StorageTek T10000 Tape Drive

Fibre Channel Interface Reference Manual

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StorageTek T10000 Tape Drive Fibre Channel Interface Reference Manual

E20425-01

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Preface

The *Fibre Channel Interface Reference Manual* is intended for independent software vendors (ISVs) plus operating system designers and developers implementing Fibre Channel on Oracle's StorageTek T10000 Tape Drive.

This manual is also intended for solutions delivery engineers, systems engineers; plus hardware, software, and service representatives.

This manual describes information about the StorageTek T10000*A,* T10000*B*, and T10000C Tape Drives. Unless otherwise specified, this information pertains to all models of the T10000. Where information changes, the following is used to identify them:

- 2FC = T10000*A* with a 2 Gb interface
- 4FC = T10000*A* or T10000*B* or T10000C with a 4 Gb interface
- T10000*A* or T10000*B* or T10000C

FC = Fibre Channel

Access to Oracle Support

Oracle customers have access to electronic support through My Oracle Support. For information, visit http://www.oracle.com/support/contact.html or visit http://www.oracle.com/accessibility/support.html if you are hearing impaired.

Related Publications

The following list contains the names of publications that provide additional information about the StorageTek T10000 tape drive.

T10000 Tape Drive Installation Manual

T10000 Tape Drive Operator's Guide

T10000 Tape Drive Service Manual

Virtual Operator Panel User's Guide

Regulatory and Safety Compliance Guides:

Important Safety Information for Sun Hardware Systems

Sun Storage Regulatory and Safety Compliance Manual

Documentation, Support, and Training

Web Site: http://www.oracle.com/index.html

Documentation:

- Customer: http://www.oracle.com/technetwork/indexes/documentation/index.html
- Employee: http://docs.sfbay.sun.com/
- Partner: https://spe.sun.com/spx/control/Login

Downloads:

- Customer: http://www.oracle.com/technetwork/indexes/downloads/index.html
- Employee: https://dlrequest-zn-dlapps1.sfbay.sun.com/usr/login

Support: http://support.oracle.com/CSP/ui/flash.html

Training: http://www.oracle.com/global/us/education/sun_select_country.html

What’s New

Removed Sun branding:

- Removed the front and back cover pages
- Replaced the title page
- Revised the copyright page

The part number was changed to an Oracle part number.

Removed the Summary of Changes and added a What’s New section in the frontmatter of the manual.

Added information about the T10000C tape drive.

General Information

1

This chapter contains an overview about the Fibre Channel specifications for Oracle's StorageTek T10000 Tape Drive, which conforms to the:

- American National Standards Institute (ANSI),
- National Committee for Information Technology Standards (NCITS)
- Table 1 lists the documents that help define this implementation.

Table 1. Fibre Channel Reference Documentation

Specification		Revision
Fibre Channel Physical and Signaling Interface		FC-PH X3.230: 1994
Fibre Channel Physical and Signaling Interface 2nd Generation		FC-PH-2 X3.297: 1997
Fibre Channel Physical and Signaling Interface 3rd Generation		FC-PH-3 X3.303:1998
2FC*	Fibre Channel Arbitrated Loop	FC-AL X3.272-1996 Rev. 4.5
2FC*	Fibre Channel Arbitrated Loop 2 (August 28, 1998)	FC-AL-2 Working Draft Rev. 6.4
4FC*	Fibre Channel Physical Interface	FC-PI T11/Project 1306-0, Rev. 2
4FC*	Fibre Channel Framing and Signaling Interface	FC-FS T11/Project 1331-0, Rev. 1.2
Fibre Channel Fabric Loop Attachment Technical Report		FC-FLA NCITS/TR-20: 1998
Fibre Channel Private Loop Direct Attach Technical Report		FC-PLDA NCITS/TR-19: 1998
Fibre Channel Generic Services Definition 2nd Generation		FC-GS-2 NCITS 288.200x, Rev. 5.3
Fibre Channel Generic Services Definition 3rd Generation		FC-GS-3 Working Draft Rev. 6.2
Fibre Channel Tape Profile Technical Report (May 14, 1999)		FS-Tape T11/99-069v4, Rev. 1.17
SCSI Fibre Channel Protocol		SCSI FCP X3.269:1996, Rev. 12
SCSI Fibre Channel Protocol 2		ANSI NCITS:350:2003
SCSI Fibre Channel Protocol 3		ANSI INCITS:416:2006
SCSI–3 Architecture Model (SAM-2)		ANSI NCITS:366:2003
SCSI-3 Architecture Model (SAM-3)		ANSI INCITS:402:2005
SCSI–3 Primary Commands (SPC–2)		ANSI NCITS:351:2001
SCSI-3 Primary Commands (SPC-3)		ANSI NCITS:408:2005
SCSI–3 Stream Commands (SSC)		ANSI NCITS:335:2000
SCSI-3 Stream Commands (SSC-3)		T10/1611-D Revision 04a
* Indicates specific reference for that implementation of the Fibre Channel interface.		

Overview

- Serial connection
- Copper (electrical) or fiber (optical) transmissions
- Multiple protocols (such as SCSI, IP, HIPPI, IPI-3)
- Information transparent
- 100 – 400 MB data transfer rates
- 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.

See Table 2 for a description of the Fibre Channel layers.

Table 2. Fibre Channel Layers

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

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
- Fabric F_Port attach operation
- N_Port to N_Port (point-to-point) attach operation
- Hard assigned port addresses (AL-PA)
- Basic and extended link services
- Connections to an external hub
- Data transfer rate (burst) of up to 400 megabytes per second (MB/s)
- Standard approved length shortwave fibre optic cables
- Multimode laser operating at 850 nanometers (shortwave) non–OFC
- 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

Switch:

- Attachment to F_Port is supported on T10000 tape drive

Tape Drive Description

Size: The T10000 tape drive is a small, modular, high-performance tape drive designed for high-capacity storage of data. The drive is:

- Height = 8.89 cm (3.5 in.)
- Width = 14.6 cm (5.75 in.)
- Depth = 42.5 cm (16.75 in.)

Capacity: The T10000 uses a technology called partial response, maximum likelihood (PRML) to provide the high-density data format that allows the tape drive to record and store up to:

- T10000A = 500 gigabytes (GB) of uncompressed data.
- T10000B = 1 terabyte (TB) of uncompressed data.
- T10000C = 5 terabytes (TB) of uncompressed data.

Media: The new tape cartridge for this drive uses a single-reel hub for high capacity; the supply reel is inside the cartridge and the take-up reel is inside the tape drive.

Interface: The host connections to the T10000 are fiber-optic to provide a high rate of data transfer, such as Fibre Channel and FICON.

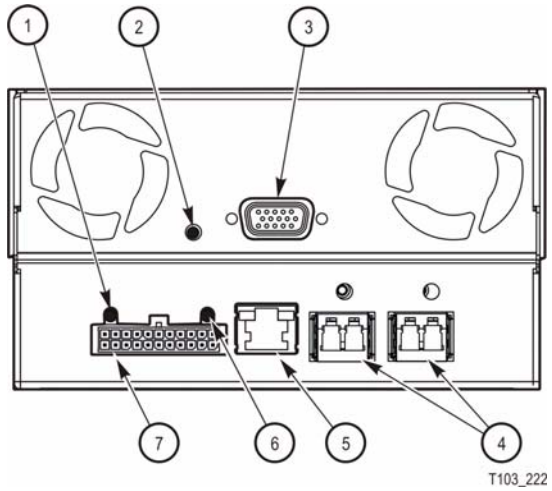
Configurations: The T10000 supports two configurations: library and stand-alone, for a variety of operating system platforms:

- Enterprise mainframes (z/OS and OS/390)
- Open system platforms (Windows, UNIX, and Linux)

Figure 1 shows a rear view of the T10000A and T10000B tape drive.

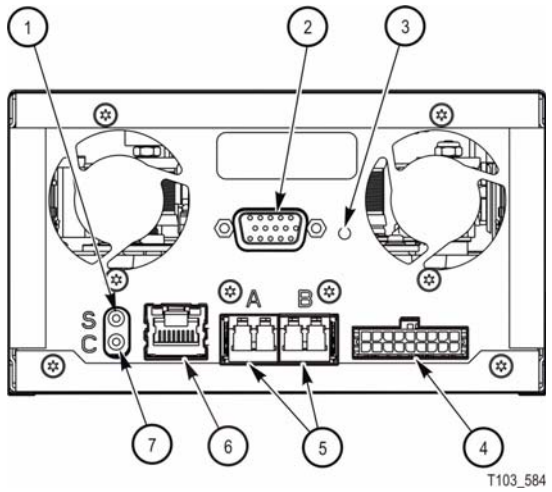
Figure 2 shows a rear view of the T10000C tape drive.

Figure 1. T10000A and T10000B Tape Drive Rear View



1. Drive status LED	5. Ethernet port
2. Recessed switch (service only)	6. Encryption status LED
3. Tape transport interface (TTI) connector	7. Power supply connector
4. Fibre Channel, LC interface ports (2) A & B	

Figure 2. T10000C Tape Drive Rear View



1. Drive status LED	5. Fibre Channel, LC interface ports (2) A & B
2. Tape transport interface (TTI) connector	6. RJ-45 Ethernet connector
3. Recessed switch (service only)	7. Encryption status LED
4. Power supply connector	

Specifications

This section lists the physical, environmental, and performance specifications for the T10000 tape drive.

