubs

Because of the fast growth and the increase in demand of fibre channel attachments, hubs can provide cascading (multiple) loops within a fibre channel network. Sun StorageTek tape drives are designed to use hubs to provide for an arbitrated loop which provides the following capabilities:

- Centralizes the attachment of the tape drives within the arbitrated loop
- Establishes connections with either copper or fiber optic cables
- Provides translation of physical media (such as copper to optical fiber)
- Provides an external power supply for the port bypass
- Provides port bypass functionality for port failures
- Allows cascading to increase tape drive and initiator attachment
- Supports the ability to power-on and -off, install or de-install tape drives
- Creates a central point of port management and monitoring of the drives
- Extends the distances between tape drives and initiators

Giga-Bit Interface Converters

Hubs use Giga-bit Interface Converters (GBICs) to provide the physical connection to the tape drives.

GBICs connectors are available for:

- High speed serial data (HSSDC)
- Copper, 9-pin shielded “D” (DB9)
- Shortwave non-OFC
- Longwave laser

These GBICs comply with ANSI Fibre Channel physical layer requirements.

Considerations

Jitter is a consideration when selecting, installing, and configuring hubs within a Fibre Channel network. Jitter is the deviation of timing of an exchange.

The accumulation of jitter occurs and continues to grow within a chain of repeaters. As a signal is input to a repeater, jitter is not removed from the clock and is transferred to the data at the output. At some level within the network, jitter could exceed the allowable limit causing excessive errors. Assuring that there are NL_Ports within the loop to reclock the signal, jitter will be minimized.

Loop Port State Machines (LPSM) are required to control the operation of the loop and ensure Loop Initialization Protocol (LIP) is executed whenever a reset or power-on occurs.

Limitations

There is no limit to cascading the number of hubs within a network as long as the following guidelines are followed:

Note: Refer to the hub manufacturer's requirements for cascading, the following are just general guidelines.

- The length of the cable affects the number of allowable ports.
- The hub adds length to the cabling in the network.
- Use ports 1 and 4 to cascade to other hubs. This increases the potential of dual port devices and redundant paths.
- Do not exceed the maximum number of hubs per cascade link.
- The maximum number of hubs before retiming is six (6) with short cables, two (2) with maximum length cascade cables.
- Configure the loop so the devices are properly positioned in relation to the hub.

Figure 3 is an example of cascading hubs.

Figure 2. Loop Containing a Switch and a Hub

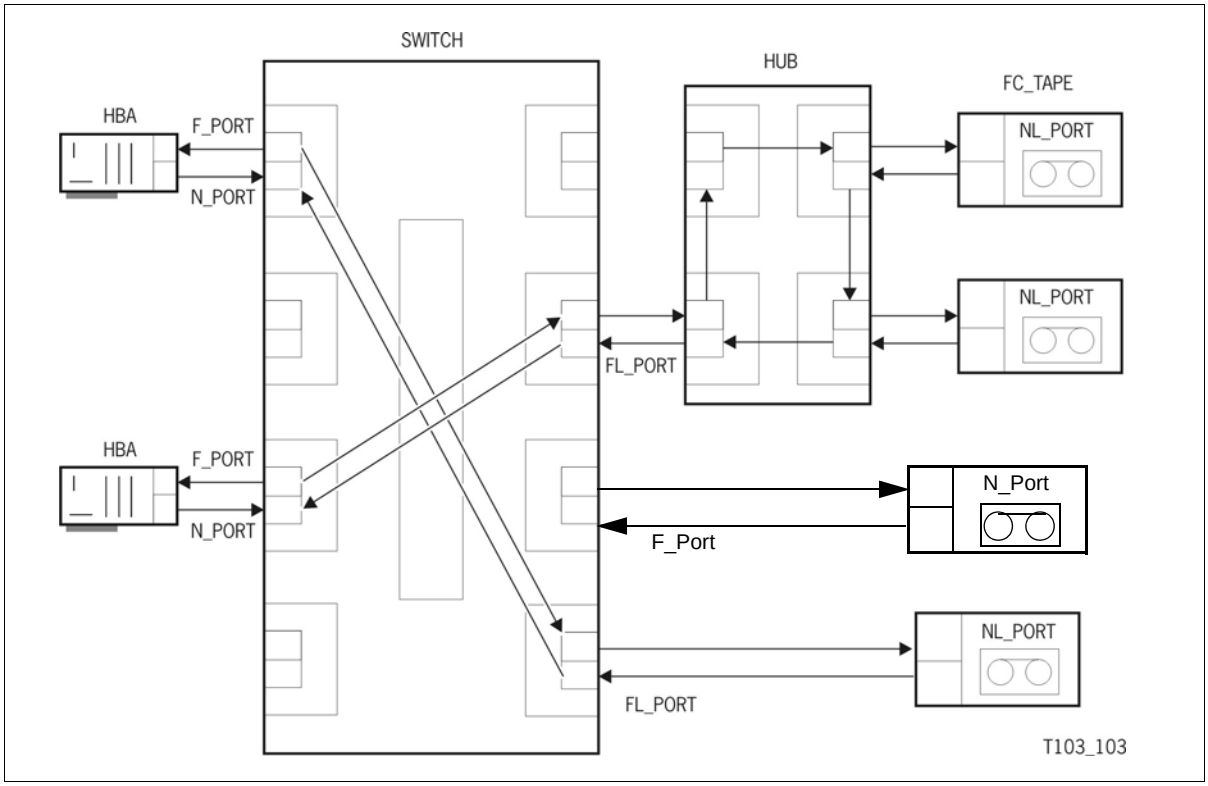
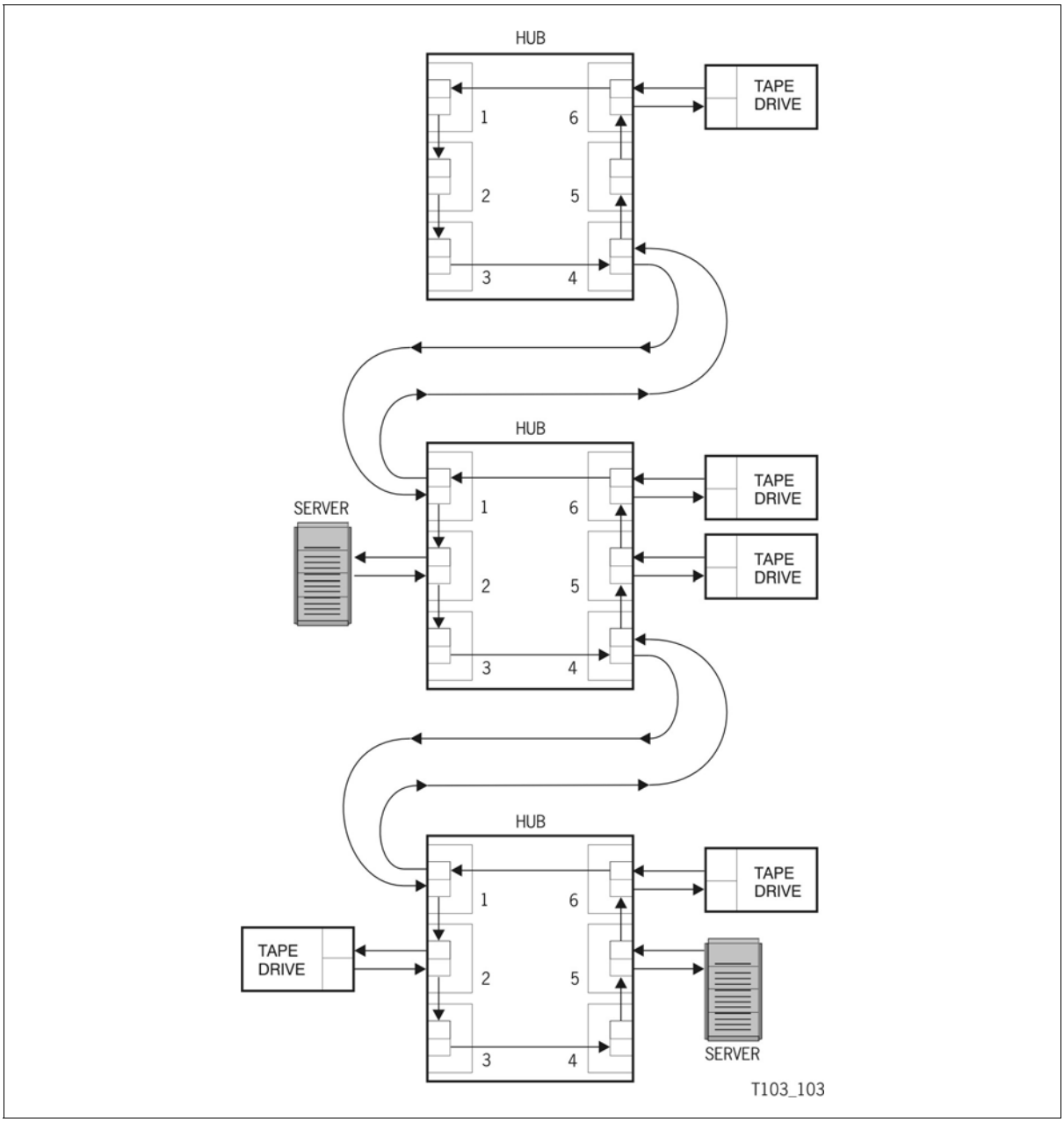


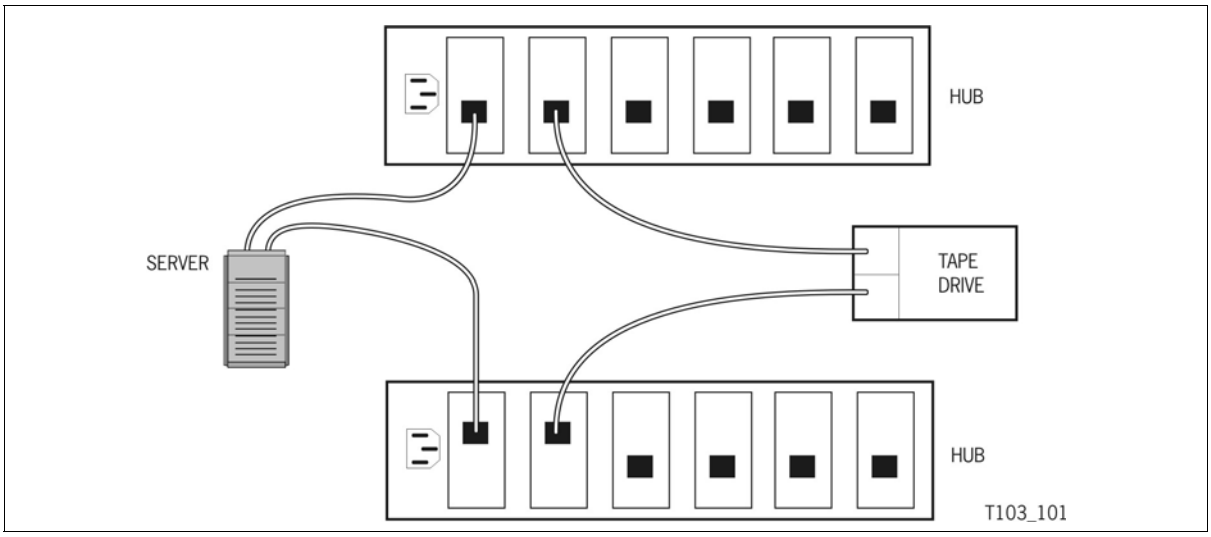
Figure 3. Cascading Hubs



Redundant Paths

The tape drive interface cards are dual port to support redundant paths. Figure 4 is an example of one server using hubs to provide redundant paths to the same device.

Figure 4. Redundant Paths



Cables and Connectors

Because the link to a port can be driven either optically or electrically, the term "fibre" in Fibre Channel refers to either a fiber optic or a copper cable.

- Optical transmission occurs over both single and multi–mode fibers using both laser and light emitting diodes (LEDs) for both short (770–850 nm) and long (1300–1360 nm) wavelengths.
- Electrical transmissions occur over video coax, miniature coax, twin coax (Twin Ax), or twisted pair.

Note: The two types of links, either fiber optic and/or copper, can be integrated into a single network, as long as there is a Fabric, hub, or other type of converter present.

Cable Guidelines

Guidelines for 1 Gb cable lengths and hubs per cascade include:

- Minimum cable length is 2 m (6.5 ft)
- Maximum cable length depends on the type of connection:
  - Copper = 13 m (42.6 ft) intra-cabinet
  - Copper = 33 m (108 ft) inter-cabinet
  - Short-wave fiber optics = 500 m (1,640 ft)
  - Long-wave fiber optics = 10 kilometers (6.2 miles)

Interface Ports

Tape drives can support either short or long wavelength interface ports.

The T9840D tape drive is designed to accept the small form-factor pluggable (SFP) transceivers in to the interface ports. It is acceptable to use one port as short wave and one port as long wave (mixed).

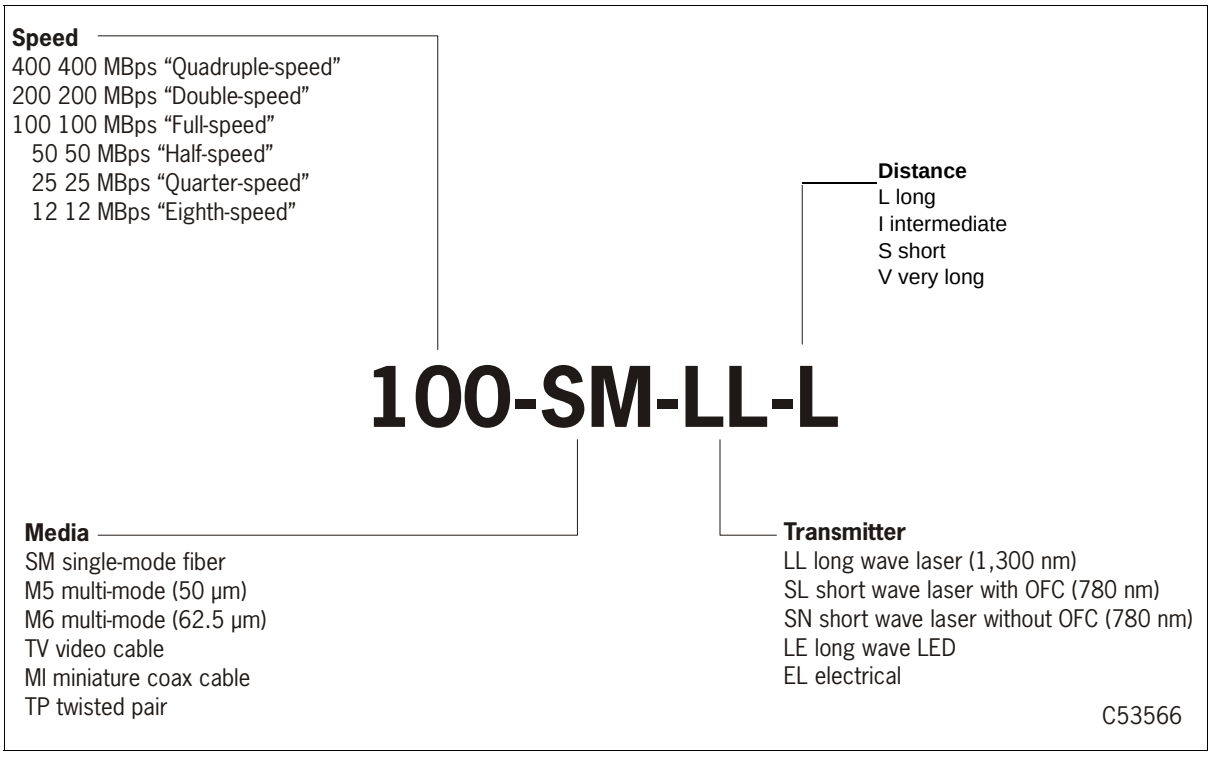
Table 5 and Figure 5 list the cable and connector specifications.

Table 5. Cable Specifications

Data Rate	Distance(maximum)		FC-0 Code	Cable	Type	Connector
	Meters	Feet				
1.062 Gb/s	500	1,640	100-M5-SN-I	Multimode	850 nm Short wave	Duplex LC
2.125 Gb/s	300	984	200-M5-SN-I	Multimode	850 nm Short wave	Duplex LC
4.250 Gb/s	150	492	400-M5-SN-I	Multimode	850 nm Short wave	Duplex LC
1.062 Gb/s	10,000	32,808	100-SM-LC-L	Single mode	1300 nm Long wave	Duplex LC
2.125 Gb/s	10,000	32,808	200-SM-LC-L	Single mode	1300 nm Long wave	Duplex LC
4.250 Gb/s	10,000	32,808	400-SM-LC-L	Single mode	1300 nm Long wave	Duplex LC

Figure 5 provides a description of the FC-0 codes.

Figure 5. Cable Marking Descriptions



Operations

3

This chapter describes how the Sun StorageTek™ T9x40 Series tape drives—including the T9840A, T9840B, T9840C, T9840D, plus the T9940A and T9940B—operate using a Fibre Channel (FC) interface.

Arbitrated Loop

The T9x40 tape drives can use an Arbitrated Loop as the connection to the Fibre Channel network. An arbitrated loop provides multiple connections for devices which share a single loop, but only provides point-to-point connections between an initiator and target during communications. Both public loop and private loop is supported.

Fabric F_Port Attachment

The T9840B, T9840C, T9840D, and T9940B tape drives support direct attachment to a Fabric (F_Port). The Fabric will receive frames from a source N_Port and route them to a destination N_Port whose address identifier is specified in the frame.

Addressing

Sun StorageTek tape drives use: Port name, Node name, and Port ID for login validation. All three identifiers must match or this indicates the configuration has changed and requires a Logout (LOGO).

Note: A LOGO terminates all open Exchanges between SCSI initiator and target.

The registration ID is 24 bits consisting of:

- 00 10 4F (hex)

Table 6 indicates the IEEE registered format for Name Address Authority (NAA), company ID, and vendor specific identifier for a total of 64 bits.

Table 6. Addressing Scheme

Most Significant Bit				**Least Significant Bit**
63	60	59	36	35 00
NAA		IEEE Company ID		Vendor Specific Identifier
"0101" b		**00 10 4F** (hex)		(to be assigned)

Terms and Definitions

Tables throughout this chapter use the following terms for compliance with ANSI's Fibre Channel Tape (FC–Tape) Technical Report and the StorageTek implementation.

FC–Tape Terms

Allowed (A): Can be used between an initiator and a target (tape drive). For tape drives, this is typically dependent on the particular feature or parameter and its applicability to the request from an initiator.

Invokable (I): Can be used between an initiator and a target. Such as: if a feature is invoked, the recipient must implement and respond to the feature or parameter.

Prohibited (P): Can not be used between an initiator and a target.

Required (R): Must be used between an initiator and a target. Both the initiator and target must implement the feature or parameter.

Dash (–): Indicates this parameter is not meaningful.

Blank ( ): A blank entry indicates that the feature is not part of the feature set.

Initiator: SCSI device that originates commands.

Target: SCSI device that receives commands.

StorageTek Terms

Yes (Y): StorageTek tape drives conform to that command, feature, or value.

No (N): StorageTek tape drives do not conform to that command, feature, or value.

Originate (Orig.): Originates the exchange or SCSI command from the tape drives.

Response (Resp.): Returns an acknowledgement (R_RDY and/or data) from the drives.

Transmission Word: A four byte character containing 32 bits of information. This is the smallest information unit transmitted on Fibre Channel.

Word	**Byte 0**	**Byte 1**	**Byte 2**	**Byte 3**
n	(MSB) **Bits** (LSB)			
	31 24	23 16	15 8	7 **0**

Loop Initialization Features

Arbitrated loop initialization protocol assigns up to a possible 126 addresses to different ports on the loop and builds a map of these addresses. The following pages describe some loop initialization features StorageTek tape drives perform.

Loop initialization must occur before operations on the loop can begin. The Loop Initialization Primitive (LIP) sequence is a series of initialization frames that establish NL_Ports on the loop.

Any NL_Port on the loop is capable of starting an initialization sequence by transmitting LIP. When the next NL_Port detects the LIP sequence, it retransmits it to the next NL_Port until the LIP sequence travels around the loop to the NL_Port initiating the sequence. During loop initialization, NL_Port addresses (AL_PA) are assigned (x'01' to x'EF').

NL_Port addresses (AL_PA) can be either hard (hardware assigned) or soft (system assigned) during loop initialization.

NL_Ports attempt to establish their previous acquired address before attempting to acquire another address when that NL_Port is powered-on or experiences a power-on reset, recognizes a LIP (AL_PD or AL_PS) for that port, or any other event that causes the NL_Port to lose communications.

Note: StorageTek tape drives may use a hard assigned address and attempt to regain that address during loop initialization. If unable to obtain that address, the tape drives accept soft addresses by the system.

Acquiring Addresses

When an NL_Port enters the loop (such as a power-on), it begins initialization to acquire an address and to notify other ports there is a change in configuration.

Note: If there is an exchange in process when a LIP begins, that exchange is disrupted and possible frame corruption could occur and result in a ULP timeout.

- If the NL_Port does not have a valid address, it begins the initialization sequence with LIP(F7,F7).
- If the NL_Port has a valid address, it begins initialization with LIP (F7,AL_PS).

Selective Reset

Selective resets perform a reset on the receiving port. These resets are helpful for error recovery or reconfiguration of the loop. Any NL_Port that uses a selective reset transmits a LIP(AL_PD,AL_PS). Refer to Table 31 on page 3-60 for clearing effects.

- AL_PD field contains the address of the port being reset
- AL_PS contains the address of the port issuing the reset

Loop Failures

A loop failure is any of the following:

- A loss of Signal
- A loss of Synchronization for longer than R_T_TOV

If a Loop Failure occurs, the L_Port which detects the failure issues a LIP(F8,AL_PS) if it has a valid AL_PA, or LIP(F8,F7) if it doesn't.

Open Initializing State

The open initializing (OPEN-INIT) state performs the process of loop initialization. When ports are in this state, initialization frames are transmitted and received to identify the temporary loop master and to assign AL_PA values. Entering this state assumes the loop is operational and sets the Available BB_Credit equal to zero (0).

Loop Initialization Select Master

StorageTek tape drives support the process of selecting a Loop Initialization Select Master (LISM) by using the device with the lowest PORT_NAME.

Note: If an FL_Port (fabric loop attachment) is present, it assumes the role of LISM.

Loop Initialization Fabric Assigned Address

StorageTek tape drives support the process of Loop Initialization Fabric Assigned (LIFA) addresses. This process is supported when the tape drive is operating in Public Loop mode.

Loop Initialization Previously Acquired

StorageTek tape drives support the process of Loop Initialization Previously Acquired (LIPA) addresses. This process is supported when the tape drive has previously acquired an address.

Loop Initialization Hard Assigned

StorageTek tape drives support the process of Loop Initialization Hard Assigned (LIHA) addresses. This process is supported when the tape drive is first powered on and a configuration parameter enables it.

Loop Initialization Soft Assigned

StorageTek tape drives support the process of Loop Initialization Soft Assigned (LISA) addresses. This process is supported when the hard assigned address has been used by a different device or hard assigned addressing is disabled.

Loop Initialization Report Position

StorageTek tape drives support the mapping process to build a map of the AL_PA values according to their position on the loop. The temporary loop master begins the procedure to create a Loop Initialization Report (LIRP).

This initialization report and map is done by using a word frame identifier with an offset value of one (1). As the frame is transmitted around the loop, the next NL_Port increments the offset by a value of one and stores the information in the AL_PA map.

Loop Initialization Loop Position

StorageTek tape drives support the process of Loop Initialization Loop Position (LILP) by retransmitting this sequence when required.

Failure to Obtain a Loop Address

If an NL_Port is unable to obtain an address (fabric assigned, previously assigned, hard assigned, or soft assigned) it goes into a non-participating mode and immediately implicitly logs out all logged in ports.

If an NL_Port experiences a power-on reset, or recognizes a LIP(AL_PD,AL_PS) it is not required to retain a previously acquired address to use during the next loop initialization.

Private Loop Initialization Completion

At this point in loop initialization a private loop tape device has completed initialization. It has acquired a private loop address of "00 00 xx." The xx is its assigned AL_PA.

The tape drive now waits for initiators, on this loop only, to complete a Port Login (PLOGI), a Process Login (PRLI), and then to start executing tape commands.

Public Loop Initialization Completion

The public loop tape device has now acquired a loop address of "00 00 xx" at this point in initialization, where xx is its assigned AL_PA.

Next the tape drive will attempt a Fabric Login (FLOGI) with the loop FL_Port. If the login is not successful, the tape drive will revert back to private loop operation, see the Private Loop Initialization Completion description.

With the successful completion of the FLOGI, the tape drive has now acquired its public loop address "DD AA xx." Where DD is the fabric domain, AA is the fabric area, and xx is the AL_PA.

The tape drive then attempts to Port Login (PLOGI) with the fabric directory server to register with an RFC-4 request with the name service.

The tape drive now waits for initiators, on either this loop or fabric attached, to complete a Port Login (PLOGI), a Process Login (PRLI), and then to start executing tape commands.

Fabric F_PORT Attachment Initialization

In the absence of a loop environment the StorageTek tape drives will attempt to initialize with a fabric. This is accomplished by doing a Fabric Login (FLOGI). The FLOGI process will be attempted in each class of service that the tape drive supports.

Once the FLOGI process is successful the tape drive will attempt to login (PLOGI) with the fabric attached name server, if it exists. This process allows the tape device to register its presence with the name server such that other initiators may query the name server to find target tape drives to use.

The tape drive now waits for initiators on the fabric to complete a Port Login (PLOGI), a Process Login (PRLI), and then to start executing tape commands.

Drive States

Power Up

When the drive completes the power-up process both of the FC ports will be enabled and will attempt to initialize on the attached FC topology.

When the drive completes the power-up process the LUN will be online and capable of tape operations.

Offline

When the LUN is set to offline from the drive's menu system, the state of the Fibre Channel ports are not affected.

Commands like Inquiry that do not require the LUN to be online will still execute normally.

For all other commands that require the LUN to be online, they will get a Check Condition status. The Sense Key will be 5. The ASC/ASCQ will be 0x2500.

Online

When the LUN is set to online from the drive's menu system, the state of the Fibre Channel ports are not affected.

All commands may now be executed with the LUN.

Port Disable

When a selected Fibre Channel port is set to disabled from the drive's menu system, the Online/Offline state of the LUN is not affected. The enable/disable state of the other Fibre Channel port is also not affected.

When the Fibre Channel port is disabled, an implicit LOGOUT is done to all logged in initiators. The Fibre Channel protocol chip is then held in a reset condition. This will cause the ports transmitter to be disabled and the hub will go into bypass mode.

CAUTION:
By disabling a port, operations on this port and/or other ports on the loop may be adversely affected.

Port Enable

When a selected Fibre Channel port is set to enabled from the drive's menu system, the Online/Offline state of the LUN is not affected. The Enable/Disable state of the other Fibre Channel port is also not affected.

When the Fibre Channel port is enabled, the protocol chip has its firmware reloaded and initialized. The port will attempt to do the required Fibre Channel topology initialization. For FC_AL operations, any previously acquired AL_PA will not be remembered. The port will follow loop initialization rules for acquiring its new address.

CAUTION:
By enabling a port, operations on other ports on the loop may be adversely affected by the hub coming out of bypass mode and the LIP process from our port.