Table 3. T10000A and T10000B Tape Drive Performance Specifications

Characteristic	Specification
Capacity and Performance	
T10000A Capacity, native	500 GB (5×10^{11} bytes)
T10000A Sport Cartridge, native	120 GB
T10000B Capacity, native	1 TB (1×10^{12} bytes)
T10000B Sport Cartridge, native	240 GB
Data buffer size	256 MB
Tape speeds:	
Read and write	2.0 and 4.95 m/s
File search and locates	8.0 m/s
High speed rewind	9.5 m/s
Interfaces	
Types	2FC = 1, 2 Gb Fibre Channel and FICON 4FC = 1, 2, 4 Gb Fibre Channel and FICON
Support	2FC = N_Port and NL_Port 4FC = N_Port only
Data rate (uncompressed)	120 MB/s
Compressed (maximum)	2FC = 180 MB/s 4FC = 360 MB/s
Burst transfer rate	2FC = 200 MB/s 4FC = 400 MB/s
Channel rate (Fibre Channel)	2FC = 1.0625 and 2.125 Gb/s 4FC = 1.0625, 2.125, and 4.250 Gb/s
Emulation Modes	3592 (MVS) and 3490 (VSM)
Access times	
Tape load and thread to ready	16 s
File access (includes loading)	62 s
Rewind (maximum)	91 s 23 s with the Sport cartridge
Unload time	23 s

Table 4. T10000C Tape Drive Performance Specifications

Characteristic	Specification
Capacity and Performance	
T10000C Capacity, native	5 TB (1 X 10^{12} bytes)
T10000C Sport Cartridge, native	1 TB
Data buffer size	2 GB
Tape speeds:	
Read and write	3.7 and 5.6 m/s
File search and locates	13 m/s
High speed rewind	13 m/s
Interfaces	
Types	4FC = 1, 2, 4 Gb Fibre Channel and FICON
Support	4FC = N_Port and NL_Port
Data rate (uncompressed)	240 MB/s
Compressed	4FC = 360 MB/s
Burst transfer rate	4FC = 400 MB/s
Channel rate (Fibre Channel)	4FC = 1.0625, 2.125, and 4.250 Gb/s
Emulation Modes	3592 (MVS) and 3490 (VSM)
Access times	
Tape load and thread to ready	16 s
File access (includes loading)	57 s
Rewind (maximum)	115 s 32.5 s with the Sport cartridge
Unload time	23 s

External Power Supply Module

Table 5. Power Supply Physical Dimensions

Measurement	Specification
Width	14.7 cm (5.77 in.)
Depth	20.4 cm (8.04 in.)
Height	4.7 cm (1.83 in.)
Weight:	1.4 kg (3.5 lb) 2.38 kg (5.25 lb) L-Series libraries

Table 6. Power Specifications

Characteristics	Specification
Input voltage	88 to 264 VAC
Input frequency	48 to 63 Hz
Power consumption	58 W (drive only) 90 W (drive and power supply)
Power dissipation	420 Btu/hr

Environmental Requirements

Note: Although the T10000 tape drive will function over the full list of ranges as specified below, *optimal reliability* will be achieved if the environment is maintained between the recommended ranges.

Table 7. Environmental Specifications

Description	Optimum	Recommended	Ranges
Temperature			
- Operating - Shipping - Storing	22°C (72°F)	20° – 25°C (68° – 77°F)	10° to 40°C (50° to 104°F) -40° to 60°C (-40° to 140°F) 10° to 40°C (50° to 104°F)
Relative Humidity			
- Operating - Shipping - Storing	45%	40% – 50%	20% to 80% 10% to 95% 10% to 95%
Wet bulb (non-condensing)			
- Operating - Shipping - Storing	29°C (84°F) 35°C (95°F) 35°C (95°F)		

Important: Industry best practices recommends computer rooms maintain a relative humidity of 40% to 50% for best performance.

Physical Interface

2

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

Topologies

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

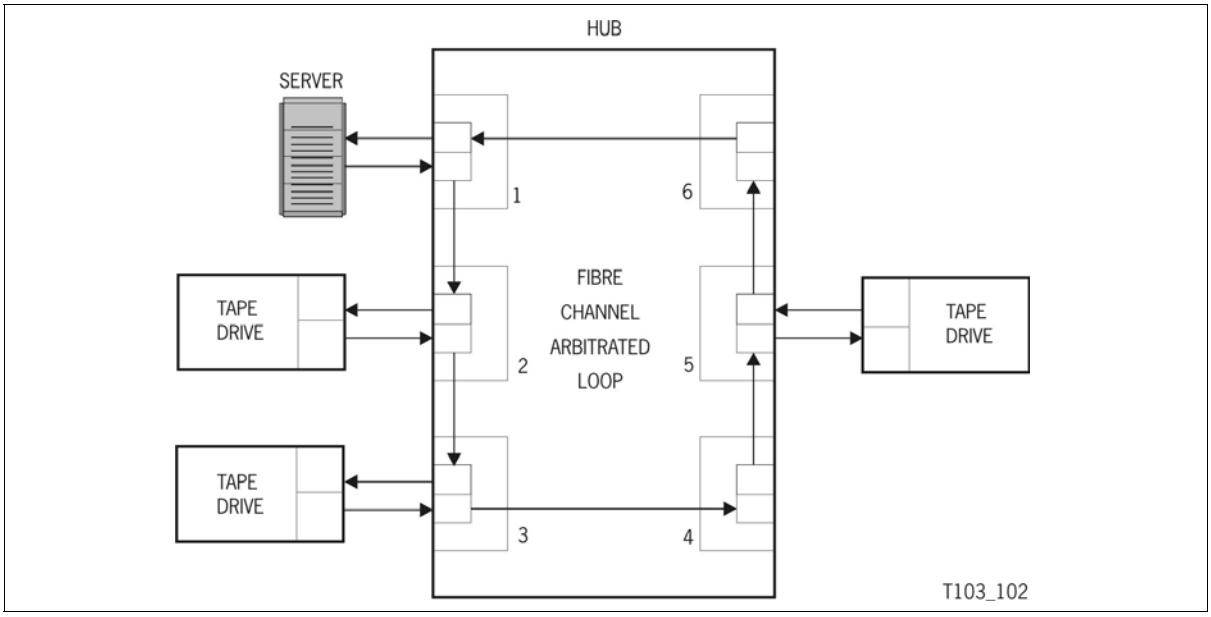
- Arbitrated Loop—private loop, NL_Port to NL_Ports
- Arbitrated Loop—public loop, NL_Port to NL_Ports, and one FL_Port
- Fabric F_Port attachment
- Point to Point attachment

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 3 is an example of a hub producing an arbitrated loop.

Figure 3. 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. 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 4 is an example of cascading hubs.

Figure 4. Loop Containing a Switch and a Hub

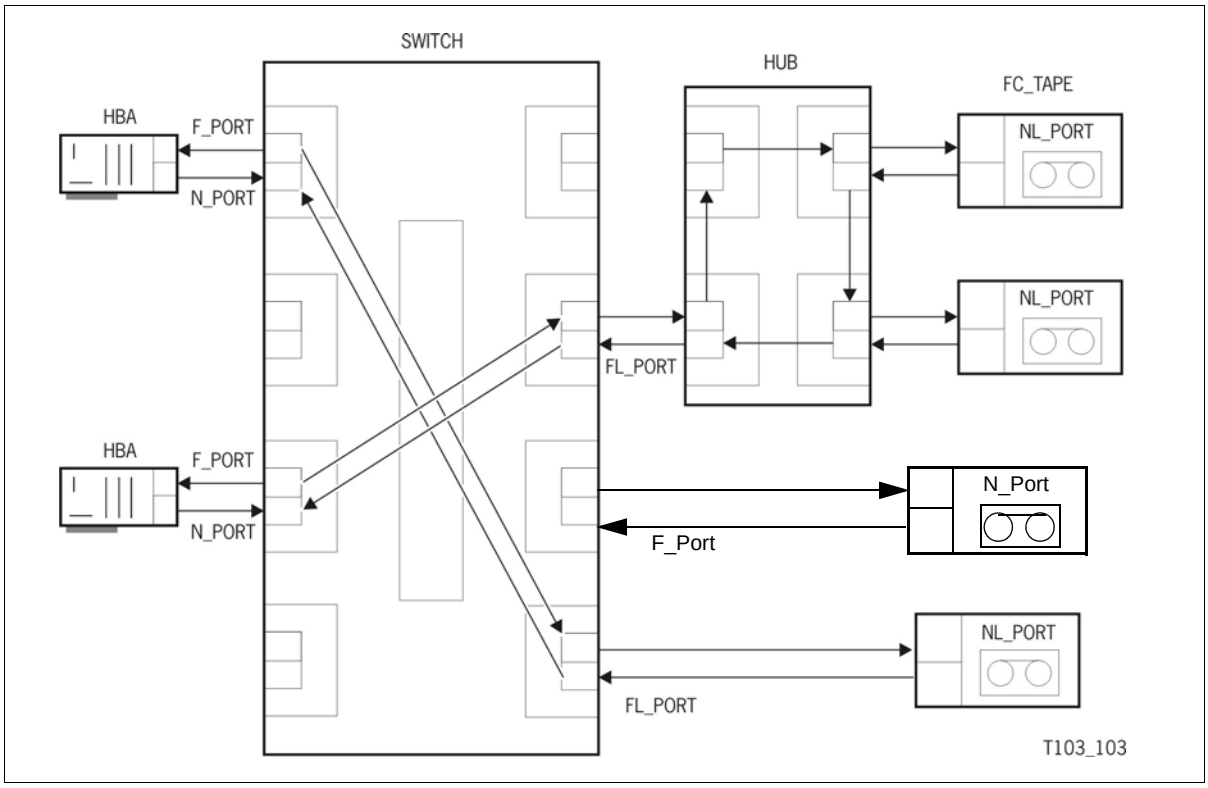
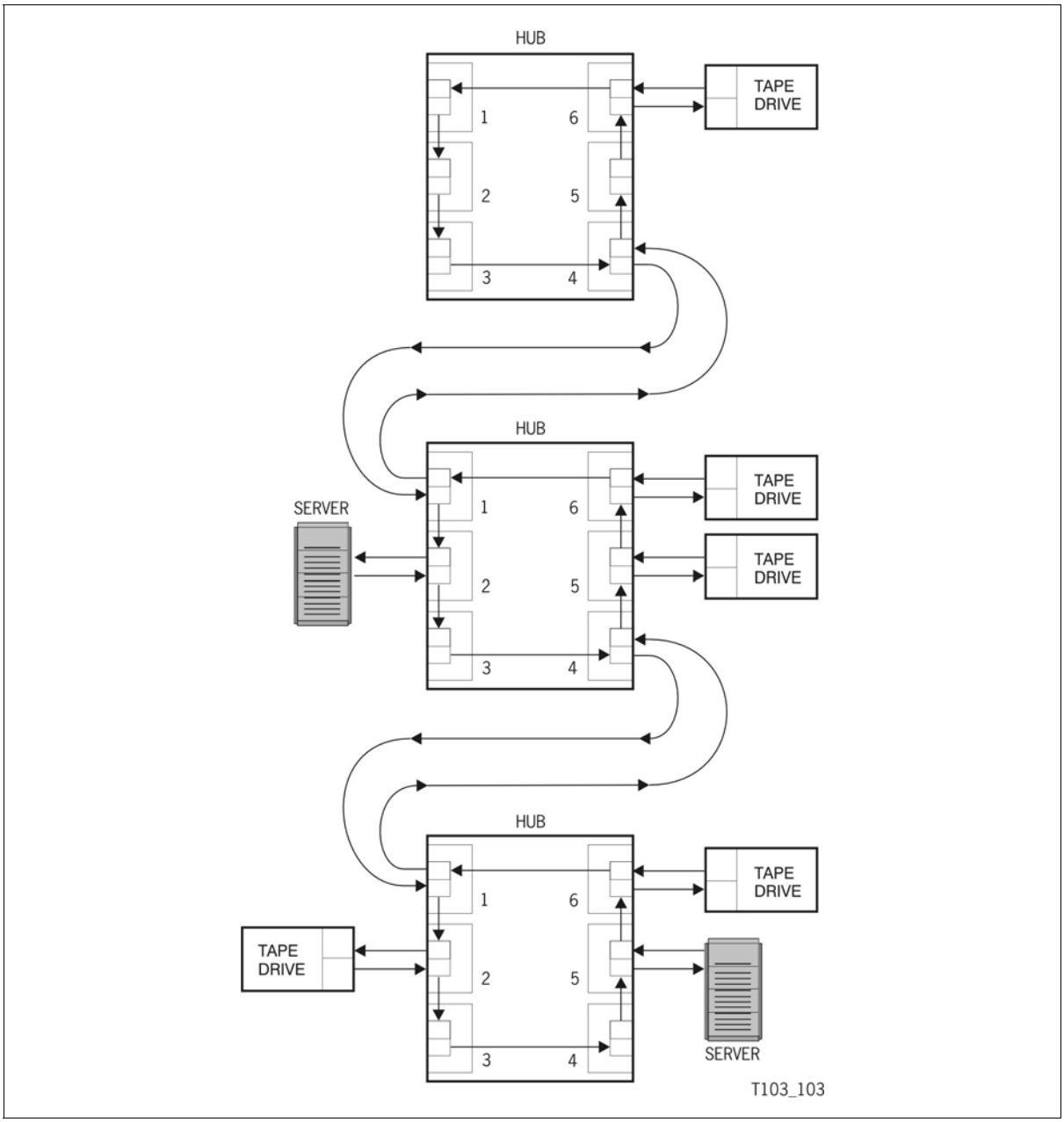