Power Down

In the process of powering down the drive, the Fibre Channel Protocol chips will lose power. The hub port bypasses will be activated.

CAUTION:
By powering down a drive, operations on these ports and/or other ports on the loop may be adversely affected.

Arbitrated Loop Feature Set

StorageTek's tape drives implement the following Fibre Channel feature set:

Table 7. FC-AL Feature Set

Feature	FC-TAPE		StorageTek	Notes
	Initiator	Target		
Attempt to acquire Hard Address during LIHA sequence of loop initialization following loss of power, power-on reset, or recognition of LIP (AL_PD or AL_PS)	R	R	Y	4
LILP/LIRP:				
Loop Master can originate	R	R	Y	
Non-loop Master L_Ports accept	R	R	Y	
Login_BB_Credit:				
Advertise Login_BB_Credit = 0	A	A	Y	
Advertise Login_BB_Credit > 0	A	A	N	
Accept Login_BB_Credit = 0	R	R	Y	
Accept Login_BB_Credit > 0	R	R	Y	1
LPEyx/LPByx/LPEfx (origination)	A	P	N	2
MRKtx (origination)	P	P	N	3
Open Full Duplex - OPN(yx):				
Open Originator can send	I	I	N	
Open Recipient accepts	R	R	Y	5
Open Half Duplex - OPN(yy):				
Open Originator can send	I	I	Y	
Open Recipient accepts	R	R	Y	
Open Multicast/Selective Replicate OPN(yr), OPN(fr):				
Open Originator	P	P	N	

Notes:

1. The actual value is between 0 and the LOGIN_BB_Credit.
2. LPEfx is useful for resetting bypass circuits of NL_Ports which have lost their address.
3. Any NL_Port receiving an MRK attempts to forward it, StorageTek drives do not originate it.
4. This feature may be disabled by a configuration item change.
5. Our target will accept the Open Full Duplex but the FCP simplex protocol does not take advantage of the full duplex capabilities.

Login_BB_Credit Equals Zero

StorageTek tape drives advertise Login_BB_Credit =0. When Login_BB_Credit=0 at the other L_Port, the following rules apply:

- The OPN originator must receive R_RDYs (receiver readys) from the tape drive before transmitting a frame.
- The OPNed responder transmits R_RDYs for the number of buffers available to receive frames.

Notes:

1. The T9840A and T9940A tape drives respond with two (2) to four (4) R_RDYs on an OPN.
2. The T9840B, T9840C, T9840D, and T9940B tape drives respond with three (3) to five (5) R-RDYs on an OPN. This is controlled by a configuration item.
3. OPN Originators open as either *full* or *half* duplex regardless of the value of the Login_BB_Credit.

Open and Close Latencies

When Login_BB_Credit=0, a latency exists while waiting for the tape drives to respond with two (2) R_RDYs. This exists for every OPN before frame transmission can begin.

To improve the latencies 2-4 and 3-5, StorageTek tape drives immediately respond with at least 2 and as many as 5(depending on drive) R_RDYs on an OPN. This is controlled by a configuration item.

Some NL_Ports reduce CLS latency in another way:

To prevent buffer overruns, a CLS Recipient is only required to have maximum Login_BB_Credit, granted to any L_Port buffers, available before receiving the next OPN.

Common Service Parameters

Table 8 lists the Common Service Parameters the tape drives support for Port Login (PLOGI):

Table 8. NL_Port Common Service Parameters, Port Login

Parameter	Word	Bits	StorageTek Value	FC-Tape
FC-PH Version: Highest Version Lowest Version	 0 0	 31–24 23–16	 x ‘09’ x ‘09’	 x x ‘20’
Buffer-to-Buffer Credit (min.)	0	15–0	0	0
Common Features:	1	31–16		
Continuously Increasing Relative Offset	1	31	1	1
Random Relative Offset	1	30	0	0
Valid Vendor Version Level	1	29	0	0
N_Port/F_Port	1	28	0	0
Alternate BB_Credit Management	1	27	1	–
E_D_TOV Resolution	1	26	0	–
Reserved	1	25–23	0	–
Dedicated Simplex	1	22	0	–
Reserved	1	21–19	0	–
Dynamic Half Duplex – DHD	1	18	0	–
SEQ_CNT	1	17	0	x
Payload Length	1	16	0	–
Buffer-to-Buffer Receive Data Field Size (min.)	1	15–0	x’0800’	256
Total Concurrent Sequences (min.)	2	31–16	x’00FF’	1
Relative Offset by Information Category = (Information Category 1 and 5 only)	2	15–0	x‘0003	x‘0002
Error Detect Timeout (E_D_TOV) 2 seconds	3	31–0	x‘000007D0’	x‘000007D0’

Table 9 lists the Common Service Parameters the tape drives support for Fabric Login (FLOGI):

Table 9. NL_Port Common Service Parameters, Fabric Login

Parameter	Word	Bits	StorageTek Value	NL-Port Originator
FC-PH Version: Highest Version Lowest Version	 0 0	 31–24 23–16	 x ‘09’ x ‘09’	 x x ‘20’
Buffer-to-Buffer Credit (min.)	0	15–0	0	–
Common Features:				
Reserved	1	31–30	0	–
Valid Vendor Version Level	1	29	0	0
N_Port/F_Port	1	28	0	0
Alternate BB_Credit Management	1	27	1	1
Reserved	1	26–19	0	–
Dynamic Half Duplex	1	18	0	–
Reserved	1	17	0	–
Payload Length	1	16	0	–
Buffer-to-Buffer Receive Data Field Size (min., see note)	1	15–0	x‘0800’	256
Reserved	2	31–0	0	–
Reserved	3	31–0	0	–
Note: This is controlled by a configuration item.				

FC Class 3

Fibre Channel provides several different strategies to ensure reliable communications between devices. These strategies are called Classes of Service. The tape drives support the Class 3 level of service which provides no notification of frame delivery or non-delivery. This class of service reduces the number of frames (traffic) on the loop.

The start-of-frame (SOF) delimiter specifies the type of service used for each frame during communications.

Table 10 indicates the two types of delimiters for Class 3 operations:

Table 10. Start of Frame Delimiters, Class 3

Delimiter	Abbreviation	Transmission Word Characters			
SOF Initiate Class 3	SOFi3	K28.5	D21.5	D22.2	D22.2
SOF Normal Class 3	SOFn3	K28.5	D21.5	D22.1	D22.1

Note: Intermixing different classes of service is not supported.

The tape drives adhere to a set of operating characteristics that insure inter-operability and reliability within a Class 3 loop environment is maintained. Table 11 and Table 12 on page 3-30 list Class 3 Service Parameters supported.

Class 3 Service Parameters, Port Login

Table 11 lists Class 3 Service Parameters the tape drives support for Port Login (PLOGI):

Table 11. Class 3 Service Parameters, Port Login

Parameters	Word	Bits	Value	FC-Tape
Class validity	0	31	1	1
Service Options:	0	30–16		
Intermix Mode	0	30	0	–
Stacked Connect Requests	0	29–28	00	–
Sequential Delivery	0	27	0	–
Dedicated Simplex	0	26	0	–
Camp-On	0	25	0	–
Buffered Class 1	0	24	0	–
Priority	0	23	0	–
Initiator Control:	0	15–0		
Sequence Initiator X_ID reassignment	0	15–14	00	–
Initial Responder Process_Associator	0	13–12	00	00
Sequence Initiator ACK_0 capable	0	11	0	–

Table 11. Class 3 Service Parameters, Port Login (Continued)

Parameters	Word	Bits	Value	FC-Tape
Sequence Initiator ACK_N Capable	0	10	0	–
ACK generation assistance	0	9	0	–
Initiator Data compression capable	0	8	0	0
Initiator Data compression history buffer size = '00'b	0	7–6	00	–
Data Encryption Capable	0	5	0	0
Clock Synchronization Capable	0	4	0	P
Recipient Control:	1	31–16		
ACK_0 Capable	1	31	0	–
ACK_N Capable	1	30	0	–
X_ID Interlock	1	29	0	–
Error Policy Supported	1	28–27	00	TBD
Categories per Sequence	1	25–24	00	00
Data compression capable	1	23	0	0
Data compression history buffer size	1	22–21	00	–
Data decryption capable	1	20	0	0
Clock synchronization capable	1	19	0	A
Reserved – fabric specific	1	18–16	0	0
Receive data field size (min, see note)	1	15–0	x'0800'	256
Concurrent Sequences > 0	2	31–16	x'00FF'	1
N_Port End-to-end Credit	2	14–0	0	–
Open Sequences per Exchange > 0	3	31–16	x'0001'	1
Class 6 Multicast RX_ID	3	15–0	0	–
Note: This is controlled by a configuration item.				

Class 3 Service Parameters, Fabric Login

Table 12 lists Class 3 Service Parameters the tape drives support for Fabric Login (FLOGI):

Table 12. Class 3 Service Parameters, Fabric Login

Parameters	Word	Bits	Value	FC-Tape
Class validity	0	31	1	1
Service Options:				
Intermix Mode	0	30	0	–
Stacked Connect Requests	0	29–28	0	–
Sequential Delivery	0	27	1	1
Dedicated Simplex	0	26	0	–
Camp-On	0	25	0	–
Buffered Class 1	0	24	0	–
Reserved	0	23	0	–
Initiator Control:				
Reserved	0	15–0	00	–
Recipient Control:				
Reserved	1	31–16	0	–
Receive data field size (min, see note)	1	15–0	x‘0800’	256
Concurrent Sequences (min)	2	31–16	x‘00FF’	–
N_Port End-to-end Credit	2	14–0	0	–
Open Sequences per Exchange (min)	3	31–16	01	–
Reserved	3	15-0	0	–
Note: This is controlled by a configuration item.				

FC Class 2

Fibre Channel provides several different strategies to ensure reliable communications between devices. These strategies are called Classes of Service. The tape drives support the Class 2 level of service which provides notification of frame delivery.

The start-of-frame (SOF) delimiter specifies the type of service used for each frame during communications.

Table 13 indicates the two types of delimiters for Class 2 operations:

Table 13. Start of Frame Delimiters, Class 2

Delimiter	Abbreviation	Transmission Word Characters			
SOF Initiate Class 2	SOFi2	K28.5	D21.5	D21.2	D21.2
SOF Normal Class 2	SOFn2	K28.5	D21.5	D21.1	D21.1

Note: Intermixing different classes of service is not supported within the same exchange.

The tape drives adhere to a set of operating characteristics that insure inter-operability and reliability within a Class 2 loop environment is maintained. Table 14 and Table 15 on page 3-33 list Class 2 Service Parameters supported.

Class 2 Service Parameters, Port Login

Table 14 lists Class 2 Service Parameters the tape drives support for Port Login (PLOGI). All "value" entries are TBD at this time.

Table 14. Class 2 Service Parameters, Port Login

Parameters	Word	Bits	Value	FC-Tape
Class validity	0	31	1	1
Service Options:				
Intermix Mode	0	30	0	–
Stacked Connect Requests	0	29–28	00	–
Sequential Delivery	0	27	0	–
Dedicated Simplex	0	26	0	–
Camp-On	0	25	0	–
Buffered Class 1	0	24	0	–
Priority	0	23	0	0
Initiator Control:				
X_ID reassignment	0	15–14	00	'00'b
Initial Responder Process_Associator	0	13–12	00	'00'b

Table 14. Class 2 Service Parameters, Port Login (Continued)

Parameters	Word	Bits	Value	FC-Tape
ACK_0 capable	0	11	0	A
ACK_N Capable	0	10	0	0
ACK generation assistance	0	9	TBD	A
Data compression capable	0	8	0	0
Data compression History buffer size	0	7–6	00	-
Data Encryption Capable	0	5	0	0
Clock Synchronization Capable	0	4	0	P
Recipient Control:				
ACK_0 Capable	1	31	0	A
ACK_N Capable	1	30	0	0
X_ID Interlock	1	29	0	A
Error Policy Supported	1	28–27	01	
Abort, discard multiple Sequences ('00'b)				A
Abort, discard a single Sequences ('01'b)				R
Process policy with infinite buffers ('10'b)				P
Discard multiple sequences w/immediate retrans ('11'b)				P
Categories per Sequence	1	25–24	00	'00'b
Data compression capable	1	23	0	0
Data compression History buffer size	1	22–21	00	–
Data decryption capable	1	20	0	0
Clock synchronization capable	1	19	0	A
Reserved	1	18–16	0	0
Receive data field size (min, *see note*)	1	15–0	2112	256
Concurrent Sequences (min)	2	31–16	01	1
N_Port End-to-end Credit (min)	2	14–0	TBD	1
Open Sequences per Exchange (min)	3	31–16	01	1
Class 6 Multicast RX_ID	3	15–0	0	–
Note: This is controlled by a configuration item.				

Class 2 Service Parameters, Fabric Login

Table 15 lists Class 2 Service Parameters the tape drives support for Fabric Logins (FLOGI). All "value" entries are TBD at this time.

Table 15. Class 2 Service Parameters, Fabric Login

Parameters	Word	Bits	Value	FC-Tape
Class validity	0	31	1	1
Service Options:				
Intermix Mode	0	30	0	–
Stacked Connect Requests	0	29–28	00	–
Sequential Delivery	0	27	1	1
Dedicated Simplex	0	26	0	–
Camp-On	0	25	0	–
Buffered Class 1	0	24	0	–
Priority	0	23	0	0
Reserved	0	22–16	0	–
Initiator Control:				
Reserved	0	15–0	00	–
Recipient Control:				
Reserved	1	31–16	0	–
Receive data field size (min, see note)	1	15–0	2112	256
Concurrent Sequences (min)	2	31–16	01	–
N_Port End-to-end Credit (min)	2	14–0	TBD	–
Open Sequences per Exchange (min)	3	31–16	01	–
Reserved	3	15–0	0	–
Note: This is controlled by a configuration item.				

FC-2 Features

The FC-2 level provides the signaling protocol and specifies the rules and requirements to transfer blocks of data.

The FC-2 level is the most complex level in Fibre Channel protocols and provides the different classes of service, packetizing, sequencing, error detection, and reassembling the transmitted data.

Table 16 lists other FC-2 features supported by the tape drives:

Table 16. Other FC-2 Features

Feature	FC-Tape		StorageTek
	Initiator	Target	
Addressing Scheme: (see note)			
Node Name Format (registered format)	R	R	Y
Port Name Format (registered format)	R	R	Y
Frame Control (F_CTL):			
Continue Sequence Condition	R	R	Y
Continuously increasing sequence count during consecutive sequences within an Exchange	R	R	Y
Ignore nonzero Continue Sequence values	A	A	Y
Sequence Chaining (C_S bit in F_CTL = 0)	R	R	Y
Optional Headers (all)	P	P	N
Routing Control (R_CTL):			
FC-4 Device_Data frame	R	R	Y
Extended Link_Data frame	R	R	Y
FC-4 Link_Data Frame	R	R	Y
Video_Data Frame	P	P	N
Basic Link_Data frame	R	R	Y
Link_Control Frame			
Class 2	R	R	Y
Class 3	P	P	N
X_ID Interlock	–	–	N
Note: Node name and Port name are not identical.			

Link Service Commands

Fibre Channel uses link service commands to manage functions such as port management, Login, Logout, and abort operations. The tape drives support both basic and extended link service commands to perform these operations.

Basic Commands

Table 17 lists the Basic Link Service commands:

Table 17. Basic Link Services

Command	FC-TAPE			StorageTek	
	From Initiator	Target Response	From Target	Drv Orig.	Drv Resp.
No Operation (NOP)	P	–	P	–	N
Abort Sequence (ABTS)	I	R	A	Y	Y
Basic Accept (BA_ACC)	A		R	–	Y
Basic Reject (BA_RJT)	A		R	–	Y
Dedicated Connection Preempted (PRMT)	P	–	P	–	N
Remove Connection (RMC) Class 1	P	–	P	–	N

Extended Commands

Table 18 lists the Extended Link Service commands:

Note: If the tape drive receives a request for Extended Link Services which are not supported, the tape drive returns a Link Services Command Reject (LS_RJT) with a reason code of "Command Not Supported".

Table 18. Extended Link Services

Command	FC-TAPE				StorageTek	
	From Initiator	Target Response	From Target	Initiator Response	Drv Orig.	Drv Resp.
Abort Exchange (ABTX)	P		P		N	–
Accept (ACC)	A		R		Y	Y
Advise Credit (ADVC)	P		P		N	–
Discover Address (ADISC)	I	R	P		N	Y
Discover F_Port Parameters (FDISC)	I		I		N	–
Discover N_Port Parameters (PDISC)	I	R	P		–	Y
Echo	P		P		N	–

Table 18. Extended Link Services (Continued)

Command	FC-TAPE				StorageTek	
	From Initiator	Target Response	From Target	Initiator Response	Drv Orig.	Drv Resp.
Establish Streaming (ESTS)	P		P		N	–
Estimate Credit (ESTC)	P		P		N	–
Fabric Activate Alias_ID (FACT)	P		P		N	–
Fabric Address Notification (FAN)	P	P	P	P	N	–
Fabric Deactivate Alias_ID (FDACT)	P		P		N	–
Fabric Login (FLOGI)	R	P	R	P	Y	–
Get Alias_ID (GAID)	P		P		N	–
Link Service Reject (LS__RJT)	A		R		Y	Y
Logout (LOGO)	R	R	R	R	Y	Y
Loop Initialize (LINIT)	I		P		N	Y
Loop Port Control (LPC)	I		P		N	N
Loop Status (LSTS)	I		P		N	N
N_Port Activate Alias_ID (NACT)	P		P		N	–
N_Port Deactivate Alias_ID (NDACT)	P		P		N	–
N_Port Login (PLOGI)	R	R	P		N	Y
Process Login: (PRLI)	R	R	P		N	Y
PRLI Common Service Parameters	P	–	P		N	N
Single Service Parameter page per request	R	R	P		N	Y
Multiple Service Parameter pages per request	P	–	P		N	N
ACC contains only those pages specified	–	R	P		N	Y
Accept Response code of Command executed	–	R	P		N	Y
Process Logout (PRLO)	I	R	I	R	Y	Y
Quality of Service Request (QoSR)	P		P		N	–

Table 18. Extended Link Services (Continued)

Command	FC-TAPE				StorageTek	
	From Initiator	Target Response	From Target	Initiator Response	Drv Orig.	Drv Resp.
Read Connection Status Block (RCS)	P		P		N	–
Read Exchange Concise (REC)	R	R	A	A	Y	Y
Read Exchange Status Block (RES)	P		P		N	–
Read Link Error Status Block (RLS)	I	R	P		N	Y
Request Sequence Initiative (RSI)	A	A	A	A	TBD	TBD
Read Sequence Status Block (RSS)	A	A	A	A	TBD	TBD
Read Timeout Value (RTV)	P		P		N	–
Read VC Status (RVCS)	P		P		N	–
Reinstate Recovery Qualifier (RRQ)	I	R	I	R	Y	Y
Registered State Change Notification (RSCN)	I	R	I	R	N	Y
Report Node Capabilities (RNC)	I	R	P		N	Y
State Change Notification (SCN)	P		P		N	–
State Change Registration (SCR)	I	P	I	P	N	N
Test	P		P		N	–
Test Process Login State	P		P		N	–
Third Party Process Logout (TPRLO)	I	R	P		N	Y

Table 19. FC-4 Link Services

Command	FC-TAPE				StorageTek	
	From Initiator	Target Response	From Target	Initiator Response	Drv Orig.	Drv Resp.
Sequence Retransmission Request (SRR)	I	R	P		N	Y

Responses to Link Services

Table 20 summarizes the response the tape drives generate when receiving different Link Service requests when the drive NL_Port is not currently logged in with the sending Port.

Table 20. Response to Link Services from Ports Not Logged-In

Frame Received	Port Not Logged In	Port Logged In	Notes
ABTS	Discard and send LOGO	BA_ACC, BA_RJT	2
ADISC	Discard and send LOGO	ACC and LS_RJT	1
FAN	Process the ELS request, no response required	Process the ELS request, no response required.	
LOGO	ACC	ACC	
PDISC	Discard and send LOGO	ACC and LS_RJT	1
PLOGI	ACC, LS_RJT	ACC	
PRLI	Discard and send LOGO	ACC	
PRLO	Discard and send LOGO	ACC and LS_RJT	3
RSCN	Process the ELS request, no response required.	Process the ELS request, no response required.	
Other Link Services	Discard and send LOGO	ACC and LS_RJT	

Notes:

1. All three identifiers must match at login for Accepts (ACC) to be returned:

   - Port ID,
   - Port Name, and
   - Node Name

   If all three identifiers do not match a logout (LOGO) is returned.

   If other conditions prevent execution of the ADISC or PDICS ELS, return a reject (LS_RJT) with the appropriate reason code.

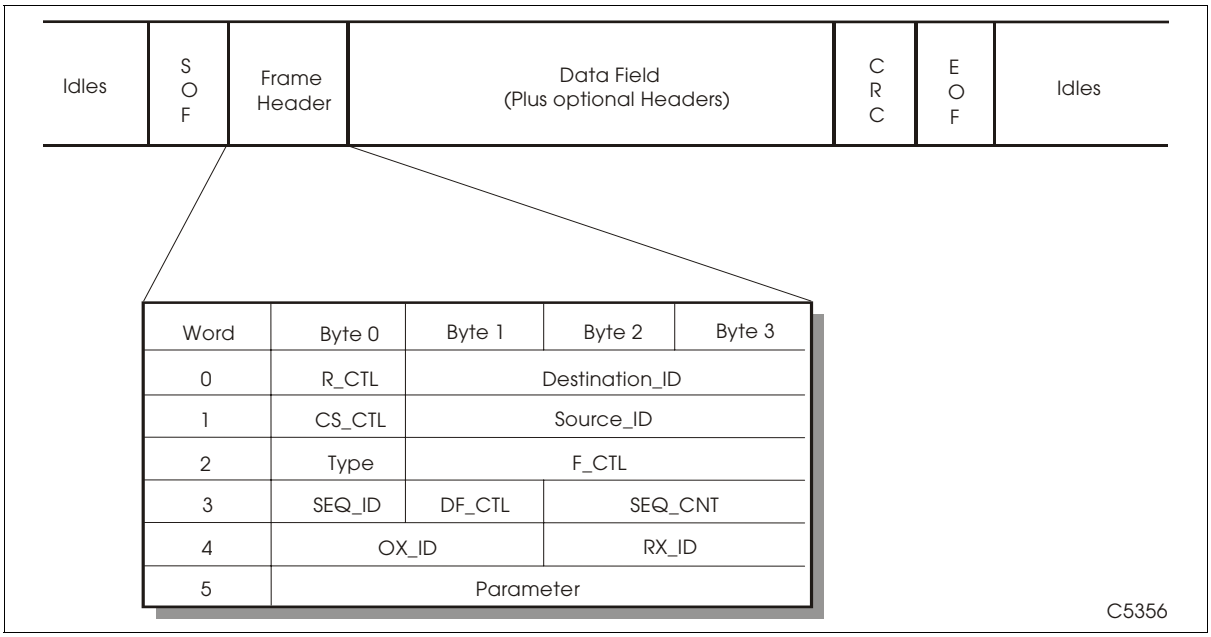
2. BA_ACC if valid RX_ID else BA_RJT

3. If PRLI has not been successfully completed, set the reason code to "Image Pair Does Not Exist."

Frame Transmission

Figure 6 shows the frame format for transmission of data and commands over Fibre Channel.

Figure 6. Frame and Frame Header Format



R_CTL Routing Control: Indicates the type of frame functions

Destination ID Identifies the port destination

CS_CTL Class specific control field

Source ID Identifies the source

Type Indicates the data structure

F_CTL Frame Control: Controls information within the frame

SEQ_ID Sequence Identifier: Identifies sequences within an exchange

DF_CTL Data Field Control: Indicates optional headers

SEQ_CNT Sequence Count: Contains frame number within exchange

OX_ID Originator Exchange ID: Identifies originator of exchange

RX_ID Responder Exchange ID: Identifies responder of exchange

Parameter Contains unique parameters for exchange

Exchange Management

Exchange (X) management is the overall control of operations over the Fibre Channel interface between the originator and responder.

Refer to the FC–PH documents for rules and guidelines pertaining to Class 2 operation.

Note: For FCP, an exchange is a *single* SCSI command.

There are two fields in the frame header dealing with exchanges:

- OX_ID = Exchange originator
- RX_ID = Exchange responder

Table 21. Exchange Content Header

Word	Byte 0	Byte 1	Byte 2	Byte 3
0	R_CTL	Destination_ID		
1	CS_CTL	Source_ID		
2	Type	F_CTL		
3	SEQ_ID	DF_CTL	SEQ_CNT	
4	**OX_ID**		**RX_ID**	
5	Parameter			

Exchange Originator

The exchange originator assigns a unique OX_ID to the exchange for the transmission of in-order delivery of frames and assumes the frames are processed in the order received. The exchange is open from the time the first frame is sent until one of the following occurs:

- Timeout
- The exchange is aborted (ABTS or ABTX)
- An end-of-frame (EOF) delimiter is sent with the last sequence bit set
- A Logout (LOGO) is sent to or received from the Exchange responder
- A Link Service Command Reject (LS_RJT) is sent in response to an ADISC or PDISC during target discovery
- A PLOGI is sent to the Exchange responder

Exchange Responder

The exchange responders assign unique RX_ID values or use the value of "FFFF." The exchange responder considers an exchange open from the time it receives the first frame of the first information unit until one of the following occurs:

- The last frame of the last information unit is sent with the last sequence bit set
- The exchange is aborted (ABTS)
- A Logout (LOGO) is sent to, or received from, the Exchange originator
- An LS_RJT is sent in response to an ADISC or PDISC during target discovery
- A PLOGI is received

Sequence Management

Sequence management deals with the actual order and transfer of frames across Fibre Channel. The SEQ_ID and SEQ_CNT identify the order of frames for reassembly at the responder.

Refer to the FC–PH documents for rules and guidelines pertaining to Class 2 operation.

Table 22. Sequence Content Header

Word	Byte 0	Byte 1	Byte 2	Byte 3
0	R_CTL	Destination_ID		
1	CS_CTL	Source_ID		
2	Type	F_CTL		
3	**SEQ_ID**	DF_CTL	**SEQ_CNT**	
4	OX_ID		RX_ID	
5	Parameter			

Sequence Open

The tape drive considers a Sequence open from the time that the first frame of the Sequence (the frame with the SOFi3 delimiter) is sent until one of the following occurs:

- An end-of-frame (EOF) delimiter is sent with the last sequence bit set
- A LOGO is sent to, or received from, the Sequence responder
- The sequence is aborted with ABTS

The tape drive as a Sequence responder considers a Sequence open from the time that the first frame of the Sequence (the frame with the SOFi3 delimiter) is received until one of the following occurs:

- An end-of-frame (EOF) delimiter is sent with the last sequence bit set
- The Sequence is aborted using ABTS
- A LOGO is sent to, or received from, the Sequence originator

Sequence Identifier Usage

The sequence identifier (SEQ_ID) is a field in the frame header that sets one frame apart from another indicating the order in which they occur. The following paragraphs summarize the rules governing the reuse of SEQ_IDs.

For sequences which transfer Sequence Initiative:

- A Port can reuse a SEQ_ID for the same Exchange following the confirmation of Sequence delivery.
- A Port can reuse the SEQ_ID with a different Exchange (to the same, or a different destination Port) immediately following transmission of the last frame of the Sequence without waiting for confirmation of Sequence delivery.

For sequences which do not transfer Sequence Initiative:

- Consecutive FCP_DATA Sequences for the same exchange follow the FC-PH rules for streamed Sequences which include:

    1) The first FCP_DATA Sequence after transfer of Sequence Initiative is not a streamed Sequence. It can use any eligible SEQ_ID and the SEQ_CNT can be either zero or a continuously increasing number.

    2) The second and subsequent Sequences within the same exchange are treated as streamed.

- Because frame delivery is not confirmed, the Sequence Initiator cannot reuse a SEQ_CNT within a given Sequence.

  For sequences beginning with a SEQ_CNT of zero, the SEQ_CNT cannot wrap when reaching a hexadecimal count of "FFFF".

  For sequences beginning with a SEQ_CNT of '*n*' (where *n* is not zero) the SEQ_CNT can wrap when reaching a hexadecimal count of "FFFF" and continue from zero up to a value of *n*-1.

Sequence Errors

Sequence errors are managed as defined in FC–Tape with the following additions:

1. If a frame with an SOFi3 delimiter is received and the SEQ_CNT is not equal to zero or +1 from the SEQ_CNT of the last frame of the previous Sequence of that Exchange.
2. If the SEQ_CNT of a received frame with an SOFn3 delimiter is not +1 greater than the previous frame received for that Sequence (such as a frame was lost).

   This also detects the case where a frame with an SOFn3 delimiter is received for a SEQ_ID that is not currently open since the SEQ_CNT of the previous frame for that Sequence is undefined.
3. If a frame with an SOFi3 delimiter is received and the previous Sequence of that Exchange is still open.
4. If the relative offset in the parameter field of a received frame with an SOFn3 delimiter is not equal to the (relative offset + the payload size) of the previous frame received for that Sequence.
5. If the next frame of a Sequence is not received within E_D_TOV.
6. If, during the same Sequence Initiative, a Sequence is received which has the same SEQ_ID as the previous Sequence of that Exchange.

When a Sequence error is detected by the tape drive, it discards that Sequence, and all remaining Sequences for the Exchange containing the Sequence in error. The tape drive attempts to take the appropriate action as defined in FCP–2.

Error Detection and Management

Error detection falls under two categories: Frame errors and link-level errors.

- Frame errors result in missing or corrupted frames which may ultimately involve Upper Level Protocols to resolve.
- Link-level errors include errors such as loss of signal, loss of synchronization, and timeouts.

Upper Level Protocols (ULP) provide for error detection and management by using timeouts which is an inefficient mechanism to detect and recover from frame transmission errors.

FC-2 layer protocols attempt to recover from errors through transmitting frames, Extended Link Services commands, and Primitive Sequence protocols.

A problem with Class 3 operation is that there is no confirmation of frame delivery. Although, the originator can deduce some delivery of frames from:

- Successfully receiving a command by:
  - FCP Transfer ready was sent by the command recipient
  - FCP read data was received
  - A response was received
- Successfully receiving write data by:
  - FCP Transfer Ready was received
  - A response was received

However, FCP data and FCP responses cannot always be detected. Currently, the FCP-2 defines detection of these missing frames by using time-outs. For FCP responses, the target may request the initiator to send an FCP confirmation to confirm receipt of the response. Refer to FCP-2 for a more detailed description.

CAUTION:
From a tape drive standpoint, it is very important that error detection and recovery ensure both the initiator and target are in sync with block position on tape.

Therefore; if the initiator suspects that the result of an error leaves the drive out of sync with the initiator, the initiator should issue a Read Position command to determine the location and to invoke the Upper Level Protocol (FC-4) to reposition the tape if necessary.

Fibre Channel provides no error correction on data during transfers but it does provide excellent error detection schemes, including:

- 8B/10B encoding and decoding
- Disparity
- Cyclic redundancy checks
- Sequence errors and out-of-order delivery

8B/10B Encoding and Decoding

Fibre Channel uses a special process called encoding and decoding that is designed to reduce distortion during transmission and aid in the detection of errors at the receiving port. This process makes it highly likely that single and multiple bit errors are detected.

Besides providing error detection, this process also balances the turning on and off of the light for the loading of the optical fiber transmitters.

The process of encoding uses an algorithm that takes the original 8 bits in each byte and transforms them into 10 bits for transmission. The result is an 8B/10B encoding of a byte and is called a transmission character.

Disparity

Fibre Channel uses a scheme along with the 8B/10B encoding to protect transmission characters and aid in error detection called running disparity. Running disparity adds a second dimension to the transmission of characters. This dimension provides a balance of ones and zeros which helps protect transmission characters and controls the heat output of the transmitter.

A negative running disparity is maintained following the transmission of the end-of-frame (EOF) delimiter and remains negative until the transmission of the next start-of-frame delimiter.

Because the running disparity within a frame is variable, two different EOF delimiters are used depending on the content of the frame following the transmission of the CRC.

Table 23. End of Frame Delimiters

Delimiter	Abbreviation	RD	Transmission Word Characters			
EOF Normal	EOFn	Neg.	K28.5	D21.4	D21.6	D21.6
		Pos.	K28.5	D21.5	D21.6	D21.6
EOF Terminate	EOFt	Neg.	K28.5	D21.4	D21.3	D12.3
		Pos.	K28.5	D21.5	D21.3	D21.3
EOF Abort	EOFa	Neg.	K28.5	D21.4	D21.7	D21.7
		Pos.	K28.5	D21.5	D21.7	D21.7
EOF Normal Invalid	EOFni	Neg.	K28.5	D10.4	D21.6	D21.6
		Pos.	K28.5	D10.5	D21.6	D21.6

CRC

Fibre Channel adds a third level of protection over the content of each frame called a cyclic redundancy check (CRC). Each frame is protected by a 4-byte CRC which provides a separate and independent error detection mechanism.

Fibre Channel Timers

StorageTek T9x40 tape drives use the timer values in Table 24.

Table 24. Timer Summary

Timer	Value	Implemented By		
		Initiator	Target	StorageTek
AL_TIME	15 ms	R	R	Y
R_T_TOV	100 ms	R	R	Y
E_D_TOV	Private = 2 sec Public = supplied + 2 sec	R R	A (note 2) R	Y Y
R_A_TOV $_{SEQ\_QUAL}$	Private = 0 sec Public = 10 sec (See note 1)	R	A (note 2)	Y
$R\_A\_TOV_{ELS}$	Private = 2 sec Public = 10 sec	R	R	Y
RR_TOV	300 sec		R	Y
REC_TOV	> = E_D_TOV + 1 sec minimum	R	R	Y
ULP_TOV	>= Operation specific timer + 4 x REC_TOV	R		N

Notes:

1. The division of R_A_TOV usage differs from the FC-PH because of the unique characteristics of an Arbitrated Loop environment.
2. SCSI target devices that support Class 2 are required to implement this timer.

Arbitrated Loop Timeout

The Arbitrated Loop timeout value (AL_TIME) is two times the worst case round-trip latency of a very large loop.

Receiver_Transmitter Timeout

The Receiver_Transmitter timeout value (R_T_TOV) is used by the receiver logic to detect a loop failure.

Error_Detect Timeout

The Error Detect Timeout value (E_D_TOV) is the maximum time permitted for a Sequence Initiator between the transmission of consecutive data frames within a single sequence. This is also the minimum time that a Sequence Recipient waits for the reception of the next frame within a single sequence before recognizing a Sequence timeout.

E_D_TOV includes the time required to gain access to the loop in addition to the actual frame transmission time.

Resource Allocation Timeouts

The Resource Allocation Timeout (R_A_TOV) has two components:

- Sequence Qualifiers (SEQ_QUAL) defines the minimum time that an initiator waits before reusing the sequence qualifiers (SEQ_ID and SEQ_CNT).
- Extended Link Services (ELS) determines the minimum time the Originator of an extended link service request waits for the response to a request as a target.

Resource Recovery Timeout

The Resource Recovery Timeout (RR_TOV) is the minimum time the target waits for an initiator to perform an exchange authentication following the completion of the loop initialization.

REC Timeout

The Read Exchange Concise Timeout value (REC_TOV) is used to time reply sequences and a polling interval for REC error detection. Refer to FCP-2 for a detailed description.

Upper Level Protocol Timeout

The Upper Level Protocol Timeout (ULP_TOV) is used by the initiator to time the completion of exchanges associated with the ULP operations. The timeout values vary depending on the operations being timed.

FCP Feature Set

Fibre Channel Protocol (FCP) provides functions such as login and logout parameters and the transfer of commands and data through the use of Information Units. The FCP command set for the tape drives is SCSI-3.

Note: Refer to Chapter 4, "SCSI Commands," for more information about the implementation of the SCSI-3 command set.

Process Login Parameters

Table 25 lists Process Login parameters supported:

Table 25. PRLI Parameters

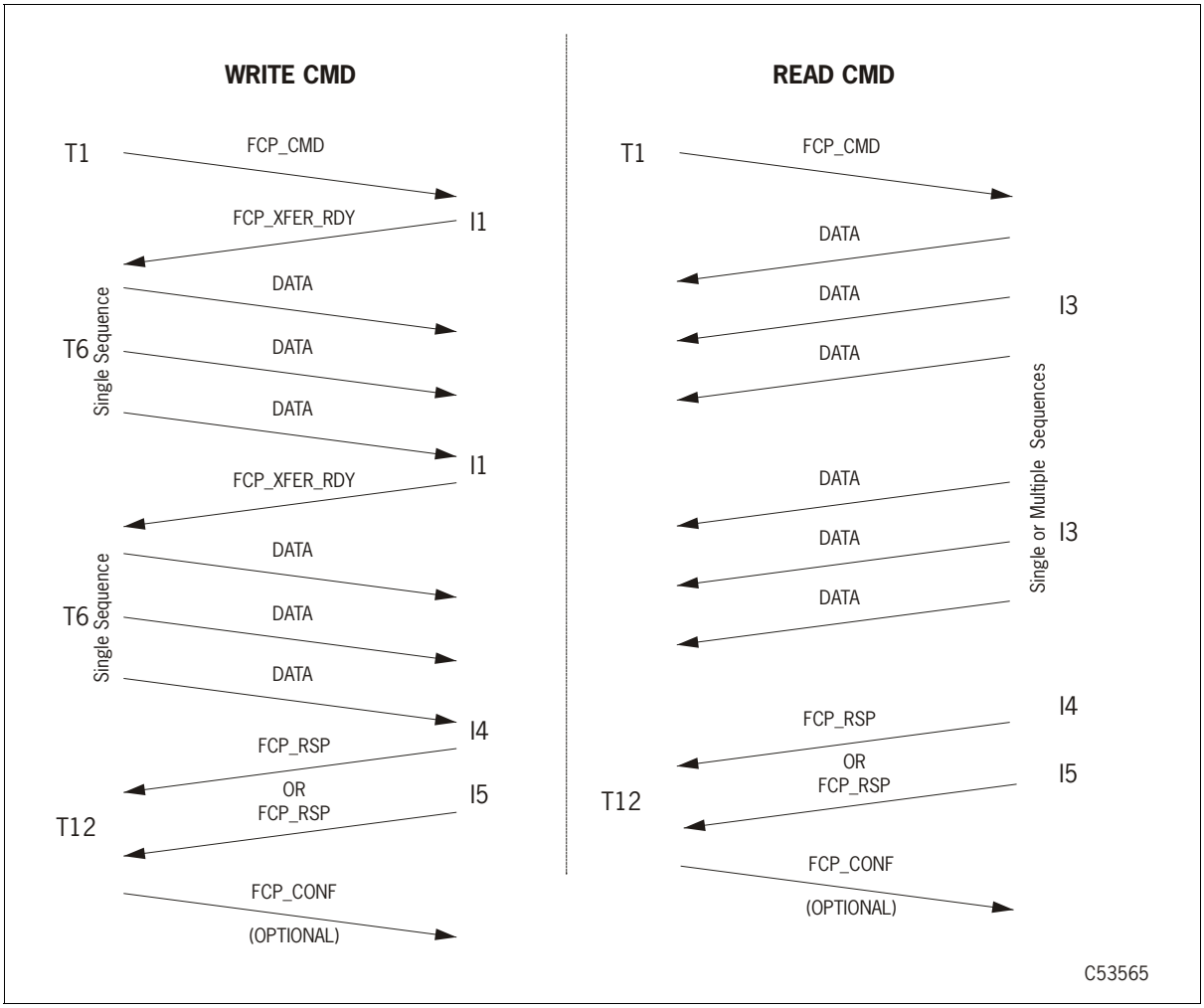
Feature	FC-Tape		StorageTek
	Initiator	Target	
Command + Data in same Sequence (Write) = 1	P	P	N
Data Overlay Allowed = 1 (see note)	I	R	Y
Data + Response in same Sequence (Read) = 1	P	P	N
Establish Image Pair (bit 13) = 0	I	R	Y
Establish Image Pair (bit 13) = 1	R	R	Y
SRR/REC Recovery Supported = 1	R	R	Y
Confirmed Completion Allowed =1	I	R	Y
Initiator Function =1	R	A	N
Originator Process Associator	P	P	N
Originator Process Associator Valid = 1	P	P	N
Responder Process Associator	P	P	N
Responder Process Associator Valid = 1	P	P	N
Obsolete (Read XFER_RDY Disabled) = 1	R	R	Y
SCSI Target Function = 1	A	R	Y
Write XFER_RDY Disabled = 1	P	P	N
Note: If the initiator requests it, the use of data overlay is only allowed in response to an SRR (i.e., error recovery).			

FCP Information Units

Information units transfer data to and from the SCSI Initiator and SCSI Target and include the following required units:

- T1 = Command and Task Management
- T6 = Write Data (such as Mode Select and Write commands)
- T12 = Response Received Confirmation
- I1 = Transfer Ready on a Write Command
- I3= Read Data (such as Mode Sense and Read commands)
- I4 = Response (such as Status)
- I5 = Response with confirm request

Figure 7. Examples of Read and Write Information Units



Command Information Unit

The Command Information Unit (T1) is a single-frame sequence.

The drive supports the "first level addressing" LUN field as defined in SAM–2. Table 26 illustrates this.

Table 26. FCP 8-Byte LUN

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
00	LUN	00	00	00	00	00	00

For all commands that transfer data to the tape drive:

FCP_DL (data length) in the FCP_CMND payload always equals the number of bytes being transferred for the command.

For SCSI commands which specify the transfer length in blocks in the Command Data Block (CDB), the FCP_DL equals the Transfer_Length x the Block_Size.

Note: If the FCP_DL value is less than the transfer length then FCP_DL data will be transferred and the command will be terminated with Check Condition. The Sense Key will be 0x5, the ASC will be 0x4B, and the ASCQ will be 0x80.

For all commands that transfer data from the tape drive:

The SCSI Initiator is responsible for making sure the amount of data returned is equal to the amount specified by FCP_DL. Even if Good Status is returned. If the amount does not match FCP_DL, a command-specific ULP recovery action needs to be invoked. Because there are no transfers of Sequence Initiative during read operations, once the SCSI Target receives the T1 Information Unit, it may return Good status even though some of the data was not received by the SCSI Initiator. This can occur as the result of lost or corrupted frames in the read data.

Note: The way a SCSI Initiator determines the correct amount of data is returned depends on the implementation and includes counting the number of bytes returned, computing the number of bytes received by use of the relative offsets.

The FCP Command Reference Number (CRN) shall be used to ensure proper ordering of Exchange's (SCSI commands). CRN usage is enabled based on I_T_L nexus by setting the Enable Command Reference Number (ECRN) bit to one in the FC Mode Page (0x19) for the LUN. Task Management functions shall set the CRN value to zero. Refer to FCP-2 (4.3 Precise Delivery of SCSI Commands) for a detailed description.

Note: The drive currently does not support command queuing, thus CRN's are not supported.

Transfer Ready Information Units

The Transfer Ready Information Unit (I1) is a single-frame sequence.

For write operations:
The FCP_XFER_RDY is sent before each write data sequence.

For read operations:
The FCP_XFER_RDY IU (I2) is not used during read type (data in) operations. This is indicated by setting the 'READ XFER_RDY DISABLED' bit during process login.

Data Information Unit

The Data Information Units (T6 and I3) are either single- or multiple-frame sequences.

The FCP_DATA IU transfers data associated with an operation. This data includes logical data to or from tape, as well as command parameter data (such as Mode Select data) or command response data (such as Mode Sense data).

Write Data

For write data sequences (such as mode select and write commands), the parameter field of the first frame sequence is set to the relative offset specified by the corresponding FCP_XFER_RDY. Then use continuously increasing relative offset values for subsequent frames.

Read Data

For read sequences (such as mode sense and read commands), the relative offset on consecutive frames within a read sequence is continuously increasing.

During read commands with multiple data (I3) sequences, Ports treat all data sequences other than the first as streamed sequences and follow the rules associated with streamed sequences.

Response Information Unit

The Response Information Unit (I4) are single- or multiple-frame sequences.

The first two bits (30 and 31) of the first word of a command status frame payload fall into the following categories:

- 00 = Successful and complete
- 01 = Successful but incomplete
- 10 = Unsuccessful but complete
- 11 = Unsuccessful and incomplete

Because the first word of FCP_RSP frames are reserved in FCP, these bits are set to zero, regardless of the content of the SCSI Status portion of the payload. SCSI Initiators do not rely on word 0, bits 31 and 30 in FCP_RSP to determine success or completion status of a command. An FCP_RSP following a data-in sequence (I3) may or may not be treated as a streamed sequence.

Residual Checking

Residual checking falls under the following categories:

- SCSI Targets that transfer exactly FCP_DL data bytes during the FCP_DATA IUs set the FCP_RESID_UNDER to a value of '0'b.

  When FCP_RESID_UNDER is set to '0'b, the SCSI Initiator tries to determine if all of the expected data was transferred by comparing the FCP_DL to the actual number of bytes transferred. If these values are not the same, the ULP is notified so that the appropriate action can be taken.

- SCSI Targets that transfer less than FCP_DL data bytes during the FCP_DATA IUs set the FCP_RESID_UNDER to a value of '1'b.

  If the FCP_RESID_UNDER bit is set to '1'b, a transfer that did not fill the buffer to the expected displacement. Failure to transfer FCP_DL bytes does not necessarily indicate an error for some devices and commands.

- If the FCP_RESID_OVER bit is set, the transfer was truncated because the data transfer required by the SCSI command extended beyond the displacement value of FCP_DL. Those bytes that could be transferred without violating the FCP_DL value may or may not have been transferred.

- Commands that do not contain an FCP_DATA IUs, FCP_RESID_UNDER and FCP_RESID_OVER are set to '0'b, and the value of the FCP_RESID is undefined.

Response Payload

Table 27 lists the FCP_RSP payload fields:

Table 27. FCP_RSP Payload

Feature	FC-Tape		StorageTek
	Initiator	Target	
FCP_CONF_REQ	A	R	Y
FCP_SNS_INFO	R	I	Y
FCP_SNS_LEN (total)	R	≤ 128	28
FCP_SNS_LEN_VALID	R	I	Y
Length of Additional Sense Bytes in FCP_SNS_INFO	R	≤ 120	16
FCP_RSP_INFO	R	I	Y
FCP_RSP_LEN	R	0 or 8	8
FCP_RSP_LEN_VALID	R	I	Y
FCP_RESID	R	R	Y
FCP_RESID_OVER	R	I	Y
FCP_RESID_UNDER	R	I	Y

Response Codes

The Response Code field (FCP_RSP_INFO) contains information that describes the failures detected during the execution of an I/O Operation and conforms to the following rules:

- The FCP_RSP_INFO does not contain link error information because FC-PH provides the mechanisms for presenting these errors.
- The FCP_RSP_INFO does not contain SCSI logical unit error information because that information is in the FCP_STATUS and FCP_SNS_INFO fields.
- RSP_CODE values of 04h and 05h are not valid responses to SCSI commands. The RSP_CODE is independent of the SCSI Status and should be examined before interpretation of the SCSI Status.
- For other non-zero values of the RSP_CODE, the SCSI Status may not be valid.

Table 28 indicates the result of a Task Management function in the RSP_CODE of the FCP_RSP_INFO fields.

Table 28. FCP_RSP Codes

RSP_CODE	Description
00	No failure or Task Management complete
01	FCP_DATA length different than BURST_LEN
02	FCP_CMND fields invalid
03	FCP_DATA RO mismatch with FCP_XFER_RDY DATA_RO
04	Task Management function not performed or supported
05	Task Management function supported but not performed
06-FF	Reserved

The FCP_CONF IU is used by the Target to confirm reception of an FCP_RSP IU at the initiator. Support for the FCP_CONF IU is negotiated via PRLI. A Target request for an FCP_CONF IU from the initiator is indicated by the Target setting the FCP_CONF_REQ bit in the FCP_STATUS field contained in the FCP_RSP. If the initiator does not need to perform any error detection or recovery procedure, the initiator shall send an FCP_CONF IU if an FCP_RSP is received with the FCP_CONF_REQ bit set in the FCP_STATUS field.

The initiator shall release Exchange information such as the Exchange Status Block (ESB) after the FCP_CONF is sent. The Target shall retain Exchange information and associated data until an FCP_CONF is received. See FCP-2 (4.4 Confirmed Completion of FCP-2 SCSI Commands) for a description of the FCP_CONF_REQ bit and FCP_CONF usage.

If the initiator supports FCP_CONF as indicated in it's PRLI pageload, the T9x40 tape drives will always set the FLP_CONF_REG bit.

Task Management Flags and Information Units

All SCSI Initiators send Task Management functions using T1.

All SCSI Targets return FCP_RSP to Task Management functions using I4.

The RSP_CODE in the FCP_RSP_INFO field indicates the result of the Task Management function. The SCSI Status byte and FCP_SNS_INFO are ignored for I4 information units sent in response to a Task Management function.

Table 29 lists the Task Management Flags the tape drives support:

Table 29. FCP Task Management Flags

Feature	FC-Tape		StorageTek
	Initiator	Target	
Terminate Task = 1	P	P	N
Clear ACA = 1 (command queuing)	R	R	N
Clear ACA = 1 (no command queuing)	P	P	N
Target Reset = 1	I	R	Y
Clear Task Set = 1	I	R	Y
Abort Task Set = 1	I	R	Y
Logical Unit Reset = 1	I	R	Y

Task Attributes

Table lists the FCP Task Attributes supported by the tape drives:

FCP Task Attributes

Feature	FC-Tape		StorageTek
	Initiator	Target	
Untagged	R	R	Y
Simple Queue Type (depth = 1)	I	A	Y
Ordered Queue Type	I	A	Y
Head of Queue Type	I	A	Y
Auto Contingent Allegiance Type NOTES: *All Queue Types Are Accepted And Behave the Same.	I	A	Y

Other Features

Table 30 lists other FCP features supported:

Table 30. Other FCP Features

Feature	FC-TAPE		StorageTek
	Initiator	Target	
FCP_LUN (in FCP_Command)	R	R	Y
FCP_LUN (0)	I	R	Y
Inquiry of FCP_LUN (0)	I	R	Y
Inquiry of FCP_LUN (>0)	I	R	Y
Auto Contingent Allegiance (ACA)	A	A	N

SCSI Features

The following sections describe the SCSI features supported by the tape drives.

Auto Contingent Allegiance

StorageTek tape drives *do not* support Auto Contingent Allegiance (ACA).

Asynchronous Event Notification

StorageTek tape drives *do not* support asynchronous event notification (AEN).

Command Linking

StorageTek tape drives *do not* support Command Linking. The Link and Flag bits of the Command Descriptor Block must be set to zero.

Status Byte

The target returns a status byte to the initiator at the completion of each command during the Status phase unless the command is cleared or interrupted. The tape drives support four status byte codes:

- Busy
- Check Condition
- Good
- Reservation Conflict
- Task Set Full

Busy

Busy (08) status occurs when the target:

- Is busy performing another operation
- Cannot accept a command

The normal initiator recovery from a Busy status is to reissue the command.

Check Condition

Check Condition (02) status occurs when any error, unit exception, or abnormal condition that generates sense data occurs. Check Condition status occurs when one of the following conditions exist:

- Issuing an invalid command or parameter
- Issuing a motion command to a device that is not ready
- Issuing a write-type command to a file-protected cartridge
- Issuing a forward motion command to a device at the physical end-of-tape
- Issuing a backspace operation to a device at the beginning-of-tape
- Detecting a deferred check condition
- Exceeding the retry operations for an interface error
- Detecting any error condition that prevents successful completion of an operation

Good

Good (00) status indicates that the device successfully completed the command.

Reservation Conflict

Reservation Conflict (18) status is returned whenever a SCSI initiator attempts an operation that violates another initiator's Logical Unit Reservation.

Task Set Full

Task Set Full (28) status is returned when the logical unit receives a command and does not have enough resources to process it.

Public Loop SCSI Target Discovery

The following private loop discovery is used except that discovery of SCSI Targets will be performed via the Simple Name Server or RSCN and the function performed by ADISC/PDISC will be replaced by FAN.

Private Loop SCSI Target Discovery

When the possibility of a configuration change exists, a SCSI Initiator may want to rediscover the new configuration. The SCSI Target Discovery procedure for a SCSI Initiator is:

For all valid AL_PAs:

```
OPN(AL_PA)
 IF OPN is successful, then
  Send ADISC or PDISC to D_ID = hex '0000' || AL_PA
   IF LOGO is returned or the Node Name or Port Name has changed, then
    Send PLOGI to D_ID = hex '0000' || AL_PA
     IF PLOGI is successful, then
   IF no hard address conflicts or application tolerant of hard
     address conflicts
       Send PRLI to D_ID = hex '0000' || AL_PA
        IF PRLI is successful, then
         Send FCP_CMND with INQUIRY CDB to D_ID = hex '0000'
        ||AL_PA(LUN_0)
        ENDIF
       ENDIF
      ENDIF
     ENDIF
    ENDIF
NEXT AL_PA
```

In order to determine if an OPN was "successful," the NL_Port must be able to:

1. Detect when an OPN has not been intercepted by the designated AL_PA.
2. Detect that an R_RDY or CLS has not been received from the AL_PA specified in an OPN within E_D_TOV of sending that OPN.
3. Detect that a CLS was received in response to the OPN.
   In this case, the Target Discovery procedure should be retried at a later time.
4. Detect that the OPN or frame Extended Link Service failed.

If the SCSI Target Discovery procedure revealed a Hard Address conflict (such as an NL_Port was unable to acquire its hard address), then the application may choose to operate in spite of that conflict.

If this is the case, then the discovery procedure can continue with the PRLI and subsequent SCSI INQUIRY command.

If the application is not tolerant of Hard Address conflicts, the SCSI Initiator may choose not to use that NL_Port.

Using this SCSI Target Discovery procedure, the SCSI Initiator has the ability to assemble a database consisting of Node name, Port name, and Port ID.

There are several confirmations a SCSI Initiator can perform on that database to determine which SCSI Targets it can continue to communicate with that are not defined by this document.

Note: Not all initiators perform the exact steps described in the above algorithm, although a SCSI Initiator is required to issue ADISC or PDISC to all SCSI Targets it is logged in with within RR_TOV of receiving LIP if it wants to remain logged in with those SCSI Targets.

The ADISC/PDISC procedure is designed to avoid the abnormal termination of all open Exchanges when a new device is attached to the loop, or when a device powers on.