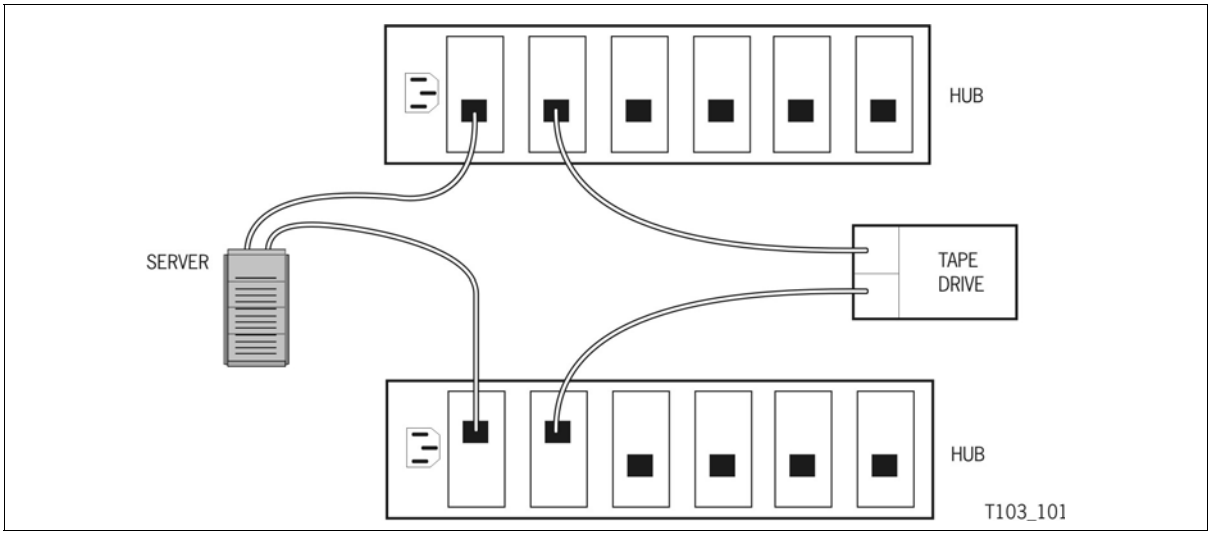
Figure 5. Cascading Hubs



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 6. 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

The T10000 tape drive can support either short or long wavelength interface ports. The 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).

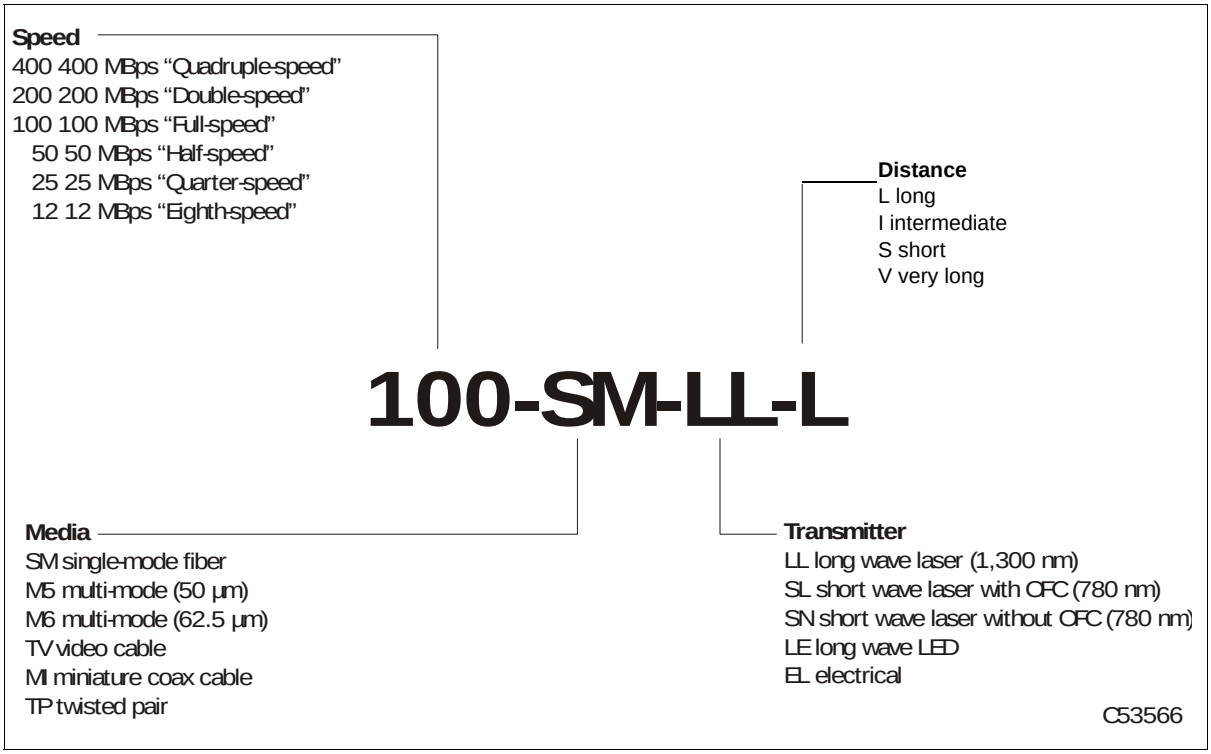
Table 8 and Figure 7 list the cable and connector specifications.

Table 8. 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 7 provides a description of the FC-0 codes.

Figure 7. Cable Marking Descriptions



Operations

3

This chapter describes how StorageTek tape drives operate using a Fibre Channel (FC) interface.

Note: This document is defined by the requirements in FC-Tape Revision 1.17. As updates occur to the FC-Tape document, this document will be updated accordingly.

Connections

The T10000 tape drives support connections for both:

- 2FC = Direct N_Port, Arbitrated Loop, and a Fabric
- 4FC = Direct N_Port and a Fabric

Arbitrated Loop

An arbitrated loop provides multiple connections for devices that share a single loop, but only provides point-to-point connections between an initiator and target during communications.

Note: Both public loops and private loops are supported.

As with SCSI protocol, when devices want to communicate on the bus, they must arbitrate and win the connection before communications can begin. The same goes with the arbitrated loop. Once a device is powered-on and initialized on the loop, it must arbitrate and win to be able to communicate with other devices on the loop.

Fabric Attachment

Fabric, or F_Ports, provide “direct” attachments to the tape drives. The Fabric receives frames from a source N_Port and routes them to a destination N_Port whose address identifier is specified within the frame.

Direct N_Port Attachment

The T10000 tape drives support direct attachment to a host through a host bus adapter (HBA) that creates an N-Port. The HBA sends and receives to and from the tape drive.

Addressing

StorageTek tape drives use: Port name, Node name, and Port ID for login validation. The StorageTek registration ID is 24 bits consisting of:

- 00104F (hex)

Table 9 indicates the Institute of Electrical and Electronics Engineers (IEEE) registered format for Name Address Authority (NAA), company ID, and vendor specific identifier for a total of 64 bits.

Table 9. 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)

All ports validate the logins by comparing Port Name, Node Name, and Port ID. 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.

Terms and Definitions

Tables throughout this chapter use the following terms for compliance with the American National Standards Institute (ANSI) Fibre Channel Tape (FC–Tape) Technical Report for 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)	The StorageTek tape drive conforms to that command, feature, or value.
No (N)	The StorageTek tape drive does *not* conform to that command, feature, or value.
Originate (Orig.)	Originates the exchange or SCSI command from the tape drives.
Response (Resp.)	Responds with an acknowledgement (R_RDY and/or data) from the tape 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).