Note: Because devices are not required to respond to Class 3 frames that have a D_ID which does not match the full 24-bit Port identifier of the receiving NL_Port, this may result in timeouts during the SCSI target discovery process if a SCSI initiator sends a frame to a Public NL_Port using a D_ID of hex'0000' or AL_PA or to a Private NL_Port using a D_ID with the upper 16 bits non-zero.

Therefore, for performance reasons SCSI initiators should originate PDISC or ADISC Exchanges by transmitting the ELS Sequence without waiting for the response. SCSI initiators may need to originate multiple concurrent Exchanges in order to hide multiple timeouts from the user.

Clearing Effects of ULP, FCP, FC-PH, and FC-AL Actions

Table 31 lists the clearing effects of Fibre Channel actions:

Table 31. Clearing Effects

FCP SCSI Target Object	Power On Reset	LIP Reset	LOGO PLOGI	ABTS	PRLI PRLO	TPRLO	SCSI Target Reset	Clear Task Set	Abort Task Set	SCSI Logical Unit Reset
PLOGI parameters:										
All logged-in initiators	Y	Y	N	N	N	N	N	N	N	N
Only ports initiating action	–	–	Y	N	N	N	N	N	N	N
Open sequences terminated:										
For all initiator with OPN seq's	Y	Y	N	N	N	Y	Y	Y	N	Y
Only ports initiating action	–	–	Y	N	Y	–	–	–	Y	–
Only for seq. with aborted exchange	–	–	–	Y	–	–	–	–	–	–
Login BB_ Credit_CNT:										
All logged-in L_Ports	Y	Y	–	N	N	N	N	N	N	N
Only transmitting ports	–	–	Y							
Hard address acquisition attempted	Y	Y	N	N	N	N	N	N	N	N
PRLI parameters cleared:										
All logged-in initiators	Y	Y	N	N	N	N	N	N	N	N
Only ports of specific type	–	–	N	N	Y	Y	N	N	N	N
Only ports initiating action	–	–	Y	N	Y	N	N	N	N	N
Open exchanges aborted:										
All tasks, all initiators, open tasks	Y	Y	N	N	N	Y	Y	Y	N	Y
All tasks, port initiating action	–	–	Y	N	Y	–	–	–	Y	–
Specific task, port initiating action	–	–	N	Y	N	–	–	–	N	–
SCSI target mode page parameters restored from saved pages:										
All initiators	Y	Y	N	N	N	Y	Y	N	N	Y
Only ports initiating action	–	–	Y	N	Y	–	–	N	N	–
Pre-existing ACA, UA, and deferred error conditions cleared:										
All initiators	Y	Y	N	N	N	Y	Y	N	N	Y
Only ports initiating action	–	–	Y	N	Y	–	–	N	N	–

Table 31. Clearing Effects (Continued)

FCP SCSI Target Object	Power On Reset	LIP Reset	LOGO PLOGI	ABTS	PRLI PRLO	TPRLO	SCSI Target Reset	Clear Task Set	Abort Task Set	SCSI Logical Unit Reset
Device Reservations										
For all SCSI initiators	Y	Y	N	N	N	Y	Y	N	N	Y
Only for SCSI Initiator port initiating action	–	–	Y	N	Y	–	–	N	N	–
Persistent Device Reservations										
For all SCSI initiators	Y	N	N	N	N	N	N	N	N	N
Only for SCSI Initiator port initiating action	–	–	N	N	N	–	–	N	N	–
CRN (Command Reference Number)										
For all SCSI initiators	Y	Y	N	N	N	Y	Y	N	N	Y
Only for SCSI Initiator port initiating action	–	–	Y	N	Y	–	–	N	N	–
Prevent Allow Medium Removal state										
For all SCSI initiators	Y	Y	N	N	N	Y	Y	N	N	Y
Only for SCSI Initiator port initiating action	–	–	N	N	Y	–	–	N	N	–
Exchange Information										
For all SCSI initiators	Y	Y	N	N	N	Y	Y	N	N	Y
Only for SCSI Initiator port initiating action	–	–	Y	N	Y	–	–	N	N	–

Device Reservations

The T9x40 Series tape drives support the Reserve/Release management method and also the Persistent Reservations management method. These methods are defined in the ANSI SCSI-3 Primary Commands (SPC-2) standard. For the reservation restrictions placed on commands for the Reserve/Release management method refer to Table 32. For the reservation restrictions placed on the Persistent Reservations management method refer to Table 33 on page 3-63.

conflict Command will not be performed and the drive will terminate the command with Reservation Conflict status.

allowed Command will be allowed to execute to normal completion.

Table 32. Reserve/Release Management Method

Command	Action when Reserved by a different Initiator
Erase (19h)	Conflict
Inquiry (12h)	Allowed
Load Display (06h)	Conflict
Load/Unload (1Bh)	Conflict
Locate (2Bh)	Conflict
Log Select (4Ch)	Conflict
Log Sense (4Dh)	Allowed
Mode Select (15h/55h)	Conflict
Mode Sense (1Ah/5Ah)	Conflict
Persistent Reserve In (5Eh)	Conflict
Persistent Reserve Out (5Fh)	Conflict
Prevent/Allow Removal (1Eh)	Prevent = 0, allowed Prevent = NZ, conflict
Read (08h)	Conflict
Read Block Limit (05h)	Allowed
Read Buffer (3Ch)	Conflict
Read Position (34h)	Conflict
Recover Buffered Data (14h)	Conflict
Release Unit (17h/57h)	Allowed, the reservation is not released.
Report Density Support (44h)	Allowed
Report LUNs (A0h)	Allowed
Request Sense (03h)	Allowed
Reserve Unit (16h/56h)	Conflict
Rewind (01h)	Conflict
Send Diagnostic (1Dh)	Conflict
Space (11h)	Conflict
Test Unit Ready (00h)	Conflict
Write (0Ah)	Conflict
Write Buffer (3Bh)	Conflict
Write Filemarks (10h)	Conflict

Table 33. Persistent Reservation Management Method

Command	Non-registered Initiators	Registered Initiators
Erase (19h)	Conflict	Allowed
Inquiry (12h)	Allowed	Allowed
Load Display (06h)	Conflict	Allowed
Load/Unload (1Bh)	Conflict	Allowed
Locate (2Bh)	Conflict	Allowed
Log Select (4Ch)	Conflict	Allowed
Log Sense (4Dh)	Allowed	Allowed
Mode Select (15h/55h)	Conflict	Allowed
Mode Sense (1Ah/5Ah)	Conflict	Allowed
Persistent Reserve In (5Eh)	Allowed	Allowed
Persistent Reserve Out (5Fh)	Register, allowed Reserve, conflict Release, conflict Clear, conflict Preempt, conflict Pre/Abt, conflict	Register, allowed Reserve, conflict Release, allowed Clear, allowed Preempt, allowed Pre/Abt, allowed
Prevent/Allow Media Removal (1Eh)	Prevent = 0, allowed Prevent = NZ, conflict	Allowed
Read (08h)	Conflict	Allowed
Read Block Limit (05h)	Allowed	Allowed
Read Buffer (3Ch)	Conflict	Allowed
Read Position (34h)	Conflict	Allowed
Recover Buffered Data (14h)	Conflict	Allowed
Release Unit (17h/57h)	Conflict	Conflict
Report Density Support (44h)	Allowed	Allowed
Report LUNs (A0h)	Allowed	Allowed
Request Sense (03h)	Allowed	Allowed
Reserve Unit (16h/56h)	Conflict	Conflict
Rewind (01h)	Conflict	Allowed
Send Diagnostic (1Dh)	Conflict	Allowed
Space (11h)	Conflict	Allowed
Test Unit Ready (00h)	Conflict	Allowed
Write (0Ah)	Conflict	Allowed
Write Buffer (3Bh)	Conflict	Allowed
Write Filemarks (10h)	Conflict	Allowed

Command Reference

4

This chapter defines the commands for the Sun StorageTek T9x40 Series of Tape Drives with a Fibre Channel interface.

Overview

The Sun StorageTek tape drives use the SCSI-3 command set to transfer commands and data over Fibre Channel. The following describes how StorageTek implements these SCSI commands:

- A single command may transfer one or more logical blocks of data.
- The target may disconnect from the arbitrated loop to allow activity by other SCSI devices while a device prepares to transfer data.
- On completion of normal commands (successful or unsuccessful), the target returns a Status Byte to the initiator. Because most error and exception conditions cannot be adequately described with a single status byte, a Check Condition status code indicates that additional information is available in the FCP Response Information Unit (IU).
- An initiator should never attempt to send a second command to a device until the command in progress ends. The second command terminates with a Check Condition status (Command Overrun).

Implementation Requirements

The initiator sends commands to the target using Command Descriptor Blocks (CDBs). The CDBs contain a format that includes:

- Operation code
- Command parameters
- Control byte

For some commands, a list of parameters accompanies the request during subsequent FCP_DATA Information Units.

For all commands, if there is an invalid parameter in the Command Descriptor Block, then the device terminates the command without altering the medium or executing the command.

Note: The CDB Field in Byte 1, Bits 7-5, which was the LUN Field is now reserved. The drive will ignore this field.

List of Commands

Table 34. Supported Commands

Command	Code	Page
Erase	19h	69
Inquiry	12h	70
Load Display	06h	79
Load/Unload	1Bh	81
Locate	2Bh	83
Log Select	4Ch	84
Log Sense	4Dh	85
Mode Select	15h / 55h	96
Mode Sense	1Ah / 5Ah	109
Persistent Reserve In	5Eh	122
Persistent Reserve Out	5Fh	126
Prevent/Allow Media Removal	1Eh	130
Read	08h	131
Read Attribute	8Ch	133
Read Block Limit	05h	135
Read Buffer	3Ch	136
Read Position	34h	138
Receive Diagnostic Results	1Ch	141
Recover Buffered Data	14h	142
Release Unit	17h / 57h	143
Report Density Support	44h	145
Report LUNs	A0h	149
Request Sense	03h	150
Reserve Unit	16h / 56h	159
Rewind	01h	160
Send Diagnostic	1Dh	161
Space	11h	162
Security Protocol In	A2h	164
Test Unit Ready	00h	171
Write	0Ah	172
Write Buffer	3Bh	174
Write Filemarks	10h	176

Command Descriptor Block

Initiators use three types of CDBs to communicate commands to the targets:

- 6–Byte commands (Table 35)
- 10–Byte commands (Table 36)
- 12-Byte commands (Table 37 on page 4-67)

The first byte in the command descriptor block contains the operation code.

Table 35. 6-Byte Command Descriptor Block

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Command Parameters				
2–4	Command Parameters							
5	Control Byte							

Table 36. 10-Byte Command Descriptor Block

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Command Parameters				
2–8	Command Parameters							
9	Control Byte							

Table 37. 12-Byte Command Descriptor Block

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Command Parameters				
2–9	Command Parameters							
10	Reserved							
11	Control Byte							

Control Byte

The control byte is the last byte of every Command Descriptor Block and has the following structure:

Table 38. Control Byte

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
5/9	Vendor-specific		Reserved				Flag	Link

Vendor-specific:

These bits provide specific information about the device (shall be zero).

Flag bit:

The flag bit causes an interrupt in the initiator between linked commands allowing the device to respond with Intermediate status (shall be zero).

Link bit:

The link bit allows the initiator to "link" or continue I/O process and allows devices that support command linking to indicate to the initiator the command was accepted by returning Intermediate status to the initiator (shall be zero).

Erase Command

The Erase command erases the remainder of the tape starting at the current, logical position. Any buffered write data and filemarks are written on the tape *before* the erase operation starts.

Note: At the completion of the Erase command, the tape is positioned at the physical end of volume (PEOV). If DSE Set to Full.

Table 39. Erase Command

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

Immed: The Immediate bit supports the following values:

0 = Return status when erase is completed
1 = Return status when erase is started

Long: The Long bit supports the following values:

0 = Not supported (ignored, no action taken)
1 = Erase to the physical end of volume (PEOV)

Note: Issuing a Test Unit Ready command after an Erase command with the Immed bit set returns Busy status until the erase is complete.

Inquiry Command

The Inquiry command returns information about the type and capabilities of a SCSI device (the tape drives).

Table 40. Inquiry Command

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

CmdDt: Command support data (must be 0)

0 = Do not return command support data

EVPD: Enable vital product data bit:

0 = Return normal inquiry data
1 = Return Product Data page codes

Page Code: EVPD page to return

Allocation Length: Specifies the maximum length of inquiry data to return.

Notes:

1. The Inquiry command returns 56 bytes of data. If the allocation length is less than 56 bytes, the data is truncated.
2. The Inquiry command returns check condition status only when the requested data cannot be returned. This command will not clear any pending unit attention conditions.

Inquiry Data Format

The Inquiry data format contains 56 bytes shown in Table 41.

Table 41. Inquiry Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral Qualifier			Peripheral Device Type				
1	RMB	Reserved						
2	ISO version		ECMA version			ANSI version		
3	AERC	TrmTsk	Norm-ACA	Reserved	Response Data Format			
4	Additional Length (n - 4)							
5	Reserved							
6	BQue	EncServ	0	MultiP	MChngr	Reserved		
7	RelAdr	Reserved			Linked	Reserved	CmdQue	0
8 thru 15	Vendor Identification (ASCII)							
16 thru 31	Product Identification (ASCII)							
32 thru 39	Product Revision Level (ASCII)							
40 thru 53	Vendor Specific							
54	KM							
55	Reserved			Encrypt	LibAtt	VolSafe	DCMP	CSL

Reserved: bits = 0

Peripheral Qualifier: Values include:

000b = Peripheral device is connected to this logical unit
011b = Not capable of supporting a device on this logical unit

Peripheral Device Type: Values include:

01h = Device is a sequential device (tape drive)
1Fh = Device does not exist or is offline

RMB: Removable medium bit

1 = medium is removable

ISO Version:

00h = Does not claim compliance with ISO 9316

ECMA Version:

00h = Does not claim compliance with ECMA–111

ANSI Version:

03h = Complies with ANSI SCSI–3 standard

AERC: Asynchronous event reporting capability:

0 = not supported

TrmTsk: Terminate task support:

0 = message not supported

NormACA: Normal Auto Contingent Allegiance:

0 = ACA not supported

Response Data Format:

02 = Inquiry data is in ANSI SCSI–2 format

Additional Length:

33h = 51 additional bytes of data follows

BQue: Basic Queuing

0 = Not Supported

EncServ: Enclosure services:

0 = not supported

MultiP: Multi-Port:

1 = supports dual port or multiple port attachments

MChngr: Medium changer:

0 = not supported

RelAdr: Relative address:
0 = not supported

Linked: Linked commands:
0 = not supported

CmdQue: Command queuing:
0 = Tagged command queuing not supported

SftRe: Soft reset:
0 = Device implements the hard reset alternative

Vendor Identification:

STK = StorageTek, Sun Microsystems (ASCII)

Product Identification: Device type in ASCII

9840 = Drive is a T9840A
T9840B = Drive is a T9840B
T9840C = Drive is a T9840C
T9840D = Drive is a T9840D
T9940A = Drive is a T9940A
T9940B = Drive is a T9940B

Product Revision: 8 byte ASCII field

1.23.456 = Indicates major release 1, revision 23, minor release 456.

This field will change with each drive firmware release.

KM: Key Management

0 = None
1 = KMS 1
2 = KMS 2

Encrypt: Encryption

0 = Not an encryption-capable drive
1 = Encryption-capable drive

VolSafe: VolSafe available:

0 = VolSafe is disabled by front panel
1 = VolSafe is enabled

LibAtt: Library Attach

0 = Drive not attached to a library
1 = Drive is attached to a library

DCMP: Data compression:

0 = Data compression is disabled
1 = Data compression is enabled

CSL: Cartridge Scratch Loader installed:

0 = CSL is not installed
1 = CSL is installed

Vital Product Data Pages

There are five vital product data (VDP) pages that contain product specific information:

- 00h = Supported vital product data pages (Table 42 on page 4-74)
- 80h = Device serial number page (Table 43 on page 4-74)
- 83h = Device identification page (Table 44 on page 4-75)
- 85h = Management Network Access page (Table 45 on page 4-77)
- B0h = Sequential Access Device Capabilities page (Table 46 on page 4-78)

For all vital product data pages the **Peripheral Qualifier** and **Peripheral Device Type** fields have the same definitions used in Inquiry data.

Table 42. Supported Vital Product Data Pages

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (00h)							
2	Reserved							
3	Page Length (03h)							
4	Supported Vital Product Data Pages (00h)							
5	Device Serial Number Page (80h)							
6	Device Identification Page (83h)							
	Management Network Access Page (85h)							
	Sequential Access Device Capabilities page (B0h)							

- Vital Product Data (VPD) page 00h returns a list of the supported VPD pages.

Table 43. Device Serial Number Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (80h)							
2	Reserved							
3	Page Length (OCh)							
4 thru 15	(MSB) Serial Number (ASCII) (LSB)							

- VPD page 80h returns the tape drive serial number in ASCII.

Table 44. Device Identification Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (83h)							
2	Reserved							
3	Page Length (20h)							
Node Name Identifier								
4	Reserved				Code Set (1)			
5	Reserved		Association (0)		Identifier Type (3)			
6	Reserved							
7	Identifier Length (08h)							
8 thru 15	(MSB) Node Identifier (binary) (LSB)							
Port Name Identifier								
16	Reserved				Code Set (1)			
17	Reserved		Association (1)		Identifier Type (3)			
18	Reserved							
19	Identifier Length (08h)							
20 thru 27	(MSB) Port Identifier (binary) (LSB)							
Port Number Identifier								
28	Reserved				Code Set (1)			
29	Reserved		Association (1)		Identifier Type (4)			
30	Reserved							
31	Identifier Length (04h)							
32 thru 35	(MSB) Port Number (binary) (LSB)							

- VPD page 83h returns three identifying numbers. The World Wide Name (WWN) for the tape drive, the WWN for the port that accepted the Inquiry command, plus a Port Number (1 or 2) for that port. (See Chapter 3, "Operations," for more information).

Code Set:

1 = Identifier field contains binary values

Association:

0 = Identifier is for the device.
1 = Identifier is for a port.

Identifier Type:

3 = Identifier field contains a 64 bit IEEE registered format address, also known as a World Wide Name.

4 = Identifier field contains a 4 byte port number.

Identifier Length: Length in bytes of the WWN or Port Number Identifier.

Node Identifier: Contains the device WWN.

Port Identifier: Contains WWN for the current port.

Port Number: Number for the current port:.

1 = Command accepted by port A.
2 = Command accepted by port B.

Table 45. Management Network Addresses Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (85h)							
2	Page Length (1Eh)							
3								
4	RSVD	Association		Service Type				
5	Reserved							
6	(MSB) Network Address Length							
7								(LSB)
8	(MSB) Network Address							
33								(LSB)

Peripheral Qualifier:

000b = Peripheral Device is connected to this Logical Unit

Peripheral Device Type:

01h = Device is a sequential-access device (tape drive)

Association:

2h = Network address is associated with this SCSI target device

Service Type:

00h = Service type is unspecified

Network Address: URL of accessing drive management port

For example, TELNET://123.123.123.123/

Field is an ASCII string terminated with one or more null (00h) characters. If management port is not connected to an active network, field will be filled with 00h.

Table 46. 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 (02h)							
3								
4	Reserved							WORM
5	Reserved							

Peripheral Qualifier:

000b = Peripheral Device is connected to this Logical Unit

Peripheral Device Type:

01h = Device is a sequential-access device (tape drive)

WORM:

01h = Device supports write once, read many (WORM) modes of operation (VolSafe)

Load Display Command

The Load Display command (vendor specific) displays ASCII messages on the operator display for that device. This command transfers 17 bytes of data to the display. The data transferred contains one byte of display control data and two, eight-byte ASCII messages.

Table 47. Load Display Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (06h)							
1 thru 3	(MSB) Reserved (LSB)							
4	Transfer Length (11h)							
5	Control Byte							

Load Display Data Format

Table 48. Load Display Data Bytes

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Overlay			Alt	Blink	L/H	Reserved	
1 thru 8	(MSB) Message 1 (ASCII) (LSB)							
9 thru 16	(MSB) Message 2 (ASCII) (LSB)							

Messages in bytes 1–8 and 9–16 use the ASCII printable character set. Non-printable characters are displayed as blanks. The format control byte controls the way the device displays the remaining 16 bytes.

Overlay: New message overlay:

000 = Display the message in bytes 1–8 or 9–16 until the next command that initiates tape motion or the next Load Display Command.

001 = Maintain the message in bytes 1–8 until the cartridge is unloaded. If the drive does not contain a cartridge when the Load Display Command is received, the message will not be changed.

010 = Maintain the message in bytes 1–8 and turn on the Attention light until the drive is next loaded. If the drive is loaded when the Load Display Command is received, the command is ignored.

011 = Physically access the tape drive without changing the message display.

111 = Display the message in bytes 1–8 until the tape drive is unloaded, then display the message in bytes 9–16 until the tape drive is loaded again. If the tape drive is not loaded when the Load Display Command is issued, only the message in bytes 9–16 are displayed.

ALT: Alternate message:

0 = The device displays only the message specified in bit 2.

1 = The device alternately displays both messages specified in bytes 1–8 and 9–16. Each message is displayed for about two seconds, with 0.5 seconds between messages. Bits 2 and 3 are ignored.

Blink: Blinking message:

0 = The message specified by the setting of bit 2 does not blink.
1 = The message specified by the setting of bit 2 flashes on and off.

L/H: Display low/high message:

0 = Display message specified in bytes 1–8.
1 = Display message specified in bytes 9–16.

Load/Unload Command

The Load/Unload command loads or unloads tape from the device. If a Cartridge Scratch Loader (CSL) is installed, this command loads a tape from the scratch loader. Any buffered write data and filemarks are written on the tape *before* this operation starts.

CAUTION:
If the drive is in Buffered Mode and a previous command terminated with Check Condition status (such as buffered data unwritten to tape and the condition was not cleared or otherwise recovered), the drive will discard any unwritten buffered data and filemarks before this operation starts.

Table 49. Load/Unload Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Bh)							
1	Reserved							Immed
2 thru 4	(MSB) Reserved (LSB)					EOT	Reten	Load
5	Control Byte							

Immed: Immediate bit

0 = Status is returned when the load or unload is finished
1 = Status is returned when the load or unload is started

EOT: End-of-tape bit (must be 0).

0 = Tape is unloaded from BOT

Reten: Retention bit.

0 = Do not retention the tape

1 = Retention tape (ignored).

Load: Load bit

0 = Unload the tape
1 = Load the next tape if a CSL is installed and in system mode or drive is a T9840D

Notes:

1. After a load or unload operation with the Immediate bit set, a Test Unit Ready command returns Busy status while the Load/Unload command is still in progress.
2. After a successful load operation, Good status is returned. The next command returns a sense key of unit attention.
3. If a Load command is issued when a tape is already loaded, the Load command is ignored.
4. The Inquiry command can indicate if a CSL is installed.
5. When the clean light is on during an unload operation, Check Condition status is returned with a Sense Key of 0h and an ASC/ASCQ of 0017h indicating the tape drive requires cleaning.
6. A load command with the immediate bit set is not allowed on a T9840D tape drive.

Locate Command

The Locate command requests the tape drive to position the tape to a specified block address. Any buffered write data and filemarks are written on the tape *before* this operation starts.

Table 50. Locate Command

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

BT: Block address type:

0 = SCSI logical block address
1 = Not supported (ignored, no action taken)

CP: Change partition bit (must be 0).

0 = Ignore partition field

Immed: Immediate bit:

0 = Returns Status when locate is completed
1 = Returns Status when locate is started

Block Address: Block number to position to

Partition: Must be 0.

Note: After a Locate command with the Immediate bit set, a Test Unit Ready command returns Busy status while the operation is in progress.

Log Select Command

The initiator uses the Log Select command to manage information about the device or media.

Table 51. Log Select Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (4Ch)							
1	Reserved						PCR	SP
2	PC		Reserved					
3 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Parameter List (LSB)							
9	Control Byte							

PCR: Parameter code reset

0 = No operation performed
1 = Reset all implemented parameters

SP: Save parameters (not supported, must be 0)

PC: Page control field (must be 11b)

11b = Set Default Cumulative Values

Parameter List:
Length in bytes of log parameter data to be transferred to the drive (must be 0)

Notes:

1. Setting the parameter code reset bit to one, clears all cumulative statistics.
2. If the parameter code reset (PCR) bit is set to 0, this command is ignored and no values are reset.
3. If the SP bit and the parameter list length field are not both 0, this command is rejected.

Log Sense Command

The Log Sense command returns device statistical data to the host.

Table 52. Log Sense Command

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

PPC: Parameter pointer control
0 = Send all available log parameters for the specified log page.

SP: Save parameters (not supported, must be 0).

PC: Page control field:

00b = Current Threshold Values
01b = Current Cumulative Values
10b = Default Threshold Values
11b = Default Cumulative Values

Page Code: Specifies which page of data to return:

00h = Supported log pages
02h = Write error counter page
03h = Read error counter page
06h = Non-medium error page
0Ch = Sequential access device page
2Eh = Tape Alert page
30h = Vendor unique page

Parameter Pointer:
Allows the initiator to request data starting at a specific parameter code.

Allocation Length:
Maximum length of parameter data to transfer

Log Sense Page Format

Each log page begins with a four–byte page header followed by variable–length log parameters.

Table 53. Log Sense Page Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved		Page Code					
1	Reserved							
2 thru 3	(MSB) Page Length (n-3) (LSB)							
4	Log Parameter (First)							
x + 3	(Length = x)							
...								
n – y+1	Log Parameter (Last)							
n	(Length = y)							

Note: The page length reflects the absolute length of the page, and is not adjusted because of the allocation length or the parameter pointer fields.

Log Sense Parameter Format

Table 54. Log Sense Parameter Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Parameter Code (LSB)							
2	DU	DS	TSD	ETC	TMC		Reserved	LP
3	Parameter Length (n-3)							
4 to n	Parameter Value							

The parameter code identifies the log parameter being transferred.

DU: Disable update (always 0)

For Log Sense commands always returns a 0 indicating the target updates the log parameter value instead of the initiator. Ignored in a Log Select command.

DS: Disable save (always 1)

When set to 1, indicates saving the log is not supported.

TSD: Target save disable

When set to 1, indicates that the target does not provide a target defined method for saving the log parameters.

When set to 0, indicated that the target provides a target defined method for saving log parameters.

ETC: Enable threshold comparison

When set to 0, indicates a comparison is not performed.

When set to 1, indicates a comparison is performed.

TMC: Threshold met criteria

00b = Every update
01b = Cumulative value equal threshold value
10b = Cumulative value not equal threshold value
11b = Cumulative value greater than threshold value

LP: List parameter (always 0)

Should be set to 0 indicating the log parameter is a data counter.

Log Sense Supported Pages

The Log Sense supported pages reports which pages the tape drive supports.

Table 55. Log Sense Supported Pages

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved		Page Code (00h)					
1	Reserved							
2 thru 3	(MSB) Page Length (LSB)							
4	Supported Log Pages (00h)							
5	Write Error Counter Page (02h)							
6	Read Error Counter Page (03h)							
7	Non-medium Error Page (06h)							
8	Sequential Access Device Page (0Ch)							
9	Tape Alert Page (2Eh)							
10	Vendor Unique Page (30h)							
11	Vendor Unique Page (31h) — T9840D only							
12	Vendor Unique Page (32h) — T9840D only							

Page length: Number of log pages supported

Write Error Counter Page

The Write Error Counter page (02h) reports write statistical errors. Each parameter is a counter incremented by the target each time a corresponding event occurs.