- 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 1-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.

Tape Drive States

Power Up

When the drive completes the power-on 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-on 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.

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 tape drives implement the following Fibre Channel feature set:

Table 10. 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 does 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.

Note: 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, and 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 11 lists the Common Service Parameters for Port Login (PLOGI):

Table 11. NL_Port Common Service Parameters, Port Login

Parameter	Word	Bits	StorageTek Value			FC-Tape
			2FC N_Port	2FC NL_Port	4FC N_Port	
FC-PH Version: Highest Version Lowest Version	 0 0	 31–24 23–16	 x ‘09’ x ‘09’	 x ‘09’ x ‘09’	 x ‘20’ x ‘20’	 x x ‘20’
Buffer-to-Buffer Credit (min.)	0	15–0	x’0003’	x’0000’	x’025A’ [1] x’0003’ [2]	0
Common Features:	1	31–16				
Continuously Increasing Relative Offset	1	31	1	1	1	1
Random Relative Offset	1	30	0	0	0	0
Valid Vendor Version Level	1	29	0	0	0	0
N_Port/F_Port	1	28	0	0	0	0
Alternate BB_Credit Management	1	27	1	1	1	–
E_D_TOV Resolution	1	26	0	0	0	–
Reserved	1	25–23	0	0	0	–
Dedicated Simplex	1	22	0	0	0	–
Reserved	1	21–19	0	0	0	–
Dynamic Half Duplex – DHD	1	18	0	0	0	–
SEQ_CNT	1	17	0	0	0	x
Payload Length	1	16	0	0	0	–
Buffer-to-Buffer Receive Data Field Size (min.)	1	15–0	x’0800’	x’0800’	x’0800’	256
Total Concurrent Sequences (min.)	2	31–16	x’00FF’	x’00FF’	x’00FF’	1
Relative Offset by Information Category = (Category 1 and 5 only)	2	15–0	x‘000F	x‘000F	x‘001F’	x‘0002
Error Detect Timeout (E_D_TOV) 2 seconds	3	31–0	x‘000007D0’			x‘000007D0’

1. With inline credit extender *enabled*.
2. With inline credit extender *disabled*.

Table 12 lists the Common Service Parameters the tape drive supports for Fabric Login (FLOGI):

Table 12. NL_Port Common Service Parameters, Fabric Login

Parameter	Word	Bits	StorageTek Value			NL-Port Originator
			2FC N_Port	2FC NL_Port	4FC N_Port	
FC-PH Version: Highest Version Lowest Version	 0 0	 31–24 23–16	 x ‘09’ x ‘09’	 x ‘09’ x ‘09’	 x ‘20’ x ‘20’	 x x ‘20’
Buffer-to-Buffer Credit (min.)	0	15–0	x’0003’	x’0000’	x’025A’ [1] x’0003’ [2]	–
Common Features:						
Reserved	1	31–30	0	0	0	–
Valid Vendor Version Level	1	29	0	0	0	0
N_Port/F_Port	1	28	0	0	0	0
Alternate BB_Credit Management	1	27	0	1	0	1
Reserved	1	26–19	0	0	0	–
Dynamic Half Duplex	1	18	0	0	0	–
Reserved	1	17	0	0	0	–
Payload Length	1	16	0	0	0	–
Buffer-to-Buffer Receive Data Field Size (min., see note)	1	15–0	x‘0800’	x‘0800’	x‘0800’	256
Reserved	2	31–0	0	0	0	–
Reserved	3	31–0	0	0	0	–
Note: This is controlled by a configuration item.						
1. With inline credit extender *enabled*. ? 2. With inline credit extender *disabled*.						

FC Class 3

Fibre Channel provides several different strategies to ensure reliable communications between devices. These strategies are called Classes of Service. The tape drive supports 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 13 indicates the two types of delimiters for Class 3 operations.

Table 13. 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 14 and Table 15 list Class 3 Service Parameters supported.

Class 3 Service Parameters, Port Login

Table 14 lists Class 3 Service Parameters for Port Login (PLOGI):

Table 14. Class 3 Service Parameters, Port Login

Parameters	Word	Bits	StorageTek Value			FC-Tape
			2FC N_Port	2FC NL_Port	4FC N_Port	
Class validity	0	31	1	1	1	1
Service Options:	0	30–16				
Intermix Mode	0	30	0	0	0	–
Stacked Connect Requests	0	29–28	00	00	00	–
Sequential Delivery	0	27	0	0	0	–
Dedicated Simplex	0	26	0	0	0	–
Camp-On	0	25	0	0	0	–
Buffered Class 1	0	24	0	0	0	–
Priority	0	23	0	0	0	–

Table 14. Class 3 Service Parameters, Port Login (Continued)

Parameters	Word	Bits	StorageTek Value			FC-Tape
			2FC N_Port	2FC NL_Port	4FC N_Port	
Initiator Control:	0	15–0				
Sequence Initiator X_ID reassignment	0	15–14	00	00	00	–
Initial Responder Process_Associator	0	13–12	00	00	00	00
Sequence Initiator ACK_0 capable	0	11	0	0	0	–
Sequence Initiator ACK_N Capable	0	10	0	0	0	–
ACK generation assistance	0	9	0	0	0	–
Initiator Data compression capable	0	8	0	0	0	0
Initiator Data compression history buffer size = ‘00’b	0	7–6	00	00	00	–
Data Encryption Capable	0	5	0	0	0	0
Clock Synchronization Capable	0	4	0	0	0	P
Recipient Control:	1	31–16				
ACK_0 Capable	1	31	0	0	0	–
ACK_N Capable	1	30	0	0	0	–
X_ID Interlock	1	29	0	0	0	–
Error Policy Supported	1	28–27	00	00	00	TBD
Categories per Sequence	1	25–24	00	00	00	00
Data compression capable	1	23	0	0	0	0
Data compression history buffer size	1	22–21	00	00	00	–
Data decryption capable	1	20	0	0	0	0
Clock synchronization capable	1	19	0	0	0	A
Reserved – fabric specific	1	18–16	0	0	0	0
Receive data field size (min.)	1	15–0	x‘0800’	x‘0800’	x‘0800’	256
Concurrent Sequences > 0	2	31–16	x‘00FF’	x‘00FF’	x‘00FF’	1
N_Port End-to-end Credit	2	14–0	0	0	0	–
Open Sequences per Exchange > 0	3	31–16	x‘0001’	x‘0001’	x‘0001’	1
Class 6 Multicast RX_ID	3	15–0	0	0	0	–

Class 3 Service Parameters, Fabric Login

Table 15 lists Class 3 Service Parameters the tape drives support for Fabric Login (FLOGI):

Table 15. Class 3 Service Parameters, Fabric Login

Parameters	Word	Bits	StorageTek Value			FC-Tape
			2FC N_Port	2FC NL_Port	4FC N_Port	
Class validity	0	31	1	1	1	1
Service Options:						
Intermix Mode	0	30	0	0	0	–
Stacked Connect Requests	0	29–28	0	0	0	–
Sequential Delivery	0	27	1	1	1	1
Dedicated Simplex	0	26	0	0	0	–
Camp-On	0	25	0	0	0	–
Buffered Class 1	0	24	0	0	0	–
Reserved	0	23	0	0	0	–
Initiator Control:						
Reserved	0	15–0	00	00	00	–
Recipient Control:						
Reserved	1	31–16	0	0	0	–
Receive data field size (min, see note)	1	15–0	x‘0800’	x‘0800’	x‘0800’	256
Concurrent Sequences (min)	2	31–16	0	0	0	–
N_Port End-to-end Credit	2	14–0	0	0	0	–
Open Sequences per Exchange (min)	3	31–16	0	0	0	–
Reserved	3	15-0	0	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 drive:

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 3	R	R	Y
Class 2	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 Pre-empted (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	–
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

Table 18. Extended Link Services (Continued)

Command	FC-TAPE				StorageTek	
	From Initiator	Target Response	From Target	Initiator Response	Drv Orig.	Drv Resp.
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	–
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

Table 18. Extended Link Services (Continued)

Command	FC-TAPE				StorageTek	
	From Initiator	Target Response	From Target	Initiator Response	Drv Orig.	Drv Resp.
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:

8. All three identifiers must match at login for Accepts (ACC) to be returned:
   - Port ID,
   - Port Name, and
   - Node Name

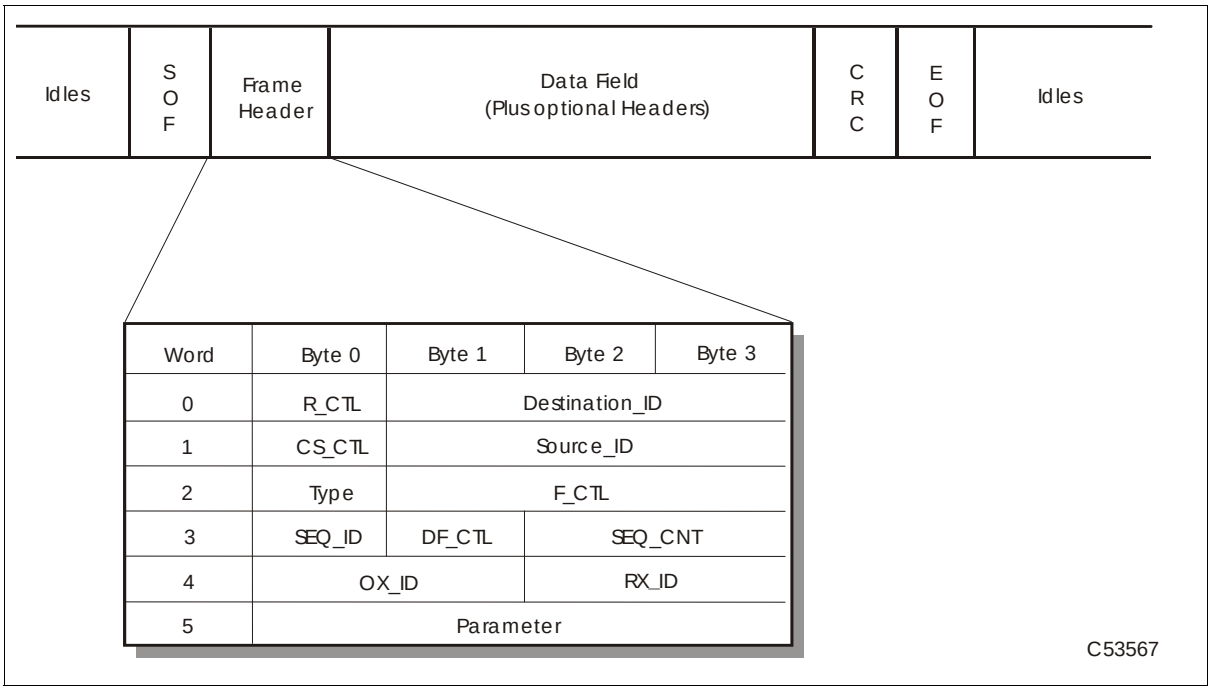
   If all three identifiers do not match a logout (LOGO) is returned.

   If other conditions prevent execution of the ADISC or PDICS ELS, return a reject (LS_RJT) with the appropriate reason code.
9. BA_ACC if valid RX_ID else BA_RJT
10. If PRLI has not been successfully completed, set the reason code to "Image Pair Does Not Exist."

Frame Transmission

Figure 8 shows the frame format for transmission of data and commands over Fibre Channel.

Figure 8. 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:
    a. 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.
    b. 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 (as defined in FCP-2)

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 timeouts. 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's 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[2] R	Y Y
$R\_A\_TOV_{SEQ\_QUAL}$	Private = 0 sec. Public = 10 sec. (note 1)	R	A (note 2)	Y
$R\_A\_TOV_{ELS}$	Private = 2 sec. Public = 10 sec.	R	R	Y
RR_TOV_{AUTH}	2 sec.		R	Y
$RR\_TOV_{SEQ\_INIT}$	> = REC_TOV + 2 x $R\_A\_TOV_{ELS}$ + 1 sec.		R	Y
REC_TOV	> = E_D_TOV + 1 sec. (min.)	R	R	Y
ULP_TOV	> = Operation specific timer + 2 x RR_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.

Process Login Parameters

Table 25 and Table 26 on page 46 lists Process Login (PRLI) 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
Target Function = 1	A	R	Y
Write XFER_RDY Disabled = 1	P	P	N
If the initiator requests it, the use of data overlay is only allowed in response to an SRR (such as error recovery).			

Table 26. PRLI Accept FCP Services Parameter Page

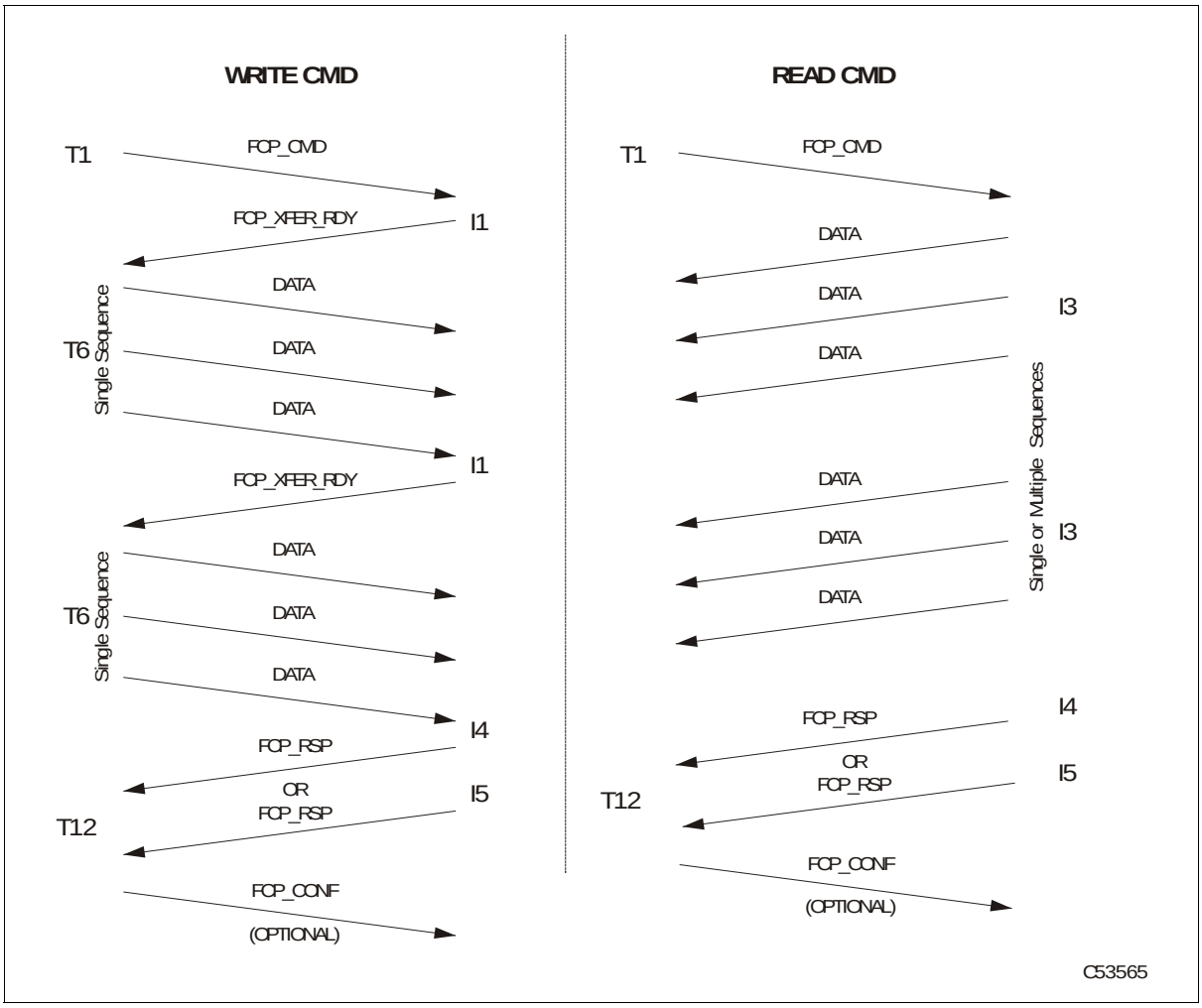
FCP Service Parameters	Word	Bits	StorageTek Value		
			2FC N_Port	2FC NL_Port	4FC N_Port
SCSI FCP (08h)	0	31–24	x'08'	x'08'	x'08'
Reserved	0	23–16	0	0	0
Originator Process_Associator Valid	0	15	0	0	0
Responder Process_Associator Valid	0	14	0	0	0
Image Pair Established	0	13	1	1	1
Reserved	0	12	0	0	0
Accept Response Code	0	11–8	b'0001'	b'0001'	b'0001'
Reserved	0	7–0	0	0	0
Originator Process_Associator	1	31–0	0	0	0
Responder Process_Associator	2	31–0	0	0	0
Reserved	3	31–10	0	0	0
Task Retry Identification Requested	3	9	1	1	1
Retry	3	8	1	1	1
Confirmed Completion Allowed	3	7	0	0	0
Data Overlay Allowed	3	6	0	0	0
Initiator Function	3	5	0	0	0
Target Function	3	4	1	1	1
Obsolete	3	3	0	0	0
Obsolete	3	2	0	0	0
Read FCP_XFER_RDY Disabled	3	1	1	1	1
Write FCP_XFER_RDY Disabled	3	0	0	0	0

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)

Figure 9. Examples of Read and Write Information Units



Command Information Unit

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

Table 27. 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.

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 28 lists the FCP_RSP payload fields:

Table 28. 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	26
FCP_SNS_LEN_VALID	R	I	Y
Length of Additional Sense Bytes in FCP_SNS_INFO	R	≤ 120	18
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 29 indicates the result of a Task Management function in the RSP_CODE of the FCP_RSP_INFO fields.

Table 29. 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 page load, the drive 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 30 lists the Task Management Flags the tape drives support:

Table 30. 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 31 lists the FCP Task Attributes supported by the tape drives:

Table 31. 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	I	A	Y
Note: All Queue Types are accepted and behave the same.			

Other Features

Table 32 lists other FCP features supported:

Table 32. 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 five 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 33 lists the clearing effects of Fibre Channel actions:

Table 33. 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	–

Table 33. 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
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	–
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 T10000 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.

- See Table 34 for the reservation restrictions placed on commands for the Reserve/Release management method.
- See Table 35 on page 62 for the reservation restrictions placed on the Persistent Reservations management method.

Each method lists the type of restriction for the command being performed:

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 34. 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 Attribute (8Ch)	Conflict
Read Block Limit (05h)	Allowed
Read Buffer (3Ch)	Conflict
Read Media Serial Number (ABh–01h)	Allowed
Read Position (34h)	Conflict

Table 34. Reserve/Release Management Method (Continued)

Command	Action when Reserved by a different Initiator
Receive Diagnostic Results (1Ch)	Conflict
Release Unit (17h/57h)	Allowed, the reservation is not released.
Report Density Support (44h)	Allowed
Report LUNs (A0h)	Allowed
Report Supported Operations Codes (A3h–0Ch)	Conflict
Report Supported Task Management Functions (A3h–0Dh)	Conflict
Report Target Port Groups (A3h–0Ah)	Allowed
Request Sense (03h)	Allowed
Reserve Unit (16h/56h)	Conflict
Rewind (01h)	Conflict
Send Diagnostic (1Dh)	Conflict
Space (11h)	Conflict
Spin (A2h)	Conflict
Spout (B5h)	Conflict
Test Unit Ready (00h)	Conflict
Verify (13h)	Conflict
Write (0Ah)	Conflict
Write Buffer (3Bh)	Conflict
Write Filemarks (10h)	Conflict

Table 35 lists the reservation restrictions placed on the Persistent Reservations management method.