Table 56. Write Error Counter Parameters

Parameter Code	Description	Length (bytes)	Default Threshold
0000h	Errors corrected without substantial delays	4	FFFFFFFF
0001h	Errors corrected with possible delays	4	FFFFFFFF
0002h	Total number of re-writes	4	FFFFFFFF
0003h	Number of records with a recovered data check while writing	4	FFFFFFFF
0004h	Always 0	4	FFFFFFFF
0005h	Number of non–compressed bytes transferred from the initiator	8	FFFFFFFF FFFFFFFF
0006h	Total number of uncorrected errors	4	FFFFFFFF

Read Error Counter Page

The Read Error Counter page (03h) reports statistical errors for read operations. Each parameter is a counter that the target increments when an event occurs.

Table 57. Read Error Counter Parameters

Parameter Code	Description	Length (bytes)	Default Threshold
0000h	Errors corrected without substantial delays	4	FFFFFFFF
0001h	Errors corrected with possible delays	4	FFFFFFFF
0002h	Total number of re-reads	4	FFFFFFFF
0003h	Number of records with a recovered data check while reading	4	FFFFFFFF
0004h	Number of times a record was retried before recovery either passed or failed	4	FFFFFFFF
0005h	Number of non–compressed bytes transferred to the initiator	8	FFFFFFFF FFFFFFFF
0006h	Total number of uncorrected errors	4	FFFFFFFF

Non-Medium Error Page

The Non-Medium Error page (06h) reports a count of recoverable errors other than read/write failures.

Table 58. Non-Medium Error Parameters

Parameter Code	Description	Length (bytes)	Default Threshold
0000h	Non-medium error count	4	FFFFFFFF

Sequential Access Device Page

The Sequential Access Device page (0Ch) returns counts of data bytes transferred to and from tape and information about cleaning in binary format.

Table 59. Sequential Access Device Parameters

Parameter Code	Description	Length (bytes)	Default Threshold
0000h	Number of bytes received from the initiator (write command)	8	FFFFFFFF FFFFFFFF
0001h	Number of data bytes written on tape	8	FFFFFFFF FFFFFFFF
0002h	Number of bytes read from tape	8	FFFFFFFF FFFFFFFF
0003h	Number of bytes read by the initiator	8	FFFFFFFF FFFFFFFF
0100h	Cleaning 000 = No cleaning required 001 = Cleaning required	2	N/A
8000h	Number of 4k bytes left on tape from the current position	4	N/A

TapeAlert Page

The TapeAlert Log Sense page (2Eh) is read from a tape drive at the following times:

- At the beginning of a write/read job, after the media is loaded.
- Immediately after a fatal error during the write/read job.
- At the end of each tape when the write/read job spans multiple tapes.
- At the end of a write/read job, when the tape has been unloaded.

Each flag will be cleared to zero in the following circumstances:

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

Note: The entire TapeAlert page should be read to obtain all the information.

When a flag is cleared by reading the TapeAlert page, a flag cannot be set again until the error condition is removed (for example, the specific corrective action has been taken).

A Log Select Reset for the TapeAlert page does not reset the TapeAlert flags. It is rejected with Illegal Request.

TapeAlert Flags

Table 60. TapeAlert Flags

Code	Flag Name	Description	Length (bytes)
0001h	Read Warning	Drive has difficulty reading	1
0002h	Write Warning	Drive has difficulty writing	1
0003h	Hard Error	Write or read hard error has occurred (flags 4, 5, 6)	1
0004h	Media	Unrecoverable read, write, or positioning error caused by faulty media	1
0005h	Read Failure	Hard read error, hardware or media	1
0006h	Write Failure	Hard write error, hardware or media	1
0007h	Media Life	Media has exceeded the life pass count	1
0008h	Not Data Grade	Not supported	1
0009h	Write Protect	Write command was issued to a write-protected tape	1
000Ah	No Removal	A manual unload or Unload command was issued while the drive was in prevent removal state – not supported	1
000Bh	Cleaning Media	The tape in the drive is a cleaning cartridge	1
000Ch	Unsupported Format	Unrecognized format	1
000Dh	Recoverable Snapped Tape	Snapped tape – not supported	1
000Eh	Unrecoverable Snapped Tape	Not supported	1
000Fh	Memory Chip in Cartridge Failure	Not supported	1
0010h	Forced Eject	A manual eject was performed before a reposition to BOT was commanded – not supported	1
0011h	Read Only Format	Not supported	1
0012h	Tape Directory Corrupted	MIR corrupted	1
0013h	Nearing Media Life	The tape is nearing the end of its calculated life	1
0014h	Clean Now	The drive has determined it needs cleaning.	1
0015h	Clean Periodic	Cleaning counter has reached threshold, cleaning LED is on	1
0016h	Expired Cleaning Media	The last cleaning cartridge inserted was used up – not supported	1
0017h	Invalid Cleaning Media	Not supported	1
0018h	Clean Requested	Tape errors caused cleaning request.	1
0019h	Reserved		
001Ch			
001Dh	Drive Maintenance	Not supported	1

Table 60. TapeAlert Flags (Continued)

Code	Flag Name	Description	Length (bytes)
001Eh	Hardware A	Not supported	1
001Fh	Hardware B	Hardware not read/write related – not supported	1
0020h	Interface	Having problems with the interface, parity errors detected	1
0021h	Eject Media	Eject the media and retry, load failure not tape snap	1
0022h	Download Fail	Microcode update failed	1
0023h	Drive Humidity	Not supported	1
0024h	Drive Temperature	Not supported	1
0025h	Drive Voltage	Not supported	1
0026h	Predictive Failure	Not supported	1
0027h	Diagnostics Required	Dump available	1
0028h	Reserved for CSL		
002Eh			
002Fh	Reserved		
0031h			
0032h	Lost Statistics	Media statistics lost at some time in the past.	1
0033h	Tape Directory Invalid at Unload	The tape directory on the tape cartridge just unloaded has been corrupted.	1
0034h	Tape System Write Area Fail	The tape just unloaded has been corrupted.	1
0035h	Tape System Area Read Fail	The tape system area could not be read successfully at load time.	1
0036h	No Start of Data	The start of data could not be found on tape.	1
0037h	Reserved		
0040h			

Vendor Unique Page

The Vendor Unique page (30h) reports a variety of vendor-unique statistics.

Table 61. Vendor-Unique Parameters

Parameter Code	Description	Length (bytes)	Default Threshold
0000h	Number of records with a recovered data check while reading	4	FFFFFFFF
0001h	Number of records with a recovered data check while writing	4	FFFFFFFF
0002h	Number of read temporary errors detected by software	4	FFFFFFFF
0003h	Number of write temporary errors detected by software	4	FFFFFFFF
0004h	Number of times a read record was retried before recovery passed or failed	4	FFFFFFFF
0005h	Number of servo position units (24 mm) used up by defects	4	FFFFFFFF
0006h	Number of times read blocks were recovered after one retry (read transients)	4	FFFFFFFF
0007h	Number of times write blocks were recovered after one retry (write transients)	4	FFFFFFFF
0008h	Adjusted read corrections	4	FFFFFFFF
0009h	Number of blocks read from tape hardware corrected	4	FFFFFFFF
000Ah	Adjusted write corrections	4	FFFFFFFF
000Bh	Number of blocks written on tape hardware corrected	4	FFFFFFFF
000Ch	Number of errors detected by the controller when transferring data between the controller and interface adapter	4	FFFFFFFF
000Dh	Number of servo errors detected	4	FFFFFFFF
000Eh	Number of permanent errors logged in the event log	4	FFFFFFFF
000Fh	Number of non-compressed bytes transferred to the initiator	8	FFFFFFFF FFFFFFFF
0010h	Number of bytes read from tape	8	FFFFFFFF FFFFFFFF
0011h	Number of non-compressed bytes transferred from the initiator	8	FFFFFFFF FFFFFFFF
0012h	Number of bytes written on tape	8	FFFFFFFF FFFFFFFF
0013h	Number of blocks successfully read by the host	4	FFFFFFFF
0014h	Number of blocks successfully written by the host	4	FFFFFFFF
0015h	Number of blocks successfully read from tape	4	FFFFFFFF
0016h	Number of blocks successfully written on tape	4	FFFFFFFF
0017h	Number of 4k bytes left on tape from the current position	4	N/A

Vendor Unique Drive Statistics Page

The Vendor Unique Drive Statistics page (31h) reports a variety of vendor unique drive statistics. This page is available only on the T9840D drive.

Table 62. Vendor Drive Statistics Page Codes

Parameter Code	Description	Length (Bytes)	Default Threshold
0001h	Write data checks forward	4	FFFFFFFF
0002h	Write data defects	4	FFFFFFFF
0003h	Write data defects forward	4	FFFFFFFF
0004h	Write servo defects	4	FFFFFFFF
0005h	Write servo defects forward	4	FFFFFFFF
0006h	Write MIR defects	4	FFFFFFFF
0007h	Read transient conditions	4	FFFFFFFF
0008h	Read transient conditions forward	4	FFFFFFFF
0009h	Write transient conditions	4	FFFFFFFF
000Ah	Write transient conditions forward	4	FFFFFFFF
000Bh	Servo temporaries	4	FFFFFFFF
000Ch	Servo temporaries forward	4	FFFFFFFF
000Dh	Servo transients	4	FFFFFFFF
000Eh	Servo transients forward	4	FFFFFFFF
000Fh	Device read blocks corrected	4	FFFFFFFF
0010h	Device write blocks corrected	4	FFFFFFFF
0020h	Times track found dead	128	All FF's
0022h	Times track corrected	128	All FF's

Vendor Unique Drive Statistics Page

The Vendor Unique Drive Statistics page (32h) reports a variety of vendor unique drive statistics. This page is available only on the T9840D drive.

Table 63. Vendor Drive Statistics Page Codes

Parameter Code	Description	Length (Bytes)	Default Threshold
0010h	servo_stripe_PES_offtrack	40	FFFFFFFF
0011h	servo_stripe_dropout	40	FFFFFFFF

Mode Select Command

The Mode Select command specifies options and parameters for a device. StorageTek recommends the host system perform a Mode Sense command before each Mode Select command to determine the current settings and to avoid any unwanted alterations to other Mode Select fields.

The Mode Sense command determines which fields can be changed by the Mode Select command and what the default values are for these fields.

The tape drives support both 6- and 10-byte commands.

Table 64. Mode Select—6 Byte Command

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

Table 65. Mode Select—10 Byte Command

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

Mode Select data consists of a header, an optional block descriptor, and optional page data:

PF: Page format:

0 = No page formatted data
1 = Page formatted data follows block descriptor, or header

SP: Save parameters (must be 0)

0 = Save parameters not supported

Parameter List Length:

Contains the total number of bytes in the header, block descriptor, and all pages.

- If this length results in the truncation of the header, block descriptor, or any page, the command is rejected.
- If this length is 0, no mode select data is sent and the command is ignored.

Mode select data can be sent as:

- Header only
- Header and page formatted data
- Header and block descriptor
- Header, block descriptor, and page formatted data

Pages are sent in any order. If any page formatted data is sent, the PF bit is set in the command.

Mode Select Header Data

Table 66. Mode Select (6) Header Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 1	Reserved							
2	N/A	Buffered Mode			Speed Code			
3	Block Descriptor Length							

Table 67. Mode Select (10) Header Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 2	(MSB) Reserved (LSB)							
3	0	Buffered Mode			Speed Code			
4 5	Reserved							
6 thru 7	(MSB) Block Descriptor Length (LSB)							

Page data may follow header if 00 is returned for block descriptor length.

N/A: Not defined

Buffered Mode: Valid parameters are:

000 = Return status after data is on tape
001 = Return status when data is in the buffer

Speed Code: Must be 0 = Use default speed

Block Descriptor Length:

00 = No Block Descriptor
08 = Block Descriptor follows

Page data follows header if 00 is returned for block descriptor length.

Mode Select Block Descriptor Data

Table 68. Mode Select Block Descriptor Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Density Code							
1 thru 3	(MSB) Block Count (LSB)							
4	Reserved							
5 thru 7	(MSB) Block Length (LSB)							

Density Code: Valid parameters are:

00h = Default density
42h = T9840A default density
42h = T9840B default density
43h = T9940A default density
44h = T9940B default density
45h = T9840C default density
46h = T9840D default density
7Fh = Do not change density

Block Count: Must be 0

Block Length:

Variable block mode length is 0

Fixed block mode length 1 to 262,144

Note: If fixed block size is set, the fixed bit must be used with Read, Read Buffer, and Write commands.

Read/Write Error Recovery Page

Table 69. Mode Select Read/Write Error Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (01h)							
1	Page Length (0Ah)							
2	Reserved		TB	Reserved	ERR	PER	DTE	DCR
3	Read Retry Count							
4 thru 7	(MSB) Reserved (LSB)							
8	Write Retry Count							
9 thru 11	(MSB) Reserved (LSB)							

TB: Transfer block (must be 0)

0 = Unrecoverable data block not transferred

ERR: Enable early recovery (must be 0)

0 = Normal error recovery

PER: Post error (must be 0)

0 = Normal mode
1 = Return check condition on recovered errors

DTE: Disable transfer on error (must be 0)

0 = Normal mode
1 = Terminate data transfer after recovered error

DCR: Disable correction (must be 0)

0 = Always use error correction codes

Read Retry: Read retry count fields specify the number of times the target attempts recovery during read operations (must be 0).

Write: Retry: Write retry count fields specify the number of times the target attempts recovery during write operations (normally 0). Default is 0 and 1 is reduced error recovery.

Disconnect–Reconnect Page

Table 70. Mode Select Disconnect—Reconnect Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (02h)					
1	Page Length (0Eh)							
2	Buffer full ratio							
3	Buffer empty ratio							
4 thru 5	(MSB) Bus inactivity limit (LSB)							
6 thru 7	(MSB) Disconnect time limit (LSB)							
8 thru 9	(MSB) Connect time limit (LSB)							
10 thru 11	(MSB) Maximum burst size (LSB)							
12	EMDP	FARd	FAWrt	FAStat	Reserved	Reserved		
13	Reserved							
14 thru 15	(MSB) First burst size (LSB)							

PS: Parameters savable bit (must be 0)

0 = Not supported.

Buffer Full Ratio: (must be 0)

0 = Not supported.

Buffer Empty Ratio: (must be 0)

0 = Not supported.

Bus Inactivity Limit: (must be 0)

0 = Not supported.

Disconnect Time Limit: (must be 0)

0 = Not supported.

Connect Time Limit: (must be 0)

0 = Not supported.

Maximum Burst Size: (must be 0)

0 = No limit.

EMDP: Enable modify data pointers (must be 0)

0 = Modify data pointers is disabled.

FARd: Loop fairness algorithm read (must be 0)

0 = Target chooses.

FAWrt: Loop fairness algorithm write (must be 0)

0 = Target chooses.

FAStat: Loop fairness algorithm status (must be 0)

0 = Target chooses.

First Burst Size: (must be 0)

0 = No limit.

Data Compression Page

Table 71. Mode Select Data Compression Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (0Fh)					
1	Page Length (0Eh)							
2	DCE	DCC	Reserved					
3	DDE	RED		Reserved				
4 thru 7	(MSB) Compression Algorithm (LSB)							
8 thru 11	(MSB) Decompression Algorithm (LSB)							
12 thru 15	(MSB) Reserved (LSB)							

PS: Parameters savable bit (must be 0)
0 = Not supported.

DCE: Data compression enabled (changeable)

0 = Data compression on writes is disabled.
1 = Data compression on writes is enabled.

DCC: Data compression capable (controlled by configuration menu, not changeable)

0 = Not supported.
1 = Supported.

DDE: Data decompression enable (must always be 1)
1 = Data decompression on reads is enabled.

RED: Report Exception on Decompression (must be 00b)
00b = Not supported.

Compression Algorithm: (changeable)

00h = No compression algorithm.
01h = Default algorithm.

Decompression Algorithm: (changeable)

00h = No decompression algorithm.
01h = Default algorithm.

Device Configuration Page

Table 72. Mode Select Device Configuration Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (10h)					
1	Page Length (0Eh)							
2	Reserved	CAP	CAF	Active Format				
3	Active Partition							
4	Write Buffer Full Ratio							
5	Read Buffer Empty Ratio							
6 thru 7	(MSB) Write Delay Time (LSB)							
8	DBR	BIS	RSMK	AVC	SOCF		RBO	REW
9	Gap Size							
10	EOD Defined			EEG	SEW	Reserved		
11 thru 13	(MSB) Buffer Size at Early Warning (LSB)							
14	Select Data Compression Algorithm							
15	Reserved							

PS: Parameters savable bit (must be 0)
0 = Not supported

CAP: Change active partition (must be 0)
0 = Active partition not changeable

CAF: Change active format (must be 0)
0 = Active format not changeable

Active Format: Must be 0
0 = Default format not changeable

Active Partition: Must be 0
0 = Default partition not changeable

Write Buffer Full Ratio: Must be 0
0 = Controlled by device

Read Buffer Empty Ratio: Must be 0
0 = Controlled by device

Write Delay Time: (must be 28h)
4 seconds (28h)

DBR: Data buffer recovery (must be 1)
1 = Supports recovered buffer data

BIS: Block IDs supported (must be 1)
1 = Tape format includes block ID

RMSK: Report setmarks (must be 0)
0 = Setmarks not supported

AVC: Automatic velocity control (must be 0)
0 = Speed not selectable

SOCF: Stop on consecutive filemarks (changeable)

00b = Stop read ahead when buffer is full
01b = Stop on first filemark
10b = Stop on two consecutive filemarks
11b = Stop on three consecutive filemarks

RBO: Recover buffer order (must be 1)
1 = Last in first out

REW: Report early warning (must be 0)
0 = Report early warning only on Write and Write Filemarks commands

Gap Size: Must be 0
0 = Gap size not selectable

EOD Defined: End of data (must be 000b)
000b = Default EOD only

EEG: EOD enabled generation (must be 1)
1 = EOD generated per EOD field

SEW: Synchronize at early warning (Default is 1)

0= Buffered write data and filemarks not flushed at Early Warning
1 = Buffered write data and filemarks written when Early Warning detected

Buffer Size at Early Warning: Must be 0
0 = Buffer size not selectable

Select Algorithm: Select Data Compression Algorithm (changeable)

00h = No data compression
01h = LZ1 compression of write records

Note: The Select Algorithm field will be ignored if Mode Page 0Fh (Data Compression) is also sent in the same Mode Select command.

Fibre Channel Logical Unit Control Page

Table 73. Fibre Channel Logical Unit Control Page (18h)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (18h)					
1	Page Length (06h)							
2	Reserved							
3	Reserved							EPDC
4 thru 7	(MSB) Reserved (LSB)							

PS: Parameters Savable bit (must be 0)

0 = Not supported

EPDC: Enable Precise Delivery Checking (must be 0)

0 = Not supported

Note: When the drive supports command queuing, this bit will be supported.

Fibre Channel Port Control Page

Table 74. Fibre Channel Port Control Page (19h)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (19h)					
1	Page Length (06h)							
2	Reserved							
3	DTFD	PLPB	DDIS	DLM	DSA	ALWI	DTIPE	DTOLI
4 thru 6	(MSB) Reserved (LSB)					RR_TOV units		
7	Resource Recovery Time Out Value (RR_TOV)							

PS: Parameters Savable bit (must be 0)
0 = Not supported

DTFD: Disable Target Fabric Discovery (must be 0)
0 = Not supported

PLPB: Prevent Loop Port Bypass (must be 0)
0 = Not supported

DDIS: Disable Discovery (must be 0)
0 = Not supported

DLM: Disable Loop Master (must be 0)
0 = Not supported

DSA: Disable Soft Address (must be 0)
0 = Not supported

ALWI: Allow Login Without Loop Initialization (must be 0)
0 = Not supported

DTIPE: Disable Target Initiated Port Enable (must be 0)
0 = Not supported

DTOLI: Disable Target Originated Loop Initialization (must be 0)
0 = Not supported

RR_TOV units: (must be 101b)
101b = 10 second units

RR_TOV value: (must be 0x1E)
0x1E = 300 seconds

TapeAlert Page

Table 75. Mode Select TapeAlert Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Page Code (1Ch)							
1	Page Length (0Ah)							
2	Perf	Reserved			DExcpt	Test	Reserved	LogErr
3	Reserved			EWasc	MRIE (3h)			
4 thru 7	(MSB) Interval Timer (LSB)							
8 thru 11	(MSB) Report Counter / Test Flag Number (LSB)							

Perf: Performance bit (must be 0)

0 = Informational exception operations that causes delays are acceptable

DExcpt: Exception bit (must be 1)

1 = Indicates the target disables all information exception operations ignoring the MRIE field.

Note: In this mode the software must poll the TapeAlert Log page.

Test: Test operations bit (must be 0)

0 = Do not generate any false/test informational exception conditions

LogErr: Log information exception conditions (must be 0)

0 = Logging of informational exception conditions is vendor-specific

EWasc: Early Warning

0 = Disable reporting an Early Warning, MRIE field, ignored

MRIE: This field indicates the method the tape drive uses to report informational exception conditions (must be set to 3h)

3h = Indicates the tape drive reports any informational exception conditions by returning Check Condition status

Interval Timer: (must be 0)

Report Count/Test Flag Number: (must be 0)

Mode Sense Command

The Mode Sense (6) and Mode Sense (10) commands return the current operating modes and parameters of a device to the host. The Mode Sense commands also return the default parameters or information on which fields and bits can be changed using the Mode Select command. The device returns a header, block descriptor, and one or all supported pages following the block descriptor.

Note: The tape drives support both 6- and 10-byte commands. The Mode Sense (10) command allows for a longer Allocation length, but otherwise operates identically to the Mode Sense (6) command.

Table 76. Mode Sense Command—6 Byte

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

Table 77. Mode Sense Command—10 Byte

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

DBD: Disable block descriptor bit:

0 = Return block descriptor after header

1 = Do not return the block descriptor

PC: The page control field defines the type of values returned in the mode pages. The header and block descriptor always return the current values regardless of the setting.

00b = Return current values

01b = Return changeable values

10b = Return default values

11b = Return saved values (not supported)

Page Code: Page code field specifies the mode page or pages to return after block descriptor or following the header if the DBD bit is set. If page code is not supported, this command is rejected. The following pages are supported.

00h = No page data

01h = Return Read/Write Error Recovery page

02h = Return Disconnect–Reconnect page

0Fh = Return Data Compression page

10h = Return Device Configuration page

18h = Return Fibre Channel Logical Unit Control page

19h = Return Fibre Channel Port Control page

1Ch = Return Tape Alert page

3Fh = Return all pages

Allocation Length: Maximum number of bytes to transfer to the host

If both PC and Page Code are 00, no page data is returned.

Mode Sense Header Data

Mode Sense (6) returns a 4-byte header. Mode Sense (10) returns an 8-byte header.

Table 78. Mode Sense (6) Header Data

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 79. Mode Sense (10) Header Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 1	(MSB) Mode Data Length (LSB)							
2	Medium Type							
3	WP	Buffered Mode			Speed			
4 5	Reserved							
6 thru 7	(MSB) Block Descriptor Length (LSB)							

Medium Type: Will always be 0

0 = Vendor-specific (Reserved)

WP: Write protect

0 = Not file-protected
1 = File-protected

Buffered Mode: Valid values are:

000b = The target shall not report good status on write commands until the data is written on tape.

001b = The target reports good status after all data has been transferred to the targets data buffer

010b – 111b = Reserved

Speed: Will always be 0

0 = Default speed

Mode Sense Block Descriptor Data

Table 80. Mode Sense Block Descriptor Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Density Code							
1 thru 3	(MSB) Block Count (LSB)							
4	Reserved							
5 thru 7	(MSB) Block Length (LSB)							

Density Code: Valid parameters are:

42h = T9840A default density

42h = T9840B default density

43h = T9940A default density

44h = T9940B default density

45h = T9840C default density

46h = T9840D default density

Block Count: Will always be 0

Block Length:

Variable block mode length is 0

Fixed block mode length 1 to 262,144

Notes:

1. Density code 43h will be returned by a T9940B drive while reading a tape written on a T9940A drive.
2. Density code 42h will be returned by a T9840C or T9840D drive while reading a tape written on T9840A or T9840B drives.
3. Density code 45h will be returned by a T9840D drive while reading a tape written on a T9840C drive.

Read/Write Error Recovery Page

Table 81. Mode Sense Read/Write Error Recovery Page

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

PS: Parameters savable bit (will always be 0)

0 = Not supported

TB: Transfer block (will always be 0)

0 = Unrecoverable data block not transferred

ERR: Enable early recovery (will always be 0)

0 = Normal error recovery

PER: Post error (will always be 0)

0 = Normal mode

DTE: Disable transfer on error (will always be 0)

0 = Normal mode

DCR: Disable correction (will always be 0)

0 = Always use error correction codes

Read Retry: Read retry count fields specify the number of times the target attempts recovery during read operations (will always be 0).

Write: Retry: Extent of error recovery during write operations.

0 = Normal
1 = Limited Error Recovery

Disconnect–Reconnect Page

Table 82. Mode Sense Disconnect—Reconnect Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (02h)					
1	Page Length (0Eh)							
2	Buffer full ratio							
3	Buffer empty ratio							
4 thru 5	(MSB) Bus inactivity limit (LSB)							
6 thru 7	(MSB) Disconnect time limit (LSB)							
8 thru 9	(MSB) Connect time limit (LSB)							
10 thru 11	(MSB) Maximum burst size (LSB)							
12	EMDP	FARd	FAWrt	FAStat	Reserved	Reserved		
13	Reserved							
14 thru 15	(MSB) First burst size (LSB)							

PS: Parameters savable bit (will always be 0)

0 = Not supported.

Buffer Full Ratio: (will always be 0)

0 = Not supported.

Buffer Empty Ratio: (will always be 0)

0 = Not supported.

Bus Inactivity Limit: (will always be 0)

0 = Not supported.

Disconnect Time Limit: (will always be 0)

0 = Not supported.

Connect Time Limit: (will always be 0)

0 = Not supported.

Maximum Burst Size: (will always be 0)

0 = No limit.

EMDP: Enable modify data pointers (will always be 0)

0 = Modify data pointers is disabled.

FARd: Loop fairness algorithm read (will always be 0)

0 = Target chooses.

FAWrt: Loop fairness algorithm write (will always be 0)

0 = Target chooses.

FAStat: Loop fairness algorithm status (will always be 0)

0 = Target chooses.

First Burst Size: (will always be 0)

0 = No limit.

Data Compression Page

Table 83. Mode Sense Data Compression Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (0Fh)					
1	Page Length (0Eh)							
2	DCE	DCC	Reserved					
3	DDE	RED	Reserved					
4 thru 7	(MSB) Compression Algorithm (LSB)							
8 thru 11	(MSB) Decompression Algorithm (LSB)							
12 thru 15	(MSB) Reserved (LSB)							

PS: Parameters Savable bit (will always be 0)

0 = Not supported.

DCE: Data Compression Enabled

0 = Data compression on writes is disabled.
1 = Data compression on writes is enabled.

DCC: Data Compression Capable (controlled only by operator configuration menu)

0 = Not supported.
1 = Supported.

DDE: Data Decompression Enable (will always be 1)

1 = Data decompression on reads is enabled.

RED: Report Exception on Decompression (will always be 0)

0 = Not supported.

Compression Algorithm: (will always be 01h)

01h = Default algorithm.

Decompression Algorithm: (will always be 01h)

01h = Default algorithm.