Table 35. Persistent Reservation Management Method

Command	From Non-registered Initiators	From 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 Pre-empt, conflict Pre/Abt, conflict	Register, allowed Reserve, conflict Release, allowed Clear, allowed Pre-empt, allowed Pre/Abt, allowed
Prevent/Allow Media Removal (1Eh)	Prevent = 0, allowed Prevent = NZ, conflict	Allowed
Read (08h)	Conflict	Allowed
Read Attribute (8Ch)	Conflict	Allowed
Read Block Limit (05h)	Allowed	Allowed
Read Buffer (3Ch)	Conflict	Allowed
Read Media Serial Number (ABh–01h)	Allowed	Allowed
Read Position (34h)	Conflict	Allowed
Receive Diagnostic Results (1Ch)	Conflict	Allowed
Release Unit (17h/57h)	Conflict	Allowed, reservation is not released
Report Density Support (44h)	Allowed	Allowed
Report LUNs (A0h)	Allowed	Allowed

Table 35. Persistent Reservation Management Method (Continued)

Command	From Non-registered Initiators	From Registered Initiators
Report Supported Operations Codes (A3h–0Ch)	Conflict	Allowed
Report Supported Task Management Functions (A3h–0Dh)	Conflict	Allowed
Report Target Port Groups (A3h–0Ah)	Allowed	Allowed
Request Sense (03h)	Allowed	Allowed
Reserve Unit (16h/56h)	Conflict	Allowed, reservation is not changed
Rewind (01h)	Conflict	Allowed
Send Diagnostic (1Dh)	Conflict	Allowed
Space (11h)	Conflict	Allowed
Spin (A2h)	Conflict	Allowed
Spout (B5h)	Conflict	Allowed
Test Unit Ready (00h)	Conflict	Allowed
Verify (13h)	Conflict	Allowed
Write (0Ah)	Conflict	Allowed
Write Buffer (3Bh)	Conflict	Allowed
Write Filemarks (10h)	Conflict	Allowed

Commands

4

This chapter defines the SCSI-3 commands for the StorageTek T10000 Tape Drive with a Fibre Channel interface.

Overview

StorageTek uses 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).

Commands

Table 36 lists the supported commands and references the appropriate page.

Table 36. Supported SCSI Commands

Command	Code	Reference	Page
Erase	19h	SSC	70
Inquiry	12h	SPC-2	71
Load Display	06h	Vendor specific	81
Load/Unload	1Bh	SSC	83
Locate	2Bh	SSC	85
Log Select	4Ch	SPC-2	86
Log Sense	4Dh	SPC-2	87
Mode Select	15h / 55h	SPC-2	105

Table 36. Supported SCSI Commands (Continued)

Command	Code	Reference	Page
Mode Sense	1Ah / 5Ah	SPC-2	121
Persistent Reserve In	5Eh	SPC-2	138
Persistent Reserve Out	5Fh	SPC-2	143
Prevent/Allow Media Removal	1Eh	SSC	147
Read	08h	SSC	148
Read Attribute	8Ch	SPC-4	151
Read Block Limits	05h	SSC	157
Read Buffer	3Ch	SPC-2	158
Read Media Serial Number	ABh – 01h	SPC-3	161
Read Position	34h	SSC	162
Receive Diagnostic Results	1Ch	SPC-2	167
Release Unit	17h / 57h	SPC-2	169
Report Density Support	44h	SSC	171
Report LUNs	A0h	SPC-2	176
Report Supported Operation Codes	A3h – 0Ch	SPC-4	177
Report Supported Task Management Functions	A3h – 0Dh	SPC-4	183
Report Target Port Groups	A3h – 0Ah	SPC-4	185
Request Sense	03h	SPC-2	189
Reserve Unit	16h / 56h	SPC-2	199
Rewind	01h	SSC	201
Security Protocol In (SPIN)	A2h	SSC-3	202
Security Protocol Out (SPOUT)	B5h	SSC-3	217
Send Diagnostic	1Dh	SPC-2	225
Space	11h	SSC	226
Test Unit Ready	00h	SSC	228
Verify	13h	SSC-2	229
Write	0Ah	SSC	231
Write Buffer	3Bh	SPC-2	234
Write Filemarks	10h	SSC	236

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.

Notes:

- The CDB Field in Byte 1, Bits 7-5, which was the LUN Field is now reserved. The drive will ignore this field.
- RSVD indicates that “bit” is reserved.

Command Descriptor Block

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

- 6–Byte commands (Table 37)
- 10–Byte commands (Table 38)
- 12-Byte commands (Table 39)

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

Table 37. 6-Byte Command Descriptor Block

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

Table 38. 10-Byte Command Descriptor Block

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Command Parameters				
2 thru 8	(MSB) Command Parameters (LSB)							
9	Control Byte							

Table 39. 12-Byte Command Descriptor Block

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Command Parameters				
2 thru 9	(MSB) Command Parameters (LSB)							
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 40. Control Byte

Byte	Bit							
	7	6	5	4	3	2	1	0
5/9/11	Vendor-specific		Reserved				Flag	Link

Parameter	Value
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 the data security erase (DSE) configuration option is set to full.

Table 41. 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							

Parameter	Value
Immed: Immediate	0 = Return status when erase is completed 1 = Return status when erase is started
Long: Long	0 = Ignored, no erase performed 1 = Erase to the physical end-of-volume starting at the current logical position.

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.

Table 42. Inquiry Command

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

Parameter	Value
CmdDt: Command support Data	0 = Do not return command support data
EVPD: Enable Vital Product Data	0 = Return normal inquiry data 1 = Return Vital Product Data
Page Code	EVPD page to return
Allocation Length	Specifies the maximum length of inquiry data to return

Notes:

- The Inquiry command returns 74 bytes of data. If the allocation length is less than 74 bytes, the data is truncated.
- 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 74 bytes shown in Table 43.

Table 43. Inquiry Data Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral Qualifier			Peripheral Device Type				
1	RMB	Reserved						
2	ECMA Version							
3	AERC	RSVD	NormACA	HiSup	Response Data Format			
4	Additional Length (n - 4)							
5	SCCS	ACC	TGPS		3PC	Reserved		Protect
6	BQue	EncServ	VS	MultiP	MChngr	Reserved		
7	RelAdr	Reserved			Linked	RSVD	CmdQue	VS
8 thru 15	(MSB) Vendor Identification (LSB)							
16 thru 31	(MSB) Product Identification (LSB)							
32 thru 39	(MSB) Product Revision Level (LSB)							
40 thru 53	(MSB) Vendor Specific (LSB)							
54	Key Management (KM)							
55	Reserved			Encrypt	LibAtt	VolSafe	DCMP	CSL
56 thru 57	(MSB) Reserved (LSB)							
58 thru 73	(MSB) Version Descriptor 1 to 8 (2 bytes each) (LSB)							

Parameter	Value
Peripheral Qualifier	000b = Peripheral device is connected to this logical unit 011b = Not capable of supporting a device on this logical unit
Peripheral Device Type	01h = Device is a sequential access device (tape drive) 1Fh = Device does not exist or is offline
RMB: Removable Medium Bit	1 = Medium is removable
ECMA Version European Computer Manufacturers Association	05h = Complies with ANSI INCITS 408-2005 (SPC-3)
AERC: Asynchronous Event Reporting Capability	0 = Not supported
NormACA: Normal Auto Contingent Allegiance	0 = Not supported
HiSup: Hierarchical Support	0 = Not supported
Response Data Format	02 = Inquiry data is in ANSI SPC–2 format
Additional Length	45h = 69 additional bytes of data follows
SCCS: SCSI Controller Command Support	0 = Not supported
ACC: Access Controls Coordinator	0 = Not supported
TPGS: Target port group support	0 = Not supported
3PC: Third-Party Copy	0 = Not supported
Protect	0 = The logical unit does not support protection information. 1 = The logical unit supports protection information.
BQue: Basic Queuing	0 = Not Supported
EncServ: Enclosure Services	0 = Not supported
VS: Vendor Specific	0 = Not supported
MultiP: Multi-Port	1 = Supports two ports
MChngr: Medium Changer	0 = Not supported

Parameter	Value
RelAdr: Relative Address	0 = Not supported
Linked: Linked commands	0 = Not supported
CmdQue: Command Queuing	0 = Not supported
Vendor Identification	STK = StorageTek, Sun Microsystems (ASCII)
Product Identification: Device type in ASCII	T10000A = Drive is a T10000A T10000B = Drive is a T10000B T10000C = Drive is a T10000C
Product Revision: 8 byte ASCII field	For example: 1.23.456 Indicates: • Major release 1, • Revision 23, • Minor release 456 This field will change with each drive firmware release.
VS: Vendor Specific	Vendor Specific 0 = Not supported
Key Management (KM)	0 = None 1 = Key Management Station (KMS) Version 1 2 = Key Management System (KMS) Version 2 4 = Data Path Key Management (DPKM) Spin/Spout
Encrypt: Encryption	Encryption: 0 = Not encrypting drive 1 = Encrypting drive
LibAtt: Library Attach	Library Attachment: 0 = Drive is not attached to a library 1 = Drive is attached to a library
VolSafe: VolSafe available	1 = VolSafe enabled A Sun StorageTek write once, read many (WORM) technology to designated tape cartridges.
DCMP: Data Compression	0 = Data compression is disabled 1 = Data compression is enabled
CSL: Cartridge Scratch Loader installed	0 = CSL is not installed

Parameter	Value
Version Descriptor	Standards supported by this device: 0000h = Empty 0077h = SAM-3_ANSI_INCITS.402:2005 0314h = SPC-3_ANSI_INCITS.408:2005 0403h = SSC-3 T10/1611-D Revision 04a 0A11h = FCP-3_ANSI_INCITS.416:2006

Vital Product Data Pages

There are three vital product data pages that contain specific information:

00h = Supported vital product data pages (Table 44)
80H = Device serial number page (Table 45)
83h = Device identification page (Table 46)
85h = Management Network Address page (Table 47)
B0h = Sequential Access Device Capabilities page (Table 48)

Table 44. 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 (05h)							
4	Supported VDE Pages (00h)							
5	Device Serial Number Page (80h)							
6	Device Identification Page (83h)							
7	Management Network Addresses Page (85h)							
8	Sequential Access Device Capabilities page (B0h)							

Vital Product Data (VPD)
Page Code = 00h returns a list of the supported VPD pages.