Device Configuration Page

Table 84. Mode Sense Device Configuration Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (10h)					
1	Page Length (0Eh)							
2	Reserved	CAP	CAF	Active Format				
3	Active Partition							
4	Write Buffer Full Ratio							
5	Read Buffer Empty Ratio							
6 thru 7	(MSB) Write Delay Time (LSB)							
8	DBR	BIS	RSMK	AVC	SOCF		RBO	REW
9	Gap Size							
10	EOD Defined			EEG	SEW	Reserved		
11 thru 13	(MSB) Buffer Size at Early Warning (LSB)							
14	Select Data Compression Algorithm							
15	Reserved							

PS: Parameters savable bit (will always be 0)

0 = Not supported

CAP: Change active partition (will always be 0)

0 = Active partition not changeable

CAF: Change active format (will always be 0)

0 = Active format not changeable

Active Format: Will always be 0

0 = Default format not changeable

Active Partition: Will always be 0

0 = Default partition not changeable

Write Buffer Full Ratio: Will always be 0

0 = Controlled by device

Read Buffer Empty Ratio: (will always be 0)

0 = Controlled by device

Write Delay Time:

4 seconds (28h)

DBR: Data buffer recovery (will always be 1)

1 = Supports recovered buffer data

BIS: Block IDs supported (will always be 1)

1 = Tape format includes block ID

RMSK: Report setmarks (will always be 0)

0 = Setmarks not supported

AVC: Automatic velocity control (will always be 0)

0 = Speed not selectable

SOCF: Stop on consecutive filemarks (default is 10b)

00b = Stop read ahead when buffer is full
01b = Stop on first filemark
10b = Stop on two consecutive filemarks
11b = Stop on three consecutive filemarks

RBO: Recover buffer order (will always be 1)

1 = Last in first out

REW: Report early warning (will always be 0)

0 = Report early warning only on Write and Write Filemarks commands

Gap Size: Will always be 0

0 = Gap size not selectable

EOD Defined: End of data (will always be 0)

000b = Default EOD only

EEG: EOD enabled generation (will always be 1)

1 = EOD generated per EOD field

SEW: Synchronize at early warning

0 = Buffered write data and filemarks not flushed at Early Warning
1 = Buffered write data and filemarks written when Early Warning detected

Buffer Size at Early Warning: Will always be 0

0 = Buffer size not selectable

Select Algorithm: Select Data Compression Algorithm

00h = No data compression
01h = LZ1 compression of write records

Fibre Channel Logical Unit Control Page

Table 85. Fibre Channel Logical Unit Control Page (18h)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (18h)					
1	Page Length (06h)							
2	Reserved							
3	Reserved							EPDC
4 thru 7	(MSB) Reserved (LSB)							

PS: Parameters Savable bit (will always be 0)

0 = Not supported

EPDC: Enable Precise Delivery Checking (will always be 0)

0 = Not supported

Note: When the drive supports command queuing, this bit will be supported.

Fibre Channel Port Control Page

Table 86. Fibre Channel Port Control Page (19h)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (19h)					
1	Page Length (06h)							
2	Reserved							
3	DTFD	PLPB	DDIS	DLM	DSA	ALWI	DTIPE	DTOLI
4 thru 6	(MSB) Reserved (LSB)					RR_TOV units		
7	Resource Recovery Time Out Value (RR_TOV)							

PS: Parameters Savable bit (will always be 0)
0 = Not supported

DTFD: Disable Target Fabric Discovery

0 = Public Loop behavior supported
1 = Private Loop only behavior supported

PLPB: Prevent Loop Port Bypass (will always be 0)
0 = Not supported

DDIS: Disable Discovery (will always be 0)
0 = Not supported

DLM: Disable Loop Master (will always be 0)
0 = Not supported

DSA: Disable Soft Address (will always be 0)
0 = Not supported

ALWI: Allow Login Without Loop Initialization (will always be 0)
0 = Not supported

DTIPE: Disable Target Initiated Port Enable (will always be 0)
0 = Not supported

DTOLI: Disable Target Originated Loop Initialization (will always be 0)
0 = Not supported

RR_TOV units: (will always be 101b)
101b = 10 second units

RR_TOV value: (will always be 0x1E)
0x1E = 300 seconds

TapeAlert Page

Table 87. Mode Sense Tape Alert page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved		Page Code (1Ch)				
1	Page Length (0Ah)							
2	Perf	Reserved			DExcpt	Test	Reserved	LogErr
3	Reserved				MRIE (3h)			
4 thru 7	(MSB) Interval Timer (LSB)							
8 thru 11	(MSB) Report Counter / Test Flag Number (LSB)							

Perf: Performance bit (will always be 0)

0 = Informational exception operations that causes delays are acceptable

DExcpt: Exception bit (will always be 1)

1 = Indicates the target disables all information exception operations ignoring the MRIE field.

Note: In this mode the software must poll the TapeAlert Log page.

Test: Test operations bit (will always be 0)

0 = Do not generate any false/test informational exception conditions

LogErr: Log information exception conditions (will always be 0)

0 = Logging of informational exception conditions is vendor–specific

MRIE: This field indicates the method the tape drive uses to report informational exception conditions – will always be 3h.

3h = Indicates the tape drive reports any informational exception conditions by returning Check Condition status

Interval Timer: (will always be 0)

Report Counter/Test Flag Number: (will always be 0)

Persistent Reserve In Command

The Persistent Reserve In command returns information about registered persistent reservation keys and the currently active persistent reservations.

Table 88. Persistent Reserve In Command

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

Service Action:

00h = Read Keys: Returns a list of all registered persistent reservation keys.

01h = Read Reservation: Returns information about the currently active persistent reservation.

Allocation Length: Maximum length of parameter data to return

Read Keys

A Persistent Reserve In command with a Service Action of 00h (Read Keys) will return a list of the reservation keys for all currently registered initiators.

Table 89. Read Keys Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 3	(MSB) Generation (LSB)							
4 thru 7	(MSB) Additional Length (n-7) (LSB)							
8 thru n	(MSB) Reservation Keys (8 bytes each) (LSB)							

Generation: A 32-bit counter that is incremented when persistent reservations are changed or registration keys are modified

Additional Length: Length of the Reservation Keys list. If 0, no Reservation Keys are active

Reservation Keys: A list of all registered reservation keys known by the device

Read Reservations

A Persistent Reserve In command with a Service Action of 01h (Read Reservations) will return information about the currently active persistent reservation.

Table 90. Read Reservations Parameter Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 3	(MSB) Generation (LSB)							
4 thru 7	(MSB) Additional Length (n-7) (LSB)							
8 thru n	(MSB) Reservation descriptor(s) (see Table 91) (LSB)							

Table 91. Reservation Descriptors

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 7	(MSB) Reservation Key (LSB)							
8 thru 11	(MSB) Scope-Specific Address (LSB)							
12	Reserved							
13	Scope				Type			
14 15	Obsolete							

Generation: A 32-bit counter that is incremented when persistent reservations are changed or registration keys are modified

Additional Length: Length of the Reservation Descriptors that follow. This will be 16 if a persistent reservation is active. If no persistent reservation is active, this field will be 0 and the following fields will not be returned

Reservation Key: Reservation key for the active Persistent Reservation

Scope Specific Address: Not used, will be 0

Scope: (will always be 0)

0 = Persistent Reservation is for the Logical Unit

Type: Persistent Reservation type

3h = Exclusive Access for one initiator
6h = Exclusive Access by all registered initiators

Persistent Reserve Out

The Persistent Reserve Out command is used to register Reservation Keys and create Persistent Reservations using these keys.

Table 92. Persistent Reserve Out Command

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

Service Action: Persistent Reserve function to perform

00h = Register. Register a Reservation Key.
01h = Reserve. Create a persistent reservation using a previously registered reservation key.
02h = Release. Release a persistent reservation
03h = Clear. Remove all reservation keys and reservations
04h = Preempt. Take over a reservation previously made by another initiator
05h = Preempt and Abort. Take over a reservation and abort commands.

Scope: (must be 0)

00h = Logical Unit reservations

Type: Type of reservation to make or release

03h = Exclusive Access
06h = Exclusive Access, registrants only

Parameter List Length: Length of parameter data sent (must be 18h)

Parameter List

Table 93. Persistent Reserve Out Parameter List

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 7	(MSB) Reservation Key (LSB)							
8 thru 15	(MSB) Service Action Reservation Key (LSB)							
16 thru 19	(MSB) Scope Specific Address (LSB)							
20	Reserved							APTPL
21 thru 23	(MSB) Reserved (LSB)							

Reservation Key: Contains the currently registered key for the initiator. An unregistered initiator sets this field to zero when registering

Service Action Reservation Key: Contains the new Reservation Key for a Register, Preempt, or Preempt and Abort service action

Scope Specific Address: not used, will be ignored

APTPL: Active Persist Through Power Lost (must be 0)

0 = Reservations will be cleared when power is lost.

Registering a Reservation Key

An initiator must register a key before performing any other Persistent Reserve Out commands. To register a key, the initiator sends a Persistent Reserve Out command with the Service Action field set to Register (0h), and the Parameter List length set to 18h. The Scope and Type fields will be ignored. In the parameter data, the Reservation Key field is set to 0h, the Service Action Reservation Key is set to the desired key value and the APTPL bit to 0h. The Scope Specific Address field will be ignored. If the initiator is already registered, the key can be changed by sending the same command with the Reservation Key field set to the current reserved key.

Once an initiator has registered a key, it becomes a registered initiator and can perform other Persistent Reserve functions.

Creating a Persistent Reservation

To create a Persistent Reservation, a registered initiator sends a Persistent Reserve Out command with a Service Action field of Reserve (01h). The Scope field is set to 0, the Type field to Exclusive Access (03h) or Exclusive Access Registrants Only (06h), and the Parameter List Length to 18h. In the parameter data, the Reservation Key is set to the currently registered key for this initiator, the Service Action Reservation Key and Scope-Specific Address fields are ignored, and the APTPL bit is set to zero.

A Type field of Exclusive Access will reserve the device for this initiator only. A Type field of Exclusive Access, Registrants Only will allow access by all initiators registered with the same Reservation Key.

When a reservation of type Exclusive Access, Registrants Only is cleared, a unit attention condition is established for the initiators holding the reservation.

Releasing a Persistent Reservation

To release a Persistent Reservation, a registered initiator sends a Persistent Reserve Out command with a Service Action field of Release (02h). The Scope and Type fields must match those used when making the reservation. The Parameter List Length is set to 18h. In the parameter data, the Reservation Key is set to the currently registered key for this initiator, the Service Action Reservation Key and Scope-Specific Address field are ignored and the APTPL bit is set to zero.

When a reservation of type Exclusive Access, Registrants Only is released, a unit attention condition is established for the other registered initiators.

Clearing all Persistent Reservations and Keys

To clear all Persistent Reservations and key registrations, a registered initiator sends a Persistent Reserve Out command with a Service Action field of Clear (03h). The Scope and Type fields are ignored. The Parameter List Length is set to 18h. In the parameter data, the Reservation Key is set to the currently registered key for this initiator, the Service Action Reservation Key and Scope–Specific Address fields are ignored and the APTPL bit is set to zero.

Clearing reservations should only be done in an error recovery situation.

Preempting Reservations Made by Another Initiator

A registered initiator can clear active reservations and registration keys by issuing a Persistent Reserve Out command. The Service Action field is set to Preempt, the Scope and Type fields are ignored. The Parameter List Length is set to 18h. In the parameter data, the Reservation Key is set to the currently registered key for this initiator. The Service Action Reservation Key field contains the registered key to be cleared. If the Service Action Reservation Key was used to make the currently active persistent reservation, the reservation is released.

If the Service Action field is set to Preempt and Abort instead of Preempt, all commands belonging to initiators who registered with the cleared key will be aborted.

When a reservation of type Exclusive Access, Registrants Only is preempted, a unit attention condition is established for the preempted initiators.

Prevent/Allow Medium Removal Command

The Prevent/Allow Medium Removal command enables and disables the unload switch. The switch is enabled unless this command is used.

Table 94. Prevent/Allow Medium Removal Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Eh)							
1 thru 3	(MSB) Reserved (LSB)							
4	Reserved							Prevent
5	Control Byte							

Prevent: Prevent medium removal:

00 = Allow medium removal (enable switch)
01 = Prevent medium removal (disable switch)

Notes:

1. The tape does not have to be ready when a Prevent command is issued. The Prevent Medium Removal command disables only the unload switch. Unload commands from the host are still permitted.
2. Allow Medium Removal returns status to the host only after all buffered data is written on tape (the tape must be loaded and ready).
3. Medium removal is allowed only after all initiators that issued a Prevent have issued an Allow Medium Removal command.
4. A reset condition clears the prevent condition.

Read Command

The Read command transfers the next record or records from tape to the host. After successful completion of a Read Command, the tape is positioned after the last block read.

Table 95. Read Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (08h)							
1	Reserved						SILI	Fixed
2 thru 4	(MSB) Transfer Length (LSB)							
5	Control Byte							

SILI: Suppress illegal length indication

0 = Check condition status is returned if the record length does not match Transfer Length. ILI (Illegal Length Indication) and Valid bits in sense data are set.

In variable block mode, the Information bytes are set to the Transfer Length minus the actual record size.

In fixed block mode, Information bytes are set to the Transfer Length minus the number of blocks transferred, not including the incorrect length block.

1 = Return Check Condition status only when the actual record length is larger than transfer length, and the Mode Sense block length field in not zero.

Note: This option is not allowed if the fixed bit is 1.

Fixed: Indicates the block mode for data transfer:

0 = Variable block mode. Transfer Length is the number of bytes requested.

1 = Fixed block mode. Transfer Length is the number of blocks requested.

Transfer Length: Number of blocks or bytes requested.

Notes:

1. Setting of the Fixed bit is only allowed if the fixed block length is not zero. In fixed block mode, the record size is specified by the block length. The Mode Sense command reports the fixed block length.
2. If a filemark is encountered, Check Condition status is returned, the filemark and valid bits in sense data are set, and tape is positioned after the file mark. In variable block mode the Information bytes are set to transfer length. In fixed block mode, Information bytes are set to transfer length minus the actual number of blocks read, not counting the filemark.
3. If end-of-data is encountered, Check Condition status is returned, the Sense Key is set to Blank Check, and the valid bit is set. Tape is positioned after the last valid record. Information Bytes are calculated as for a file mark.
4. A Read past the logical end-of-tape (LEOT) does not generate a Check Condition. Reading into the physical end-of-tape (PEOT) generates Check Condition status with a sense key indicating Medium Error.
5. After a Read command, the drive continues reading records into the buffer until the buffer is full or end of data or consecutive filemarks are found. Reading ahead allows faster response to subsequent Read commands.
6. A transfer length of zero will not transfer any data, does not generate Check Condition status, and does not change the position of the tape.

Read Attribute Command

The Read Attribute command returns information associated with the media on a T9840D drive.

If the media is not ready, the command will be rejected.

Table 96. Read Attribute Command

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

Service Action: Type of data to return

00h = Return attribute values.

01h = Return attribute list.

Volume number: Not supported, must be 0.

Partition number: Not supported, must be 0.

First attribute Identifier: ID of first attribute to return when attribute values are requested.

Attribute Values Data

The format of the attributes values data is as follows:

Table 97. Read Attribute Value Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 3	(MSB) Available Data (n – 3) (LSB)							
4 – 5	Attribute ID							
6	RO	Reserved					Format	
7 – 8	Attribute Length (bytes)							
9 – n	Attribute Value							

RO: Read only

1 = Read only attribute

Format: Format of attribute value field

00b = Binary

Supported Attribute IDs

Table 98. Supported Attribute IDs

ID	Length	Description
224h	8	First Encrypted Block 0h= An encrypted tape. FFFFFFFFFFFFFFFFh = A non-encrypted tape.

Attribute List Data

Table 99. Attribute List Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 – 3	(MSB) Available Data (2h) (LSB)							
4 – 5	(MSB) Attribute ID (0224h) (LSB)							

Read Block Limits Command

The Read Block Limits command establishes the longest and shortest record size supported by the tape drive. Six bytes of data are returned by this command.

Table 100. Read Block Limits Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (05h)							
1 thru 4	(MSB) Reserved (LSB)							
5	Control Byte							

Read Block Limits Data

Table 101. Read Block Limits Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved			Granularity				
1 thru 3	(MSB) Maximum Block Length (LSB)							
4 thru 5	(MSB) Minimum Block Length (LSB)							

Notes:

1. Granularity is 0
2. Maximum block length is 262,144
3. Minimum block length is 1 byte

Read Buffer Command

The Read Buffer retrieves trace dump data from T9x40 tape drives. Any buffered write data and filemarks are written on the tape *before* this operation starts.

Table 102. Read Buffer Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (3Ch)							
1	LUN			Reserved		Mode		
2	Buffer ID							
3 thru 5	(MSB) Buffer Offset (LSB)							
6 thru 8	(MSB) Allocation Length (LSB)							
9	Vendor–specific		Reserved				Flag	Link

Mode: Read buffer mode (must be 001b)

001b = Vendor-specific

Buffer ID:

FBh = Drive statistics data
FCh = MIR data
FDh = Permanent traces data
FEh = Event log data
FFh = Dump buffer

Buffer Offset: Offset from start of buffer (this field is ignored)

Allocation Length: Maximum length of dump data to transfer

Notes:

1. The tape drive must be unloaded when reading dump or event log data.
2. The tape drive must be loaded when reading MIR data.
3. The tape drive may be either loaded or unloaded when reading permanent traces data.
4. The minimum allocation length when reading dump data is 8,192 bytes.
5. The minimum allocation length for other buffers is 4,096 bytes.
6. When reading event log data the allocation length must be one of the following values: 4096, 8192, 16384, 32768, 65536, 131072 or 262144 bytes.
7. Multiple Read Buffer commands may be required to read the entire contents of a particular buffer. Blocks of data are transferred in sequential order. The last transfer may be truncated. All Read Buffer commands needed to read a complete buffer must use the same allocation length. The sequence of read buffer commands required to read a complete buffer should continue uninterrupted until a sense key of Blank Check is returned.
8. The dump buffer may contain multiple dumps up to a maximum of 4 Megabytes per dump; a dump is typically less than 2 Megabytes.
9. If no data remains to be transferred, Check Condition status is returned. The sense key is set to Blank Check with the valid bit set.

Read Position Command

The Read Position command returns information about the current logical and physical block address of the tape. This command returns 20 bytes of data from the logical unit.

Note: Block addresses are used with the Locate and Recover Buffered Data commands.

Table 103. Read Position Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (34h)							
1	Reserved					TCLP	LONG	BT
2 thru 8	(MSB) Reserved (LSB)							
9	Control Byte							

TCLP: Total Current Logical Position (must be 0)

0 = Return first and last block location

LONG: Long Format (must be 0)

0 = Return 20 bytes of data

BT: Block address type:

0 = SCSI logical block address
1 = SCSI logical block address

Read Position Data

Table 104. Read Position Data

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

BOP: Beginning of partition:

0 = Tape is not positioned at BOT
1 = Tape is positioned at BOT

EOP: End of partition:

0 = Tape is not past LEOT
1 = Tape is past LEO

BCU: Block count unknown:

0 = Blocks in buffer field are valid
1 = Blocks in buffer field are invalid

BCYU: Byte count unknown:

0 = Byte count field is valid
1 = Byte count field is invalid

BPU: Block position unknown:

0 = Block positions are valid
1 = Current positions are unknown or not available

PERR: Position error:

0 = Location fields are valid
1 = Location fields have overflowed and are invalid

Partition Number: 0 = Only partition supported

First Block: Address of the next record in the buffer assuming the next host operation is a write.

Last Block: Address of the next record on tape assuming the next operation is a write.

Number of blocks: Number of write records separating buffer logical position from the actual position of the tape. If this field is zero, the host and tape are synchronized.

Number of bytes: The number of uncompressed write bytes in the buffer.

Receive Diagnostic Results

The Receive Diagnostic Results command returns diagnostic information.

Table 105. Receive Diagnostic Results Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Ch)							
1	Reserved							PCV
2	Page Code							
3 thru 4	(MSB) Allocation Length (LSB)							
5	Control Byte							

PCV: Page Code Valid

0 = Return data defined by resent Send Diagnostic Command.
1 = Return data defined by page code

Page Code: Diagnostic data page to return

00 = List of supported pages
C0 = Diagnostics results page

Allocation Length: Maximum Allowed Length in Bytes of Returned Data.

Receive Diagnostic Results Page Format

Table 106. Receive Diagnostic Results Page Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code							
1	Reserved							
2 thru 3	(MSB) Page Length (n-3) (LSB)							
4 – n	Diagnostic Parameter							

Page Code: Identifies Diagnostic Page

Note: The page length reflects the absolute length of the page, and is not adjusted because of the allocation length.

Recover Buffered Data Command

The Recover Buffered Data command reads data from the buffer that could not be written on tape because of an error. Records are returned in last-in-first-out order.

Table 107. Recover Buffered Data Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (14h)							
1	Reserved						SILI	Fixed
2 thru 4	(MSB) Transfer Length (LSB)							
5	Control Byte							

SILI: Suppress illegal length indication (must be 0)

0 = Check condition status is returned if the record length does not match Transfer Length. ILI (Illegal Length Indication) and Valid bits in sense data are set.

- In variable block mode, the Information bytes are set to the Transfer Length minus the actual record size.
- In fixed block mode, Information bytes are set to the Transfer Length minus the number of blocks transferred, not including the incorrect length block.

Fixed: Fixed mode

0 = Variable block mode
1 = Fixed block mode

Transfer Length: Number of bytes or blocks to read.
When recovering records from the buffer, in variable block mode the Transfer Length should be larger than the maximum expected record size. Once a Recover Buffered Data command is issued, the record is cleared from the buffer.

Notes:

1. If no write records were trapped in the buffer, or all records have already been cleared, the Recover Buffered Data command returns Check Condition status with the EOM bit set in Sense Byte 2.
2. If a filemark is encountered, Check Condition status is returned, the filemark and valid bits in sense data are set.
3. Data buffer sizes are:

   9840 = 8 Megabytes of compressed data.
   T9840B = 32 Megabytes of compressed data.
   T9840C = 64 Megabytes of compressed data.
   T9840D = 64 Megabytes of compressed data.
   T9940A = 16 Megabytes of compressed data.
   T9940B = 64 Megabytes of compressed data.

Release Unit Command

The Release Unit command cancels reservations made by the Reserve Unit Command from the current initiator. If the unit is reserved by another initiator, good status is returned, but the unit is not released. If the unit is not currently reserved, good status is also returned.

Note: The tape drives support both 6- and 10-byte versions of the Release command.

Table 108. Release Unit—6 Byte Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (17h)							
1	Reserved			Obsolete				Extent
2	Reservation Identification							
3 thru 4	(MSB) Reserved (LSB)							
5	Control Byte							

Table 109. Release Unit—10 Byte Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (57h)							
1	Reserved			3rd Pty	Reserved		LongID	Extent
2	Reservation Identification							
3	Third Party Device ID							
4 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Parameter List Length (LSB)							
9	Control Byte							

Extent: Extent release (must be 0)

0 = Not supported

3rd Party: Third party reservations (must be 0)

0 = Cancel reservations for current host

Long ID: SCSI ID for third party release (must be 0)

Reservation Identification: (must be 0)

0 = Not supported

Third Party Device ID: (must be 0)

Parameter List Length: (must be 0)

Report Density Support Command

The Report Density command returns information about the density codes and recording formats.

Table 110. Report Density Support Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (44h)							
1	Reserved							Media
2 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Allocation Length (LSB)							
9	Control Byte							

Media:

0 = Return information about the density supported by the tape drive

1 = Return information about the density supported by the media

Allocation Length: Maximum size of data returned

Note: If the media bit is set to one, the tape drive must have a tape loaded.

Report Density Support Data

Table 111. Report Density Support Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 1	(MSB) Available Density Support Length (LSB)							
2-3	Reserved							
4	Primary Density Code							
5	Secondary Density Code							
6	WRTOK	DUP	Deflt	Reserved				
7-8	Reserved							
9 thru 11	(MSB) Bits per MM (LSB)							
12 thru 13	(MSB) Media Width (LSB)							
14 thru 15	(MSB) Tracks (LSB)							
16 thru 19	(MSB) Capacity (LSB)							
20 thru 27	(MSB) Assigning Organization (LSB)							
28 thru 35	(MSB) Density Name (LSB)							
36 thru 55	(MSB) Description (LSB)							

The T9940B will return two Density Support Blocks. The first block (bytes 4 to 55 of Table 4-68) will be for density code 43h. The second block will be for density code 44h and will start at byte 56.

The T9840C will also return two Density Support Blocks. The first block will be for density code 42h. The second block will be for density code 45h.

The T9840D will return three density support blocks for density codes 42h, 45h, and 46h.

Available Density Support Length: Control Data that follows.

36h = One density support block returned

6Ah= Two density support blocks returned (T9940B and T9840C)

9Eh = Three density support blocks returned (T9840D)

Primary Density Code:

42h = Default density code for T9840A

42h = Default density code for T9840B

43h = Default density code for T9940A

44h = Default density code for T9940B

45h = Default density code for T9840C

46h = Default density code for T9840D

Secondary Density Code:

00h = Selects the same density code

WRTOK:

0 = Writes not permitted with this density code. (T9940B, T9840C, and T9840D)

1 = Writing in this density code is OK

DUP: Will always be 0

0 = Only 1 density support data block for this density code.

Deflt: Default density code

0 = This is not the default density code. (T9940B, T9840C, and T9840D)

1 = This is the default density code.

Bits per MM: Indicates the bit density per millimeter for this recording format.

0 = Not Applicable

Media Width: Indicates the width of media in tenths of a millimeter.

127 mm = 1/2 inch

Tracks: Number of tracks with this recording format:

288 = Tracks for T9840A, T9840B, T9840C and T9940A

576 = Tracks for T9840D and T9940B

Capacity: Approximate capacity of the media in 1,000,000 byte measurement units.

20,000 (4E20h) = T9840A cartridge tape capacity

20,000 (4E20h) = T9840B cartridge tape capacity

40,000 (9C40h) = T9840C cartridge tape capacity

75,000 (124F8h) = T9840D cartridge tape capacity

60,000 (EA60h) = T9940A cartridge tape capacity

200,000 (30D40h) = T9940B cartridge tape capacity

Assigning Organization: ASCII organization defining this recording format.

STK = StorageTek, Sun Microsystems

Density Name: ASCII name for this recording format.

R-20 = T9840A recording format

R-20 = T9840B recording format

R-40 = T9840C recording format

R-75 = T9840D recording format

P-60 = T9940A recording format

P-200 = T9940B recording format

Description: ASCII description for this recording format.

Raven 20 GB = T9840A recording format

Raven 20 GB = T9840B recording format

Raven 40 GB = T9840C recording format

Raven 75 GB = T9840D recording format

PeakCapacity 60 GB = T9940A recording format

PeakCapacity 200 GB = T9940B recording format

Report LUNs Command

The Report LUNs command reports the address of the available logical units.

Table 112. Report LUNs Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (A0h)							
1 thru 5	(MSB) Reserved (LSB)							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Allocation Length: Maximum allowed length in bytes of returned data.

Report LUNs Parameter Data

Table 113. Report LUNs Parameter Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 3	(MSB) LUN List Length (8h) (LSB)							
4 thru 7	(MSB) Reserved (LSB)							
8 thru 15	(MSB) LUN Address (0) (LSB)							

LUN Address: Address of supported logical unit (will always be 0).