Table 45. 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)							

Page Code = 80h returns the tape drive serial number in ASCII.

Table 46. 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 (28h)							
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)							

Table 46. Device Identification Page (Continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
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 Identifier (binary) (LSB)							
Target Port Group								
36	Reserved				Code Set (1)			
37	Reserved		Association (1)		Identifier Type (5)			
38	Reserved							
39	Identifier Length (04h)							
40 thru 41	(MSB) Target Port Group Identifier (binary) (LSB)							

Parameter	Value
Page Code	83h returns four identifying numbers. • World Wide Name (WWN) for the tape drive • WWN for the port that accepted the Inquiry command • Port Number (1 or 2) for that port • Target Port Group Descriptor
Code Set	1h = Identifier field contains binary values
Association	00b = Identifier is for the device 01b = Identifier is for a port

Parameter	Value
Identifier Type	3h = Identifier field contains a 64 bit IEEE registered format address, also known as a World Wide Name. 4h = 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	01h = Command accepted by device port A 02h = Command accepted by device port B
Target Port Group	Contains the primary Target Port Group

Table 47. 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 thru 7	(MSB) Network Address Length (LSB)							
8 thru 33	(MSB) Network Address (LSB)							

Parameter	Value
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 The URL of the accessing drive management port	For example, TELNET://123.345.123.123/ 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 48. 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 thru 3	Page Length (02h)							
4	Reserved							WORM
5	Reserved							

Parameter	Value
Peripheral Qualifier	000b = Peripheral Device is connected to this Logical Unit
Peripheral Device Type	01h = Device is a sequential-access device (tape drive)
WORM	1 = 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 virtual operator panel 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 49. Load Display Command

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

Load Display Data Format

Table 50. 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) (ASCII) Message 1 (LSB)							
9 thru 16	(MSB) (ASCII) Message 2 (LSB)							

Notes:

- 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.

Parameter	Value
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. Any buffered write data and filemarks are written on the tape *before* an unload 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 51. Load/Unload Command

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

Parameter	Value
Immed: Immediate	0 = Return status when load or unload is complete 1 = Return status when load or unload is started
Hold	Not supported 0 = Normal load/unload
EOT: End-Of-Tape	0 = Tape is unloaded from BOT
Reten: Retention	0 = Do not retention the tape 1 = Retention tape (ignored)
Load	0 = Unload the tape 1 = Load the tape

Notes:

- 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.
- After a successful load operation, Good status is returned. The next command returns a sense key of unit attention.
- If a Load command is issued when a tape is already loaded, the Load command is ignored.
- If the drive is installed in a library, a load command to an unloaded drive is rejected.
- When the drive needs cleaning, an unload will return Check Condition status with a Sense Key of 0h and an ASC/ASCQ of 0017h indicating the tape drive requires cleaning.

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 52. 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							

Parameter	Value
BT: Block Address Type	0 = SCSI logical block address 1 = Vendor - specific (ignored)
CP: Change Partition	0 = Ignore partition field
Immed: Immediate	0 = Return status when locate is complete 1 = Return status when locate is started
Block Address	Logical block address position
Partition	00h = Default partition

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 53. 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							

Parameter	Value
PCR: Parameter Code Reset	0 = No operation performed 1 = Reset all parameters to default values
SP: Save Parameters	0 = Not supported
PC: Page Control	11b = Set Default Cumulative Values
Parameter List	Length in bytes of log parameter data to be transferred to the tape drive 00h = No parameter data

Notes:

- Setting the parameter code reset bit to one, clears all cumulative statistics.
- If the parameter code reset (PCR) bit is set to 0, this command is ignored and no values are reset.
- 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 54. 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 thru 4	(MSB) Reserved (LSB)							
5 thru 6	(MSB) Parameter Pointer (LSB)							
7 thru 8	(MSB) Allocation Length (LSB)							
9	Control Byte							

Parameter	Value
PPC: Parameter Pointer Control	0 = Send all log parameters for the specified log page 1 = Vendor specific (ignored)
SP: Save Parameters	0 = Not supported
PC: Page Control	00b = Current Threshold Values 01b = Current Cumulative Values 10b = Default Threshold Values 11b = Default Cumulative Values
Page Code: Log page 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 3Ah = Vendor unique drive statistics page (T10000A or T10000B only) 3Bh = Vendor unique port statistics page 3Ch = Vendor unique drive statistics page (T10000C only)
Parameter Pointer	Return data starting at this 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 55. 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)							
Log Parameter(s)								
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 56. 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		RSVD	LP
3	Parameter Length (n-3)							
4 thru n	(MSB) Parameter Value (LSB)							

Parameter	Value
Parameter Code	Identifies the log parameter being transferred
DU: Disable Update	0 = Drive updates log parameter value
DS: Disable Save	1 = saving the log is not supported
TSD: Target Save Disable	0 = Target provides a target defined method for saving log parameters 1 = Target does not provide a target defined method for saving the log parameters
ETC: Enable Threshold Comparison	0 = Comparison is not performed 1 = 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	0 = Log parameter is a data counter.

Log Sense Supported Pages

The Log Sense supported pages report which pages the tape drive supports. Table 57 lists pages for the T10000A or T10000B tape drives while Table 58 on page 91 lists the pages for the T10000C tape drive.

Table 57. Log Sense Supported Pages (T10000A or T10000B only)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2 thru 3	(MSB) Page Length (08h) (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 Drive Statistics Page (3Ah)							
11	Vendor Unique Port Statistics Page (3Bh)							

Table 58. Log Sense Supported Pages (T10000C only)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2 thru 3	(MSB) Page Length (08h) (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 Port Statistics Page (3Bh)							
11	Vendor Unique Drive Statistics Page (3Ch)							

Write Error Counter Page

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

Table 59. Write Error Counter Page Codes

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 60. Read Error Counter Page Codes

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 61. Non-Medium Error Page Codes

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 62. Sequential Access Device Page Codes

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	4	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, as a minimum:

- 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 63. 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

Table 63. TapeAlert Flags (Continued)

Code	Flag Name	Description	Length (bytes)
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	The RFID chip cannot be read or written to.	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	Retention Requested	Not supported	1
0019h	Dual port interface error	Not supported	1
001Ah	Cooling fan failure	Not supported	1
001Bh	Power supply failure	Not supported	1
001Ch	Power consumption	Not supported	1
001Dh	Drive Maintenance	Preventive maintenance of the drive is required	1
001Eh	Hardware A	Drive has a hardware fault	1
001Fh	Hardware B	Hardware not read/write related – not supported	1

Table 63. TapeAlert Flags (Continued)

Code	Flag Name	Description	Length (bytes)
0020h	Interface	Having problems with the interface, SCSI 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	Temperature inside the tape drive is above specified range	1
0025h	Drive Voltage	Not supported	1
0026h	Predictive Failure	A hardware failure of the drive is predicted	1
0027h	Diagnostics Required	Dump available	1
0028h thru 002Eh	Reserved for CSL		
002Fh thru 0031h	Reserved		
0032h	Lost Statistics	Media statistics lost 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	Loading failure	The operation has failed because the media could not be loaded and threaded.	1
0038h	Unrecoverable Unload failure	The operation has failed because the media could not be unloaded.	1
0039h	Automation Interface failure	Not supported.	1
003Ah	Firmware failure	The tape drive has reset itself due to a detected firmware fault.	1
003Bh thru 0040h	Reserved		

Vendor Unique Drive Statistics Page

The T10000A and T10000B Vendor Unique Drive Statistics page (3Ah) reports a variety of vendor unique drive statistics.

Table 64. T10000A and T10000B Vendor Drive Statistics Page Codes

Parameter Code	Description	Length (Bytes)	Default Threshold
0100h	Read forward data checks	4	FFFFFFFF
0101h	Write data checks	4	FFFFFFFF
0102h	Read data checks without hardware	4	FFFFFFFF
0103h	Write data checks without hardware	4	FFFFFFFF
0104h	Read recovery retry count	4	FFFFFFFF
0105h	Read transient conditions	4	FFFFFFFF
0106h	Write transient conditions	4	FFFFFFFF
0107h	Servo temporaries	4	FFFFFFFF
0108h	Servo transients	4	FFFFFFFF
0109h	Corrections 2t	4	FFFFFFFF
010Ah	Matrices with PW1 and PW2	4	FFFFFFFF
010Bh	Matrices with PWs	4	FFFFFFFF
010Ch	Progressive write for servo off track	4	FFFFFFFF
010Dh	Progressive write type 1	4	FFFFFFFF
010Eh	Progressive write type 2	4	FFFFFFFF
010Fh	Selected channel VR^2 bit insertions	4	FFFFFFFF
0110h	Matrix check diagnostic only	4	FFFFFFFF
0111h	Data check diagnostic only	4	FFFFFFFF
0112h	Write recovery retry count	4	FFFFFFFF
0200h	Read data request time-outs	4	FFFFFFFF
0201h	Write data request time-outs	4	FFFFFFFF
0202h	Data transfer errors	4	FFFFFFFF
0203h	Temporary drive errors	4	FFFFFFFF
0204h	Permanent errors logged	4	FFFFFFFF

Table 64. T10000A and T10000B Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
0300h	Channel read bytes processed	8	FFFFFFFF FFFFFFFF
0301h	Device read bytes processed (see notes)	8	FFFFFFFF FFFFFFFF
0302h	Channel write bytes processed	8	FFFFFFFF FFFFFFFF
0303h	Device write bytes processed (see notes)	8	FFFFFFFF FFFFFFFF
0304h	Channel read blocks processed	8	FFFFFFFF FFFFFFFF
0305h	Channel write blocks processed	8	FFFFFFFF FFFFFFFF
0306h	Device read blocks processed	8	FFFFFFFF FFFFFFFF
0307h	Device write blocks processed	8	FFFFFFFF FFFFFFFF
0308h	Read write servo position units	8	FFFFFFFF FFFFFFFF
0309h	High speed servo position units	8	FFFFFFFF FFFFFFFF
030Ah	Servo position units	8	FFFFFFFF FFFFFFFF
030Bh	Tape reposition cycles	4	FFFFFFFF
030Ch	Time spent writing	8	FFFFFFFF FFFFFFFF
030Dh	Time spent reading	8	FFFFFFFF FFFFFFFF
030Eh	Tape over under reposition cycles	4	FFFFFFFF
0310h	Time tape reloaded	8	FFFFFFFF FFFFFFFF
0311h	Time tape in motion for read write	8	FFFFFFFF FFFFFFFF
0312h	Time tape in motion for position	8	FFFFFFFF FFFFFFFF
0400h	Tape efficiency index (see notes)	4	FFFFFFFF