Request Sense Command

The Request Sense command transfers sense data to the initiator.

Table 114. Request Sense Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (03h)							
1 thru 3	(MSB) Reserved (LSB)							
4	Allocation Length							
5	Control Byte							

Allocation Length: Maximum length of sense data to return to the host. The device currently supports 26 bytes of sense data.

Notes:

1. FCP requires that Check Conditions be reported in the Response of the failing command with the Sense Bytes, this is called Auto Sense. When these Sense Bytes have been presented they are cleared. Therefore, there is no need to issue a Request Sense command after a command has completed with Check Condition.
2. The Request Sense command can only return Check Condition status to report errors with the Request Sense command CDB. The Sense Bytes describing the error will be in the Response as Auto Sense.
3. If a Request Sense command is issued to a tape drive that does not exist, a Check Condition is reported in the response, Auto Sense is returned with a sense key of Illegal Request.

One of the following types of sense data may be returned for an unsolicited Request Sense command:

- Good – Sense key = 0, No Sense
- Unit Attention – Sense key = 6, Unit Attention
- Deferred Errors – Response Code = 71h, Deferred Error

Sense data is cleared after:

- Resets: Power-on, LIP(AL_PD, AL_PS), SCSI Target, and SCSI Logical Unit
- Auto Sense presented to the Initiator in the command response
- A Request Sense command from the Initiator

Sense Data

Table 115. Sense Data Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Valid	Response Code (70h or 71h)						
1	Segment Number							
2	Filemark	EOM	ILI	0	Sense Key			
3 thru 6	(MSB) Information Bytes (LSB)							
7	Additional Sense Length (n–7)							
8 thru 11	(MSB) Command Specific Information (LSB)							
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	Field Replaceable Unit Code							
15	SKSV	C/D	Reserved		BPV	Bit Pointer		
16 thru 17	(MSB) Field Pointers (LSB)							
18 thru 23	(MSB) Fault Symptom Codes 1–3 (LSB)							
24	TapeType				DAvail	MIRBad	Volsafe	TapeEOL
25	CSLFail	0		OutF	InTape	0	LibAtt	0

Valid:

0 = Information field does not contain valid data
1 = Information field contains valid data

Response Code:

70h = Current error, sense data is for the command that received the check condition

71h = Deferred error, sense data is for a previously issued command. The current command that received check condition was not executed.

Segment Number: Not used, will always be 0.

Filemark:

0 = Normal
1 = A Read or Space command encountered a filemark

EOM: End of media

0 = Normal

1 = A Forward command encountered End Of Media, or a Reverse Space command encountered BOT.

ILI: Illegal length indication

0 = Normal
1 = Requested record size did not match actual record size

Sense Key: Indicates general type of error or other condition. See Table 116 on page 4-154.

Information: Contains residual or other information when the Valid bit is 1.

Additional Sense Length: Indicates the number of sense bytes that follow.

Command-specific Information: Not used, will be 0.

ASC: Additional sense code

Provides more detail about the error or other condition. Used with the Sense Key and ASCQ fields. See Table 117 on page 4-155.

ASCQ: Additional sense code qualifier

Provides additional detail about the error when used with ASC and Sense Key. See Table 117 on page 4-155.

Field Replaceable Unit Code: Not used, will always be 0.

SKSV: Sense key specific fields valid

0 = C/D and Field Pointer fields do not contain valid information.

1 = C/D and Field Pointer fields are valid. Only set when Sense Key is 5.

C/D: Command or data field.

0 = Illegal field in parameter data.
1 = Illegal field in Command Descriptor Block.

BPV: Not used, will be 0.

Bit Pointer: Not used, will be 0.

Field Pointer:

Indicates which field in parameter data or CDB is invalid. In the case of a multiple byte field, will point to the first byte of field in error.

FSC-1:

Fault Symptom Code for the first error encountered while attempting the requested operation. The FSC codes are specific to the T9x40 tape drives.

FSC-2: Fault Symptom Code for second error encountered.

FSC-3: Fault Symptom Code for last error encountered.

TapeType: Identifies type of tape currently loaded in drive.

1000b = Cleaning tape
0100b = Dump tape
0010b = Code load tape
0001b = Data tape
0000b = Unknown type

DAvail: Diagnostic information is available.

MIRBad: Metadata on the currently loaded tape is defective.

Volsafe: Current tape is append only.

TapeEOL: Tape currently loaded is at end of life.

CSLFail: Attached CSL is not operational.

OutF: CSL output stack is full.

InTape: CSL input stack has at least one tape in it.

LibAtt: Drive is attached to a library.

Sense Keys

Table 116 lists the Sense Keys that provides basic information about an error. The Sense Key, with the ASC and ASCQ, provides a description about an error.

The T9x40 tape drives support the following Sense Keys.

Table 116. Sense Key Code Descriptions

Code	Description
0	**No Sense:** Indicates there is no specific sense key information to be reported. A sense key of 0 indicates a successful command or a command that received a Check Condition status because of a filemark, end-of-medium, or illegal length indication. A sense key of 0 also indicates the tape drive needs cleaning.
2	**Not Ready:** Indicates the addressed logical unit is not ready for tape motion commands (tape is not loaded, device is not ready).
3	**Medium Error:** Indicates an unrecovered error condition that was probably caused by a defect in the tape or an error in the recorded data. This sense key may also be returned if the device cannot distinguish between a defect in the tape and/or a hardware failure, Sense Key 4.
4	**Hardware Error:** Indicates the device detected an unrecoverable hardware failure while performing the command or during a self-test.
5	**Illegal Request:** Indicates an illegal parameter in the Command Descriptor Block or parameter data.
6	**Unit Attention:** Indicates a tape may have been changed, the device was reset, or parameters were changed by another host.
7	**Data Protect:** Indicates a command that **reads or writes** to the tape was attempted on a block that is protected from this operation. **The read or write** operation was not performed.
8	**Blank Check:** Indicates the device encountered blank tape.
B	**Aborted Command:** Indicates the device aborted the command. The initiator may be able to recover by trying the command again.
D	**Volume Overflow:** Indicates a buffered device has reached the end-of-tape and data remains in the buffer.

Additional Sense Codes and Qualifiers

Table 117 on page 4-155 lists the Additional Sense Code and Qualifiers found in Bytes 12 and 13 of the sense data. These codes provide additional information about an error.

The T9x40 tape drives support the following ASC and ASCQ codes.

Table 117. Sense Key with ASC and ASCQ

Key	Byte		Description
	12	13	
0	00	00	No additional sense information
	00	01	Filemark detected
	00	02	End of partition/medium detected
	00	04	Beginning of partition/medium detected (read or space reverse into BOT)
	00	17	Cleaning requested
	5B	02	Log counter at maximum
2	04	00	Logical unit not ready, cause not reportable (tape is not loaded)
	53	00	Media load or eject failed
3	00	02	End of partition/medium detected
	0C	00	Write error (write data check)
	11	01	Read retries exhausted (read data check)
	11	02	Error too long to correct
	11	0E	Decompression failure (cannot decompress using this algorithm)
	14	04	Block sequence error (block ID in record header was out of sequence)
	15	00	Random positioning error
	26	05	Data encryption error
	30	00	Incompatible medium installed (tape too long)
	30	01	Cannot read medium, unknown format (density ID read failed)
	30	02	Cannot read medium, incompatible format (illegal data format)
	31	00	Medium format corrupted (cannot write density ID)
	33	00	Tape length error (short tape error)
	3B	00	Sequential positioning error
	3B	01	Tape position error at beginning-of-tape (BOT)
	3B	08	Reposition error (CU ERP failed and we are lost)
	51	00	Erase failure (long erase check)

Table 117. Sense Key with ASC and ASCQ (Continued)

Key	Byte		Description
	12	13	
4	03	00	Peripheral device write fault (when check message locks out a load display command)
	04	80	Drive reported failure
	08	00	Logical unit or communication failure
	08	01	Logical unit timeout
	15	01	Mechanical positioning error (tape lost tension)
4	24	8B	Firmware corrupted
	26	81	No encryption keys loaded
	40	80	Diagnostic failure on component (Self-test failed)
	44	00	Internal target failure (internally detected hardware errors)
	44	B0	Multiple bus drivers detected during buffer DMA
	44	B1	RAM port parity error detected during buffer DMA
	44	B3	CRC/LRC generation failed during buffer DMA
	44	B4	CRC/LRC check failed during buffer DMA
	44	B5	DMA zero byte count flag not set after completion
	44	B6	Tape drive detected a hardware error in the data path
	44	B7	Hardware error in the servo or a bad sensor
	44	B8	Permanent hardware malfunction in the Tape drive
	45	00	Select or reselect failure
	51	00	Erase fault
	52	00	Cartridge fault (a load/eject command failure reported by CSL)
	53	01	Unload tape failure (tape unload check)

Table 117. Sense Key with ASC and ASCQ (Continued)

Key	Byte		Description
	12	13	
5	1A	00	Parameter list length error (mode select or other parameter data was truncated)
	20	00	Invalid command operation code (first byte of CDB is not supported command)
	21	00	Logical block address out of range
	24	00	Invalid field in CDB (unsupported or illegal bits are set, field pointer indicates where)
	24	80	Fixed bit set in variable mode
	24	82	Media loaded in drive (attempted Write Buffer or Read Buffer command with tape in the drive)
	24	8E	Invalid firmware image
	25	00	Logical unit not supported (only LUN 0 supported)
	26	00	Invalid field in parameter list (unsupported or reserved bits are set, field pointer indicates where)
	26	04	Invalid release of Persistent Reservation.
	39	00	Saving parameters not supported
	4B	90	FCP_DL field not sufficient to complete the transfer
	80	00	CSL not present (a load command was issued, but CSL not installed)
	80	01	Invalid CSL position requested
	80	02	CSL not ready (no cartridge loaded)
	80	03	Load command received and the load is in progress
6	28	00	Not ready to ready transition (medium may have changed)
	29	00	Power on or reset occurred
	2A	00	Parameters changed
	2A	01	Mode parameters changed by another host
	2A	02	Log parameters changed by another host
	2A	03	Reservation preempted by another host
	2A	04	Reservations released by another host
	2A	05	Reservation preempted by another host
	3F	01	Microcode has been changed
7	27	00	Write protected (and a write-type of command was attempted)
	27	80	Unable to overwrite data
	30	05	"Cannot write medium - incompatible format (attempt to overwrite low density tape in high density drive when not as BOT".
	74	01	Unable to decrypt data
8	00	05	End-of-data detected
	14	00	Recorded entity not found (no EOD, but tape appears to be blank).

Table 117. Sense Key with ASC and ASCQ (Continued)

Key	Byte		Description
	12	13	
B	00	06	I/O process terminated due to errors
	11	00	Unrecovered read error during FCP-2 recovery
	47	00	SCSI parity error (retries not successful)
	48	00	Initiator detected error message received
	49	00	Invalid message error
	4A	00	Command phase error
	4B	00	Data phase error
	4B	80	Underrun during data phase
	4B	81	Overrun during data phase
	4B	82	DMA error during data phase
	4B	83	Command timeout
	4B	84	Reselection timeout
	4E	00	Overlapped commands attempted
D	00	02	End-of-partition/medium detected (unable to write all data to tape)
	00	04	Beginning-of-partition/medium detected

Reserve Unit Command

The Reserve Unit command reserves a device for the exclusive use of one initiator. The device returns Reservation Conflict status if any other initiator sends a command to the device except for Sense, Inquiry, or Release Unit Commands. Reservations are canceled with a reset or Release Unit Command.

Table 118. Reserve Unit—6 Byte Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (16h)							
1	Reserved			Obsolete				Extent
2	Reservation Identification							
3 thru 4	(MSB) Parameter List (LSB)							
5	Control Byte							

Table 119. Reserve Unit—10 Byte Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (56h)							
1	Reserved			3rd Pty	Reserved		LongID	Extent
2	Reservation Identification							
3	Third Party Device ID							
4–6	Reserved							
7 thru 8	(MSB) Parameter List Length (LSB)							
9	Control Byte							

Extent: Extent release not supported – Must be 0.

Reservation Identification: Not supported – Must be 0.

Parameter List Length: Not supported – Must be 0.

3rd Pty: Not supported – Must be 0.

LongID: Not supported – Must be 0.

Reservation ID: Not supported – Must be 0.

Third Party Device ID: Not supported – Must be 0.

Rewind Command

The Rewind command causes the device to rewind the media to the beginning-of-tape (BOT). The device writes any buffered write data on tape before the rewind starts.

CAUTION:
If the drive is in Buffered Mode and a previous command terminated with Check Condition status (such as, buffered data unwritten to tape and the condition was not cleared or otherwise recovered), the drive will discard any unwritten buffered data and filemarks before this operation starts.

Table 120. Rewind Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (01h)							
1	Reserved							Immed
2 thru 4	(MSB) Reserved (LSB)							
5	Control Byte							

Immed: Immediate bit:

0 = Returns Status when the rewind completes

1 = Returns Status after all buffered data is written on tape and rewind starts

Note: Issuing a Test Unit Ready command after a Rewind command with the Immed bit set returns Busy status until the rewind completes.

Send Diagnostic Command

The Send Diagnostic command provides a self-test that verifies the operation of the device. Any buffered write data and filemarks are written on the tape *before* this operation starts.

Table 121. Send Diagnostic Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Dh)							
1	Reserved			PF	Reserved	SelfTest	DevOfl	UnitOfl
2	Reserved							
3 thru 4	(MSB) Parameter List (LSB)							
5	Control Byte							

PF: Page formatted data

0 = Parameter data sent is not page-formatted
1 = Parameter data sent is page-formatted

SelfTest: Self test (must be 1)

1 = Perform default self-test

DevOfl: Device offline (must be 0)

0 = Diagnostics will not affect all logical units

UnitOfl: Unit offline (must be 0)

0 = Diagnostics will not affect media loaded on logical unit

Parameter List Length: Not supported (must be 0)

Note: The command returns Good status if the test runs without errors, and Check Condition status if the test indicates a problem. No parameter data is transferred when the Self Test option is set.

Space Command

The Space command moves the logical position of the tape. Any buffered write data and filemarks are written on the tape *before* this operation starts.

Note: The Space command does not always move tape.

Table 122. Space Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (11h)							
1	Reserved					Code		
2 thru 4	(MSB) Count (LSB)							
5	Control Byte							

Code: Type of space operation:

000b = Space blocks

001b = Space filemarks

010b = Space sequential filemarks

011b = End-of-data (EOD)

Count:
Number of blocks, filemarks or sequential filemarks to move. A negative count (two's complement notation) moves tape in reverse direction (toward BOT).

Notes:

1. A zero in the Count field does not move tape.
2. If a filemark is encountered during a Space Blocks command, Check Condition status is returned and the tape is positioned past the filemark. The Valid and Filemark bits in the sense data are set and the Information Bytes are set to the Count minus the actual number of blocks moved (not counting the filemark).
3. If an end-of-data is encountered during any space command (except space to end of data), Check Condition status is returned and the tape is positioned after the last valid record. For space blocks and filemarks, the Valid bit is set and the Information Bytes contains the Count minus the actual number of blocks or filemarks moved. The Sense Key is set to Blank Check. If the tape is positioned past LEOT, EOM is also set.
4. A forward space into PEOT returns Check Condition status and sets the EOM bit, and a sense key of Media Error. The information bytes contain the count minus the actual number of blocks or filemarks moved.
5. A reverse space operation into BOT returns Check Condition, sets the Valid and EOM bits, and sets the information bytes to the count minus the actual number of blocks or filemarks moved.
6. A space to end of data positions the tape after the last block or filemark.
7. A Check Condition caused by early termination of any space command does not result in a negative value in the information bytes.
8. A Reverse Space Operation of any type that does not complete successfully returns the count in the information bytes as a positive residual.

Security Protocol In

The Security Protocol In command returns information about security and encryption.

Table 123. Security Protocol In Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (A2h)							
1	Security Protocol							
2	(MSB) Security Protocol Specific							
3	Security Protocol Specific (LSB)							
4	INC512	Reserved						
5	Reserved							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

INC512: Allocation length increment.

0 = Normal allocation length
1 = Allocation length is number of 512 byte blocks

Information returned is determined by the Security Protocol field (SP) and the Security Protocol Specific (SPS) field.

- When the SP field is 00h, SPS selects Security Protocol pages

  0000h = Supported Security Protocol List
  0001h = Certificate data

- When the SP field is 20h, SPS selects Tape Data Encryption pages.

  0000h = Tape Data Encryption In Support page
  0001h = Tape Data Encryption Out Support page
  0010h = Tape Data Encryption Capabilities page
  0011h = Supported Key Formats page
  0012h = Data Encryption Capabilities Management page
  0020h = Data Encryption Status page

Security Protocol Information Pages

Supported Security Protocol List

Returns a list of supported values for the Security Protocol field.

Table 124. Security Protocol List

Byte	Bit							
	7	6	5	4	3	2	1	0
0 – 5	Reserved							
6 – 7	Length of remaining data in bytes (02h)							
8	Security Protocol Information (00h)							
9	Tape Data Encryption (20h)							

Certificate Data

Table 125. Certificate Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0 – 1	Reserved							
2 – 3	Length of Certificate Data (00h)							

Length of 0 (zero) indicates no certificate available.

Tape Data Encryption Pages

Tape Data Encryption In Supported Page

Returns a list of supported values for the Security Protocol Specific field when the Security Protocol field is 20h.

Table 126. Tape Data Encryption In Supported Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0 – 1	Page Code (0000h)							
2 – 3	Page Length in bytes (0012h)							
4 – 5	Security Protocol Information (0000h)							
6 – 7	Tape Data Encryption In (0001h)							
8 – 9	Tape Data Encryption Capabilities (0010h)							
10 – 11	Supported Key Formats (0011h)							
12 – 13	Data Encryption Capabilities Management (0012h)							
14 – 15	Data Encryption Status (0020h)							

Tape Data Encryption Out Supported Page

Returns a list of supported values for the Security Protocol Specific field when the Security Protocol Out command with the SP field is set to 20h.

Table 127. Tape Data Encryption Out Supported Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0 – 1	Page Code (0001h)							
2 – 3	Page Length in bytes (0000h)							

Tape Data Encryption Capabilities Page

Table 128. Tape Data Encryption Capabilities Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0 – 1	Page Code (0010h)							
2 – 3	Page Length in bytes (0000h)							
4	Reserved					EXTDECC	CFG_P	
5 – 19	Reserved							
xx – xx	Key Descriptor							

EXTDECC: External data encryption control capable

10b = The drive is capable of external data encryption control

CFG_P: Configuration prevented

10b = Configuration of encryption by the host is not allowed

Key Descriptor

Table 129. Key Descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Algorithm Index (01h)							
1	Reserved							
2 – 3	Descriptor Length (0014h)							
4	AVFMV	SDK_C	MAC_C	DED_C	Decrypt_C		Encrypt_C	
5	AVFCLP		NONCE_C		Rsvd	VCELB_C	AKADF	UKADF
6 – 7	Maximum Unauthenticated Key Associated Data Bytes							
8 – 9	Maximum Authenticated Key Associated Data Bytes							
10 – 11	Key Size							
12	Reserved				RDMC_C			EAREM
13 – 19	Reserved							
20 – 21	Security Algorithm Code							

AVFMV: Algorithm valid for mounted volume

0 = Not valid or no volume mounted
1 = Valid

SDK_C: Supplemental decryption key capable

1 = Yes

MAC_C: Message authentication code capable

0 = No

DED_C: Distinguish encrypted data capable

1 = Drive can distinguish encrypted data from unencrypted data

Decrypt_C: Decryption capable

11b = Drive can decrypt using this algorithm, control is external

Encrypt_C: Encryption capable

11b = Drive can encrypt using this algorithm, control is external

AVFCLP: Algorithm valid for current logical position

00h = Algorithm valid regardless of logical position

NONCE_C: Nonce capable.

1 = Drive generates nonce values

VCELB_C: Volume contains encrypted logical blocks capable

1 = Drive can determine that volume contains encrypted blocks when loaded.

AKADF: A_KAD fixed (Authenticated Key Associated Data)

0 = Not supported

UKADF: U_KAD fixed (Unauthenticated Key Associated Data)

0 = Not supported

Maximum Unauthenticated Key associated data bytes:

0 = Not supported

Maximum Authenticated Key associated data bytes:

0 = Not supported

Key size:

20h = Device uses 256 bit keys

RDMC_C: Raw decryption mode capable

001b = Raw decryption mode not supported

EAREM: Encryption mode recorded

1 = Encryption mode is recorded with each logical block

Security Algorithm Code:

10010h = ENCR_AES_CCM16 (RFC 4309)

Note: Advanced Encryption Standard—AES—is a block cipher encryption algorithm that uses Counter with CBC-MAC (Cipher Block Chaining–Message Authentication Code)—or CCM—as a mode of encryption that provides both a strong form of privacy (security) and efficient authentication.

Supported Key Formats Page

Table 130. Supported Key Formats Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Page Code (0011h)							
1	Page Length in bytes (0001h)							
2	Key Format 1 Supported (01h)							

Data Encryption Capabilities Management Page

This page returns information about features supported in the Set Data Encryption page.

Table 131. Data Encryption Capabilities Management Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0 – 1	Page Code (0012h)							
2 – 3	Page Length in bytes (000Ch)							
4	Reserved							LOCK_C
5	Reserved					CKOD_C	CKORP_C	CKORL_C
6	Reserved							
7	Reserved					AITN_C	LOCAL_C	PUBLIC_C
8 – 15	Reserved							

LOCK_C: LOCK bit support

0 = Not supported

CKOD_C: CKOD bit support

0 = Not supported

CKORP_C: CKORP bit support

0 = Not supported

CKORL_C: CKORL bit support

0 = Not supported

AITN_C: ALL IT_NEXUS (AITN) scope support

0 = Not supported

LOCAL_C: Local scope support

0 = Not supported

PUBLIC_C: Public scope support

0 = Not supported

Data Encryption Status Page

Table 132. Data Encryption Status Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 – 1	Page Code (0020h)							
2 – 3	Page Length in bytes (14h)							
4	IT_NEXUS_SCOPE			Reserved		Key Scope		
5	Encryption Mode							
6	Decryption Mode							
7	Algorithm Index							
8 – 11	Key Instance Counter							
12	Rsvd	Parameters Control			VCELB	CEEMS		RDMD
13 – 23	Reserved							
24 – n	Key Association Descriptor List							

IT_NEXUS_SCOPE:

0 = Scope is public

Key Scope:

0 = Key scope is public

Encryption Mode:

1h = Write data will be encrypted

Decryption Mode:

3h = Mixed mode, encrypted data will be decrypted

Algorithm Index:

1h = Algorithm to be used for encryption and decryption

Key Instance Counter:

0 = Not supported

Parameters Control:

0 = Not supported

VCELB:

0 = Not supported

CEEMS:

01b = Encryption mode is not checked

RDMD:

0 = Default mode

Key Associated Descriptor List: No descriptors will be returned

Test Unit Ready Command

The Test Unit Ready command checks if a device is loaded and ready to receive a command that accesses the media, such as Read or Write commands.

Table 133. Test Unit Ready Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (00h)							
1 thru 4	(MSB) Reserved (LSB)							
5	Control Byte							

Notes:

1. Good status is returned if the tape drive is loaded and ready.
2. Check Condition status with a sense key of Not Ready is returned if the tape drive is not loaded.
3. Busy status is returned if a Rewind, Erase, Load/Unload, or Locate command with the immediate bit set is issued and the tape drive has not completed the command.

Write Command

The Write command transfers one or more blocks of data from the host to tape.

Table 134. Write Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (0Ah)							
1	Reserved							Fixed
2 thru 4	(MSB) Transfer Length (LSB)							
5	Control Byte							

Fixed: Indicates the block mode for data transfer:

0 = Variable block mode.
Transfer Length specifies the length of the block in bytes to be written. A single block is transferred from the initiator.

1 = Fixed block mode.
Transfer Length specifies the number of blocks to be transferred to the device.

Transfer Length: Number of blocks or bytes requested

Notes:

1. Setting of the fixed bit is only allowed if the fixed block length is not zero. If block length is 0, the drive is in variable block mode. In fixed block mode, the record size is specified by the block length.

   The Mode Sense command reports the block length.

2. The Buffered Mode field of the Mode Select command controls when status is returned. If Buffered Mode is:

   0 = Status is returned after all data is written on the tape.
   1 = Status is returned after all data is in the buffer.

3. If the logical end-of-tape (LEOT) is encountered while writing on the tape, the tape drive attempts to write all buffered data on tape. Check Condition status is returned and the end-of-medium (EOM) bit is set in sense data.

4. If the physical end-of-tape (PEOT) is encountered, Check Condition status is returned and the sense key is set to Volume Overflow.

5. An uncorrectable media error generates Check Condition status with a sense key of Media Error. Buffered records or filemarks trapped by a media error may be recovered using the Recover Buffered Data command. Other tape motion commands are not allowed until the buffer is cleared by Rewind, Unload, or Recover Buffered Data commands.

6. If a Write command returns Check Condition status, the valid bit in the Request Sense data is set.

7. The Request Sense information bytes are zeros if all data was written on tape. In variable block mode, the data indicates the total number of bytes not written on tape.

8. In fixed block mode, the information bytes return the total number of blocks not written on tape. A filemark is counted as one byte or block.

9. In buffered mode this total may include records from previous Write or Write Filemarks commands.

10. The error code is set to Deferred Error if records from other than this command remain in the buffer.

Write Buffer Command

The Write Buffer command updates the functional microcode for the T9x40 tape drives. The process of updating microcode is called a download. A change in the initiator from one Write Buffer command to another during a download is interpreted as a new download process request and terminates the active process. This allows another initiator to download microcode if the first initiator goes down before completing its download request.

A successful download writes new microcode to memory and resets the tape drive after the final Write Buffer command completes. A failure of the writing process causes the drive to retain the current version of the microcode. A CRC check is performed over the entire microcode after the last command. A Unit Attention condition is set for all initiators other than the initiator that requested the download with the additional sense code set to Microcode Has Been Changed. Any buffered write data and filemarks are written on the tape *before* this operation starts.

Table 135. Write Buffer Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (3B)							
1	Reserved					Mode		
2	Buffer ID							
3 thru 5	(MSB) Buffer Offset (LSB)							
6 thru 8	(MSB) Parameter List Length (LSB)							
9	Control Byte							

Mode: Indicates the type of download:

- **110b** = Download Microcode with Offsets

  Multiple transfers are required to download the microcode. The first Write Buffer command must contain data for the start of the image. Subsequent Write Buffer commands must transfer data in sequential order.

  This mode is used for all Write Buffer commands in a download except for the last one.

- **111b** = Download Microcode with Offsets and Save

  This mode is used only once per download. It is used in conjunction with the Download Microcode with Offsets (110b) mode to indicate the last Write Buffer command of a download. This indicates that the download is finished and the microcode should be written to memory. A parameter list length of 0 is allowed for this mode.

Buffer ID: Indicates the region of memory to be modified (must be 00h).

Buffer Offset:
Offset from start of the load area (this field is ignored).

Parameter List Length:

Number of bytes to transfer.

Write Buffer Command Data:

The initiator must provide the firmware image.

Notes:

1. The process of updating firmware is called a download. A successful download writes new firmware to memory and resets the tape drive after the final Write Buffer command completes. A failure of the writing process causes the drive to retain the current version of the firmware. A CRC check is performed over the entire download after the last command. A Unit Attention condition is set following a successful firmware download.
2. The tape drive must be unloaded to perform this command.
3. Blocks of firmware data must be transferred in sequential order. Each block except the last block transferred must be the same length.
   - The minimum parameter list length is 4096 bytes.
   - The maximum parameter list length is 262,144 bytes.
   - A parameter list length of 0 is allowed for mode 111b only.
   - The parameter list length must be modulo 4.
4. For compatibility with existing systems, mode field values 100b and 101b are accepted as equivalent to 110b and 111b. New implementations should not use 100b and 101b.
5. The sequence of Write Buffer commands for a code download should be uninterrupted by other commands. It is suggested that the device be reserved during a code download.

Write Filemarks Command

The Write Filemarks command writes one or more filemarks on tape starting at the current logical position.

Table 136. Write Filemarks Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (10h)							
1	Reserved						WSmk	Immed
2 thru 4	(MSB) Transfer Length (LSB)							
5	Control Byte							

WSmk: Write setmark bit (must be 0).

0 = Write filemarks

Immed: Immediate mode:

0 = Return status after filemarks is written on tape
1 = Return status after filemarks is in the buffer.

Note: Must be in buffered mode if the immediate bit is set otherwise the command is rejected.

Transfer Length: Number of filemarks to write

A Write Filemarks command with Transfer Length of 0, and Immed of 0 forces all buffered data to be written on tape. No additional filemarks are written and Good status is returned after all buffered data is on the tape.

Note: Refer to the Write command for information about media errors and LEOT.

Glossary

This glossary defines terms and abbreviations used in this manual. For definitions of other Fibre Channel or StorageTek terms refer to the glossary in the appropriate document.

Numbers

8B/10B A type of encoding and decoding algorithm of bytes, invented and patented by IBM, to reduce transmission errors. This algorithm was adopted as part of the FC-PH-1 Standard in 1991.

A

Abort Exchange (ABTX) The Abort Exchange command can be used with Abort Sequence - Last Sequence (ABTS - LS) (SCSI-PLDA), by itself, or with ABTS Fibre Channel Link Encapsulation (FC-LE) protocol. The Abort Exchange Command used in the Extended Link Services, and is prohibited when originated by the initiator, and is prohibited when originated by a drive.

Abort Sequence (ABTS) The protocol that is invoked by devices supporting the Fibre Channel Protocol for SCSI to abort the exchange whenever a Sequence Error is detected. It comes in two protocols: Abort Sequence - Last Sequence (ABTS - LS) (SCSI-PLDA), by itself, or with ABTS Fibre Channel Link Encapsulation (FC-LE).

ABTS *See* Abort Sequence.

ABTX *See* Abort Exchange.

ACA Auto Contingent Alliance.

ACC Accept.

ACK *See* Acknowledge.

Acknowledge A response or confirmation to an address, message, or poll.

Additional Sense Bytes The additional sense bytes contain data specific to either or both the command or peripheral device, and further define the nature of the FCP_SNS_INFO feature of the FCP_RSP payload.

Addressing Scheme The order in which node and port names are presented to the recipient in a Fibre Channel transaction.

ADISC *See* Discover Address.

ADVC *See* Advise Credit.

Advise Credit The Advise Credit Command used in Extended Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

AEN *See* Asynchronous Event Notification.

AL_PA *See* Arbitrated Loop Physical Address.

AL_PD Arbitrated Loop physical destination address.

AL_PS Arbitrated Loop physical source address.

AL_TOV Arbitrated loop timeout value.

Allowable A function of Fibre Channel that allows a feature or parameter to be used between an initiator and a target.

American National Standards Institute A standards development organization that is not associated with the U.S. government, but that develops standards that can be used voluntarily by product vendors in the United States. The name of the organization was recently changed to the National Committee for Information Technology Standards (NCITS).

ANSI *See* American National Standards Institute.

Arbitrate to win loop In an arbitrated loop topology, the process that a port performs to select another port to send data to or receive data from that same port.

Arbitrated Loop A topology in Fibre Channel that provides multiple connections for devices that share a single loop, over which only two devices

can communicate at once. Similar to the SCSI protocol of the same name, it provides an "arbitrate and win" scenario between more than two devices when those devices want to communicate on the bus. The sending device must arbitrate and win the connection with the receiving device before communication can begin.

Arbitrated Loop Physical Address A one-byte value that identifies a port in an arbitrated loop topology.

Asynchronous Event Notification A form of communication used between processes to notify a process of an asynchronous action, such as an input/output activity or message transmission.

B

b The abbreviation for bit.

B The abbreviation for byte.

BB_Credit *See* buffer-to-buffer credit.

Buffer Size The amount of storage space allocated to the buffer, which is a storage space reserved temporarily for a given purpose. In Fibre Channel, this buffer is usually larger than a single frame, up to the size of an entire sequence.

Buffer-to-Buffer Credit This is a value which is managed by the R_RDY primitive signal on a link, and is used by a transmitter to determine the permission to transmit frames. If permission is granted by the recipient, this value also tells the transmitter how many are permitted. The transmitter may transmit a frame when Available BB_Credit is greater than 0. This differs from End_to_End Credit.

Buffer-to-Buffer A method of transferring information in which neither the initiator nor receiver of the information knows the contents.

Byte A group of eight bits.

C

CDB Command descriptor block. A structure for SCSI commands.

Channel An I/O interface between a central processor and peripheral device in which large amounts of data are transferred at the highest rate of speed possible for the transmission medium.

Class of Service The Fibre Channel method of defining a data transmission strategy between devices. There are three FC Classes of Service currently specified in the FC-PH-1, and StorageTek's implementation includes only one, Class 3.

Class 3 The Fibre Channel Class of Service in which the initiator sends a message to a receiving device without expecting or requiring an acknowledgement. It is analogous to the human communication method of sending an advertisement in hopes that the message is received.

CLS Close.

Company ID A unique address in IEEE proposed format.

Control Byte The last byte of every Command Descriptor Block. The Control Byte contains two vendor-specific bits, four reserved bits, one flag bit, and one link bit.

CRC *See* Cyclic Redundancy Check

Cyclic Redundancy Check A mechanism used for error detection that calculates a numeric value by using a special algorithm applied to a series of bytes that are generally appended to the data. If no error has occurred when the receiver executes the algorithm on the received data, the newly generated CRC value should be the same as the CRC value originally transmitted.

D

Delimiter In FC, a special transmission word that marks either the beginning, or ending, of a frame in an FC transmission.

Deserialization The process of receiving data, one bit at a time, and re-compiling it into a larger data unit, such as a transmission character or a byte.

Destination Address In the frame header of each frame transmitted, the destination address is a value that identifies the port in a node that is to receive the frame.

Device *See* Node and Peripheral Device.

Device Addressing One of two levels of addressing in an I/O interface, the other being link-level. Device addressing identifies the channel or control unit when the control unit has been determined through link-level addressing.

Device management Defines communications for transferring data between initiators and recipients using FCP_CMND, FCP_XFER_RDY, FCP_DATA, and FCP_RSP information units (IUs).

DF_CTL Data field control indicates optional headers in the frame.

Disassembly The process of splitting out a source buffer into payloads. These payloads are then transmitted in frames.

Discover Address (ADISC) The Discover Address command used in Extended Link Services. It is invokable when originated by the initiator, required as a response by the drive, and prohibited when originated by a drive.

Discover F_Port Parameters (FDISC) The Discover F_Port Parameters command used in Extended Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

Discover N_Port Parameters (PDISC) The Discover N_Port Parameters command used in Extended Link Services. It is invokable when originated by the initiator, requires a response by the drive, and is prohibited when originated by a drive.

Disparity A form of error detection for frame transmission. Running disparity adds a second dimension to the transmission of characters that provides a balance of ones and zeros and helps protect transmission characters and controls the heat output of the transmitter.

Drive Response One of the functions of Extended Link Services.

E

E_D_TOV *See* Error Detect Timeout value.

Echo The Echo command used in Extended Link Services. It is prohibited when originated by the initiator, and is prohibited when originated by a drive.

ECMA European Computer Manufacturers Association

Encoding The process used to change the original form in which information is available, into another form. An example of this is changing handwritten text into computer bytes.

End-of-Frame Delimiter A special transmission word in a frame used to mark the end of that frame.

Enterprise System Connection (ESCON) An IBM-patented set of products and services that provide a dynamically connected environment, over fiber optic cable, within a mainframe or client server enterprise.

EOF Delimiter *See* End-of-Frame Delimiter.

EOFa End of frame abort.

EOFn End of frame normal.

EOFni End of frame normal invalid.

EOFt End of frame terminate.

Error Detect Timeout Value The minimum period of time that an L_Port can wait for the sequence to complete before initiating a recovery action.

ESCON Enterprise Systems Connection.

Establish Streaming (ESTS) The Establish Streaming command used in Extended Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

ESTC Estimate Credit command

Estimate Credit (ESTC) The Estimate Credit command used in Extended Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

ESTS *See* Establish Streaming.

Exchange The administrative layer that controls overall operations across FC. An exchange is established when an N_Port sends a sequence of at least one frame to another N_Port.

Exchange Identifier The field (OX_ID) in the frame header that identifies a process in the source during a transmission from one N_Port to another. An exchange is established between the N_Ports when the first frame of a new operation is accepted by the destination N_Port.

F

F_CTL Frame control. Controls information within a frame. A portion of the FC-2 Sequence Chaining feature.

F_Port A port within the Fabric which attaches to an N_Port through a link.

Fabric The FC topology that is similar to a telephone switch in that the initiator of a "call" to the receiving port simply provides the receiver with the port address, and the fabric routes the transmission to the proper port. A fabric differs from a point-to-point or arbitrated loop topology in that it provides for interconnections between ports without having a point-to-point connection. The fabric also serves as a media type converter.

FACT Fabric active alias_ID.

FAN Fabric address notification.

Fault Symptom Code Four hexadecimal digits that identify a cartridge subsystem error.

FC Fibre Channel.

FC_AL Fibre Channel Arbitrated Loop standard.

FC-PH-1 The FC Physical and Signaling Interface defined in the ANSI X3.230-1994.

FC-PH-2 An extension of the FC Physical and Signaling Interface defined in the ANSI X3.230-1994 that specifies several extra protocol levels.

FC-0 The level of the FC-PH-1 Standard that defines the physical level. FC-0 defines the media types and connectors, as well as the electrical and optical characteristics, necessary for connecting ports. This level can be found in the FC-PH-1 Standard, clauses 5 to 10, and 12 to 15.

FC-1 The level of the FC-PH-1 Standard that defines the transmission protocol. FC-1 includes the 8B/10B encoding/decoding scheme, word order transmission, and error detection. This level can be found in the FC-PH-1 Standard, clauses 11, 16, and 17.

FC-2 The level of the FC-PH-1 Standard that defines the framing and signaling protocol. FC-2 includes the frame layout, frame header content, and rules for use. This level can be found in the FC-PH-1 Standard, clauses 18 to 29.

FC-3 The level of the FC-PH-1 Standard that defines the common services level that may be available across multiple ports in a node. This level has no current standard in the FC-PH-1 Standard.

FC-4 The level of the FC-PH-1 Standard that defines the mapping of protocols between the lower levels of FC, and the command sets that use FC. Separate standards exist for SCSI-3, IP, IPI-3, HIPPI, and others.

FCP *See* Fibre Channel protocol.

FCP_CMND Fibre channel SCSI-3 command service request.

FCP_DATA The action of delivering data.

FCP_RSP SCSI-3 response such as Status.

FCP_XFER_RDY The request for date.

FDACT Fabric deactivate alias_ID

FDDI *See* Fiber Distributed Data Interface.

FDISC *See* Discover F_Port Parameters

Fiber A wire or strand of optical cable. Fiber is spelled "Fibre" in Fibre Channel.

Fiber Distributed Data Interface (FDDI) An NCITS standard for transmitting data at 100 megabaud over fiber optic cable.

Fiber Optic Cable A jacketed cable of thin strands of glass which carry pulses of light that transmit data for high-speed transmissions over medium to long distances. The cable can be single mode, which carries a single signal from a laser or LED light source, or multi-mode, which carries multiple signals from either light source.

Fibre Channel The ANSI standard that defines an ultra high-speed, content independent, multi-level data transmission interface that can support multiple protocols simultaneously, support connectivity to millions of devices over copper and/or fiber optic physical media, and provides the best characteristics of both networks and channels, over diverse topologies.

Fibre Channel Physical and Signaling Interface (FC-PH-1) *See* FC-PH-1.

Fibre Channel Protocol The mapping of SCSI-3 commands over a fibre channel interface.

FIFO First in first out.

Fill Word A word transmitted between frames containing no information essential to either frame. The fill words are defined by the topology. The Idle primitive signal is an example of a fill word.

FL_Port An F_Port within the Fabric which also contains the Loop Port State Machine as defined in FC-AL-2. The FL_Port attaches to an NL_Port through a link.

FLOGI Fabric Login.

Flow Control The process of limiting the number of single frames or groups of frames received by the receiving port. This is accomplished using a credit system. *See* Buffer-to-Buffer Credit (BB_Credit) and End-to-End Credit (EE_Credit).

Frame An indivisible, encapsulated data structure containing a beginning-of-frame (BOF) and end-of-frame (EOF) designator, which carries a payload of both control data and user data from one FC port to another.

Frame Header The first field in a frame that contains addressing information, as well as other control information, about the frame.

FRU Field replaceable unit.

FSC *See* Fault Symptom Code.

Full Duplex A communication protocol that allows signals to be transmitted and received simultaneously, and usually contains flow control.

G

GAID Get alias_ID.

GBIC Giga-bit interface converter.

H

Half Duplex A communications protocol that permits a port to transmit or receive frames at any point in time, but not simultaneously, as in full duplex. The one exception to this is with link control frames, which are always allowed in full duplex.

Header Data The part of a message that contains system-defined control information. This data may contain, but not be restricted to, one or more destination fields, initiator and receiver address, and priority level of the message.

Hexadecimal A number system with a base of 16.

High Performance Parallel Interface The NCITS standard that defines high-speed information transfer using dual simplex, over a short parallel bus.

HIPPI *See* High Performance Parallel Interface.

Host A processor, usually composed of a CPU and memory, that typically communicates with

peripheral devices over channels and/or networks, to perform I/O operations such as network control. It also provides end users with computation services and database access.

HSSDC High speed serial data connectors. StorageTek tape drives use this type of connector at the interface card.

Hub A piece of hardware, separate from the actual FC interface accessible on the backplane of a device, which houses the port bypass circuitry for configurations of 8 to 16 ports per hub. Hubs may be stacked to support larger configurations, and can usually support a mix of both electrical and optical media ports in the same hub.

I

Idle A special type of fill word sent from a transmitting port to a receiving port that contains no data or control information, but communicates that the transmitting port has more frames to send. The idle word is necessary because FC needs a continuous flow of transmissions and receptions to remain operational.

ILI Illegal length indicator.

Inbound Fiber The fiber in a link that carries information into a receiving port.

Information Unit A unit of information defined by FC-4 mapping transferred as sequences.

Intelligent Peripheral Interface The NCITS standard used in host computers to control peripheral devices at a speed of up to 100 MB/s. In its FC implementation, IPI remains half-duplex within I/O operations.

Internet Protocol A stacked set of protocols, developed by the U.S. Department of Defense, to facilitate communication between dissimilar computers over networks.

Invokable A function of Fibre Channel that allows a feature to be used between an initiator and a recipient (such as cartridge subsystem). Thus, if a feature or parameter is invoked, the recipient must implement and respond to the feature or parameter.

IP *See* Internet Protocol.

IPI *See* Intelligent Peripheral Interface.

ips Inches per second, a tape movement measurement.

IU *See* information unit.

J

Jitter The deviation of timing in an exchange.

L

L_Port It is either an FL_Port or an NL_Port.

Laser A term meaning Light Amplification by Stimulated Emission of Radiation. Laser devices generate coherent radiation in the visible, ultraviolet, and infrared portions of the electromagnetic spectrum. Regarding FC, lasers can be transmitting either short waves or long waves, depending on the composition of the arbitrated loop or fabric.

LIFO Last in first out.

Link A two-fiber connection made between two FC ports in which one fiber is transmitting, the other receiving, information.

Link Bit The link bit allows the initiator to "link" or continue the input/output process. This bit allows devices that support command linking to indicate to the initiator that the command was accepted by returning a status of "Intermediate" to the initiator.

Link Service The set of commands used by FC to manage functions such as port management, login/logout, and abort operations. There are both basic and extended link services, which StorageTek cartridge tape subsystems support.

Link Services Command Reject The code returned by a recipient device (such as a cartridge subsystem) receiving a request for Extended Link

Services which are unsupported. The recipient returns a reason code of "Command not supported."

Linking (1) The activity of connecting one inbound fiber and one outbound fiber to a port. (2) The activity of linking commands, as identified in the INquiry data, where the flag bit of the Command Descriptor Block is set to zero.

LIP *See* Loop initialization primitive.

LIRP Loop Initialization Report.

LIS_HOLD_TIME Loop Initialization Sequence Hold time.

LISM Loop Initialization Select Master.

Login The FC-required process used by any initiating N_Port or NL_Port in an FC fabric to sign in with any other receiving N_Port or NL_Port port with which it plans to communicate. The signing in process provides the initiator with critical information about the attributes of the recipient port before it attempts to make a connection with it.

Login_BB_Credit On an Arbitrated Loop, this signal is the value equal to the number of receive buffers that a recipient NL_Port guarantees to have available once a loop circuit is established. Login_BB_Credit is communicated via the FLOGI, PLOGI, or PDISC Extended Link Services.

Logout An Extended Link Services command that terminates all open Exchanges with the SCSI initiator and its target. LOGO is invokable when originated by the initiator, requires a response by the drive, required when originated by the drive, and requires a response by the initiator.

LOGO *See* Logout.

Loop initialization primitive Assigns up to a possible 127 addresses to different ports on the loop and builds a map of these addresses.

LPSM Loop port state machine.

LRC Longitudinal redundancy check.

LSB Least Significant Bit.

LS_RJT *See* Link Services Command Reject.

LUN Logical unit number. A SCSI device address.

M

MB Abbreviation for megabyte (2^{20} or 1,048,076 bits).

MB/s Abbreviation for megabytes per second.

Mb/s Abbreviation for megabits per second.

MB/sec Abbreviation for megabytes per second.

Mb/sec Abbreviation for megabits per second.

Mode Select Command The command used in Fibre Channel that specifies operational parameters and options for a logical unit. The fields that can be changed by the Mode Select Command and what the default values are for these fields.

MSB Most Significant Bit.

N

N_Port A Port within the node that attaches to a link.

N_Port ID The identifier of an N_Port in a point-to-point or fabric FC topology.

N_Port Login (PLOGI) The N_Port Login command used in Extended Link Services. It is required when originated by the initiator, requires a response by a drive, and is prohibited when originated by a drive.

Nanometers (nm) One billionth meters.

National Committee for Information Technology Standards Formerly the American National Standards Institute (ANSI).

NCITS *See* National Committee for Information Technology Standards.

Network An arrangement of nodes and branches, connecting data processing devices to one another via software and hardware links, to facilitate information interchange.

NL_Port An N_Port within the Node which also contains the Loop Port State Machine as defined in FC-AL-2. The NL_Port attaches to either an FL_Port or an NL_Port through a link.

nm Abbreviation for nanometers.

No Operation (NOP) The No Operation command used in Basic Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

Node A device that contains a minimum of one N_Port or NL_Port.

Node Name A 64-bit concatenation of the Port Name, Company ID, and drive serial number, in an IEEE extended format.

NOP *See* No Operation.

O

Operation Code Structure A component of the Command Descriptor Blocks that compose Byte 0 of both the 6-Byte and 10-Byte Command Descriptor.

OPN Open.

Ordered Set Special types of transmission words, either fill words or control words, that have special meanings in a transmission. Ordered sets include primitive signals, primitive sequences, and frame delimiters.

Originated by Drive An action taken by the recipient of either a Basic Link Service Command, or an Extended Link Service Command. These actions can be Allowable, Invokable, Prohibited, or Required.

Originated by Initiator An action taken by the initiator of either a Basic Link Service Command, or an Extended Link Service Command. These actions can be Allowable, Invokable, Prohibited, or Required.

Outbound Fiber The fiber in a link used to transmit information to a receiving port.

OX_ID Originator exchange identifier.

P

Parallel Transmission The transmission of bits over multiple fibers, either copper or glass, all at one time, and accomplished by dedicating each fiber to transmitting one bit at a time. This high speed transmission method is good for short distances only. Contrast with serial transmission.

Payload The portion of the data field in a frame, not part of the optional header data, that contains the substantive information being transmitted between ports in FC.

PDISC *See* Discover N_Port Parameters.

PLDA *See* Private loop direct attach.

PLOGI *See* N_Port Login.

Point-to-Point A topology in which exactly two ports communicate. In FC, the two ports are N_Ports.

Port A specific end-point for communications within a host, or from a host to a peripheral device or vice versa. In FC, it is an access point in a device where a link attaches. Examples of this port are N_Port, NL_Port, F_Port, and FL_Port.

Port Addressing In FC, Port Addressing is used for login validation, and includes the Port Name, Node Name, and N_Port ID.

Port Name A 64-bit word consisting of the port number, Company ID, Tape Drive Number, and zeros.

Primitive Sequence A special type of ordered set transmission word sent repeatedly by a port until a proper response is received. The primitive sequence signals specific conditions such as online to offline, or link reset. *See* Ordered Set.

Primitive Signals A type of ordered set that is transmitted by a port, outside the confines of a frame transmission, to do a specific function not

associated with transmitting data per se. Examples are Idle and Receiver Ready (R_RDY). A receiving port recognizes a primitive signal when it is received as a single entity, not grouped with other signals.

Private Loop An Arbitrated Loop that does not contain a participating FL_Port but does contain two or more NL_Ports.

Private Loop Direct Attach Defines a subset of standards for operations of serial devices (tape drives) on a private loop.

Private NL_Port An NL_Port that does not attempt a Fabric Login.

PRLI *See* Process Login.

PRLO *See* Process Logout.

Process Login (PRLI) The Process Login command used in Extended Link Services. It is required when originated by the initiator, requires a response by a drive, and is prohibited when originated by a drive.

Process Logout (PRLO) The Process Logout command used in Extended Link Services. It is invokable when originated by the initiator, requires a response by a drive, is invokable when originated by a drive, and requires a response by an initiator.

Prohibited The state of a function, parameter, or operation of FC not being allowed to be used between an initiator and a target.

Public Loop An Arbitrated Loop that includes a participating FL_Port and at least one NL_Port.

Public NL_Port An NL_Port that attempts a Fabric Login.

Q

QoSR Quality of service request.

R

R_A_TOV *See* Resource Allocation Timeout.

R_CTL The Routing Control field in the frame header contains a routing bits sub-field, which has specific values indicating that FC-4 data will follow. It also contains an information category field, which indicates to the recipient the type of data that the frame contains.

R_RDY Receiver Ready.

R_T_TOV Receiver Transmitter timeout value.

RCS Read connection status block.

Read Exchange Status Block The Read Exchange Status Block command used in Extended Link Services. It is restricted when originated by the initiator, restricted when originated by a drive, and invokable when originated by a drive.

Read Link Error Status Block The Read Link Error Status Block command used in Extended Link Services. It is invokable when originated by the initiator, allowable when originated by a drive, and prohibited when originated by a drive.

Read Sequence Status Block The Read Sequence Status Block command used in Extended Link Services. It is invokable when originated by the initiator, allowable when originated by a drive, and prohibited when originated by a drive.

Receiver Read A primitive signal used in flow control by a receiving port to indicate to the transmitting port that the receiving port is ready to receive more information.

Reinstate Recovery Qualifier (RRQ) The Reinstate Recovery Qualifier Command used in Extended Link Services. It is invokable when originated by the initiator, requires a response by a drive, is prohibited when originated by a drive.

Remove Connection The Remove Connection Command used in Basic Link Services. It is prohibited when originated by the initiator, and is prohibited when originated by a drive.

Report Node Capabilities Information The Report Node Capabilities Information Command used in Extended Link Services. It is invokable

when originated by the initiator, requires a response by a drive, is prohibited when originated by a drive.

Request Sequence Initiative The Request Sense Initiative Command used in Extended Link Services. It is invokable when originated by the initiator, allowable as a response by a drive, is required when originated by a drive, and requires a response by an initiator.

Required The state of a function, parameter, or operation of FC required to be implemented by both the initiator and target.

RES *See* Read Exchange Status Block.

Resource Allocation Timeout The minimum amount of time that an L_Port waits before reinstating the Recovery Qualifier.

Resource Recovery Timeout The minimum amount of time a target waits for an ADISC or PDISC Extended Link Service following a LIP

RLS *See* Read Link Error Status Block.

RMC *See* Remove Connection.

RNC *See* Report Node Capabilities Information.

RR_TOV *See* Resource Recovery timeout value.

RRQ *See* Reinstate Recovery Qualifier.

RSCN Registered state change notification.

RSI *See* Request Sequence Initiative.

RSS *See* Read Sequence Status Block.

RTV Read timeout value.

RX_ID Responder exchange identifier.

S

SCN State change notification.

SCSI *See* Small Computer System Interface.

SCSI Commands The SCSI-3 Fibre Channel Protocol (FCP) commands issued by either the initiator or target in an arbitrated loop topology, to perform a specific SCSI task. There is a direct correspondence between the SCSI task and the FC exchange. A Fibre Channel exchange can correspond directly to either a single SCSI command, or group of linked SCSI commands.

SCSI-3 The set of SCSI commands used for Fibre Channel. SCSI-3 comes in a Generic Packetized Protocol (SCSI-3 GPP) and Fibre Channel Protocol (SCSI-3 FCP).

SEQ_CNT *See* Sequence Count.

SEQ_ID *See* Sequence Identifier.

Sequence A set of one or more frames identified as a unit within an interchange.

Sequence Count A value in a frame header that helps the receiving port identify the order in which a set of frames was transmitted.

Sequence Identifier In a transmission between a pair of terminal N_Ports, the field in the Sequence Content header portion of the Sequence Management frame that separates one sequence from another. *See* SEQ_ID.

Serial Transmission A transmission in which bits are sent in a stream in a single fiber. Contrast this with a parallel transmission.

Small Computer System Interface An input and output bus that supports the attachment of various devices to operating systems. Fibre Channel uses the SCSI-3 command set.

SOF *See* Start of Frame Delimiter.

SOFi3 The abbreviation for Start of Frame Initiate Class 3 delimiter.

SOFn3 The abbreviation for Start of Frame Normal Class 3 delimiter.

Start-of-Frame Delimiter A delimiter used to mark the beginning of a frame, as well as specify the class of service used for the frame.

T

Task management Defines when a task or group of tasks must be aborted or terminated.

Third Party Process Logout The Third Party Process Logout Command used in Extended Link Services. It is invokable when originated by the initiator, requires a response by a drive, is prohibited when originated by a drive.

Topology A method or scheme for connecting ports for communicating in FC. FC topologies include Point-to-Point, Arbitrated Loop, and Fabric.

TPRLO *See* Third Party Process Logout Command.

Transmission Word A four-byte character containing 32 bits of information, which is the smallest information unit transmitted on Fibre Channel.

U

ULP Upper level protocol.

ULP_TOV Upper Level Protocol timeout value.

X

X_ID A Class 3 Service Parameter used for Recipient Control. It contains one word with 29 bits, and a value of 0.

x Hexadecimal notation.

XFER Transfer.

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