Table 64. T10000A and T10000B Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
0401h	Read quality index (see notes)	4	FFFFFFFF
0402h	RBC quality index (see notes)	4	FFFFFFFF
0403h	DIA detected error index	4	FFFFFFFF
0404h	Reserved	4	FFFFFFFF
0405h	Reserved	4	FFFFFFFF
1000h	Outer ECC multi symbol correction	48	all FF's
1100h	Servo general purpose counter head 0	16	all FF's
1101h	Servo general purpose counter head 1	16	all FF's
1200h	Servo vote out head 0	32	all FF's
1201h	Servo vote out head 1	32	all FF's
1202h	Servo no data available head 0	32	all FF's
1203h	Servo no data available head 1	32	all FF's
1310h	PES histogram head 0 A	128	all FF's
1311h	PES histogram head 0 B	128	all FF's
1320h	PES histogram head 1 A	128	all FF’s
1321h	PES histogram head 1 B	128	all FF’s
1400h	Old VR^2 blocks	128	all FF's
1401h	Low Viterbi metric 0	128	all FF's
1402h	Low Viterbi metric 1	128	all FF's
1403h	Low Viterbi metric 2	128	all FF's
1404h	Inner ECC correction	128	all FF's
1405h	Data valid	128	all FF's
1406h	Outer ECC correction	128	all FF's

Notes:

- The device write byte count will include file marks and pad bytes. These additional bytes will not be included in the device read byte count.
- Parameters 0400 – 0402 will not be reset by a Log Select command.

Vendor Unique Port Statistics Page

The Vendor Unique Port Statistics page (3Bh) reports error counts and small form-factor plug (SFP) information for each Fibre Channel port on the drive.

Table 65. Vendor Port Statistics Page Codes

Parameter Code	Description	Length (Bytes)	Default Threshold
0100h	Port A link failure count	4	FFFFFFFF
0101h	Port A loss of sync count	4	FFFFFFFF
0102h	Port A loss of signal count	4	FFFFFFFF
0103h	Port A prim seq errors count	4	FFFFFFFF
0104h	Port A invalid transmit word count	4	FFFFFFFF
0105h	Port A invalid CRC count	4	FFFFFFFF
0110h	Port A SFP missing	4	FFFFFFFF
0111h	Port A SFP loss of signal	4	FFFFFFFF
0112h	Port A SFP fault	4	FFFFFFFF
0120h	Port A SCSI command count	8	FFFFFFFF FFFFFFFF
0121h	Port A SRR count	4	FFFFFFFF
0200h	Port B link failure count	4	FFFFFFFF
0201h	Port B loss of sync count	4	FFFFFFFF
0202h	Port B loss of signal count	4	FFFFFFFF
0203h	Port B prim seq error count	4	FFFFFFFF
0204h	Port B invalid transmit word count	4	FFFFFFFF
0205h	Port B invalid CRC count	4	FFFFFFFF
0210h	Port B SFP missing	4	FFFFFFFF
0211h	Port B SFP loss of signal	4	FFFFFFFF
0212h	Port B SFP fault	4	FFFFFFFF
0220h	Port B SCSI command count	8	FFFFFFFF FFFFFFFF
0221h	Port B SRR count	4	FFFFFFFF
1100h	Port A SFP ID block	128	all 00's
1110h	Port A SFP monitor block	128	all 00's
1200h	Port B SFP ID block	128	all 00's
1210h	Port B SFP monitor block	128	all 00's

Vendor Unique Drive Statistics Page

The T10000C Vendor Unique Drive Statistics page (3Ch) reports a variety of vendor unique drive statistics.

Table 66. T10000C Vendor Drive Statistics Page Codes

Parameter Code	Description	Length (Bytes)	Default Threshold
0100h	Read forward data checks	4	all FF's
0101h	Write data checks	4	all FF's
0102h	Read data checks without hardware	4	all FF's
0103h	Write data checks without hardware	4	all FF's
0104h	Read recovery retry count	4	all FF's
0105h	Read transient conditions	4	all FF's
0106h	Write transient conditions	4	all FF's
0107h	Servo temporaries	4	all FF's
0108h	Servo transients	4	all FF's
0109h	Corrections 2t	4	all FF's
010Ah	Matrices with pw1 and pw2	4	all FF's
010Bh	Matrices with pws	4	all FF's
010Ch	Progressive write for ind channels	4	all FF's
010Dh	Progressive write type 1	4	all FF's
010Eh	Progressive write type 2	4	all FF's
0110h	Pw sot leading head	4	all FF's
0111h	Sot trailing head	4	all FF's
0112h	Write recovery retry count	4	all FF's
0114h	Pwc matrix count	4	all FF's
0115h	Sot leading head	4	all FF's
0200h	Read data request timeouts	4	all FF's
0201h	Write data request timeouts	4	all FF's
0202h	Data transfer errors	4	all FF's
0203h	Temporary drive errors	4	all FF's
0204h	Perm errors logged	4	all FF's

Table 66. T10000C Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
0300h	Channel read bytes processed	8	all FF's
0301h	Device read bytes processed	8	all FF's
0302h	Channel write bytes processed	8	all FF's
0303h	Device write bytes processed	8	all FF's
0304h	Channel read blocks processed	8	all FF's
0305h	Channel write blocks processed	8	all FF's
0306h	Device read blocks processed	8	all FF's
0307h	Device write blocks processed	8	all FF's
0308h	Read write servo position units	8	all FF's
0309h	High speed servo position units	8	all FF's
030Ah	Servo position units	8	all FF's
030Bh	Tape reposition cycles	4	all FF's
030Ch	Time spent writing	8	all FF's
030Dh	Time spent reading	8	all FF's
030Eh	Tape over under reposition cycles	4	all FF's
030Fh	Servo position units native	8	all FF's
0310h	Time tape reloaded	8	all FF's
0311h	Time tape in motion for read write	8	all FF's
0312h	Time tape in motion for position	8	all FF's
0400h	Tape efficiency	4	all FF's
0401h	Read quality	4	all FF's
0402h	Read back quality	4	all FF's
0403h	Host dia detected error	4	all FF's
0404h	Servo statistics flags	4	all FF's
0405h	Exp prml blk cnt rev	4	all FF's
0406h	Exp prml blk cnt fwd	4	all FF's
0407h	Write efficiency	4	all FF's
1000h	Outer ECC multi symbol correction	64	all FF's
1100h	Servo general purpose counter head 0	16	all FF's

Table 66. T10000C Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
1101h	Servo general purpose counter head 1	16	all FF's
1200h	Servo vote out head 0	32	all FF's
1201h	Servo vote out head 1	32	all FF's
1202h	Servo no data available head 0	32	all FF's
1203h	Servo no data available head 1	32	all FF's
1310h	PES histogram head 0 A	128	all FF's
1311h	PES histogram head 0 B	128	all FF's
1320h	PES histogram head 1 A	128	all FF's
1321h	PES histogram head 1 B	128	all FF's
1400h	Old VR^2 blocks	128	all FF's
1401h	Channel viterbi average	128	all FF's
1402h	Channel fr2 corrections	128	all FF's
1403h	Matrix channel dead	128	all FF's
1404h	Block crc error	128	all FF's
1405h	Prml block error rev	128	all FF's
1406h	Prml block error fwd	128	all FF's
1407h	Channel viterbi_divisor	128	all FF's
2100h	Read forward data checks legacy	4	all FF's
2102h	Read data checks without hardware legacy	4	all FF's
2104h	Read recovery retry count legacy	4	all FF's
2105h	Read transient conditions legacy	4	all FF's
2107h	Servo temporaries legacy	4	all FF's
2108h	Servo transients legacy	4	all FF's
2109h	Corrections 2t legacy	4	all FF's
2204h	Perm errors logged legacy	4	all FF's
2300h	Channel read bytes processed legacy	8	all FF's
2301h	Device read bytes processed legacy	8	all FF's
2304h	Channel read blocks processed legacy	8	all FF's
2306h	Device read blocks processed legacy	8	all FF's

Table 66. T10000C Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
2401h	Read quality legacy	4	all FF's
2405h	Exp prml blk cnt rev 0 15 legacy	4	all FF's
2406h	Exp prml blk cnt rev 16 31	4	all FF's
2407h	Exp prml blk cnt fwd 0 15	4	all FF's
2408h	Exp prml blk cnt fwd 16 31	4	all FF's
3000h	Outer ecc multi symbol correction legacy	64	all FF's
3405h	Prml block error rev legacy	128	all FF's
3406h	Prml block error fwd legacy	128	all FF's
3500h-351Dh	Reserved 0 – Reserved 1F	4 each (120 total)	all FF's

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 67. Mode Select (10)—6 Byte Command

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

Table 68. Mode Select (10)—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	(MSB) Parameter List Length (LSB)							
9	Control Byte							

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

Parameter	Value
PF: Page Format	0 = Vendor specific format (same as PF = 1) 1 = Page formatted data follows block descriptor, or header
SP: Save Parameters	0 = Not supported
Parameter List Length	Contains the total number of bytes in the header, block descriptor, and all pages. If this length is 0, no mode select data is sent and the command is ignored. If this length results in the truncation of the header, block descriptor, or any page, the command is rejected. 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 can be sent in any order. If any page formatted data is sent, the PF bit is set in the command.

Mode Select Header Data

Table 69. Mode Select (6) Header Data

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

Table 70. 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 thru 5	(MSB) Reserved (LSB)							
6 thru 7	(MSB) Block Descriptor Length (LSB)							

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

Parameter	Value
N/A	Not applicable or not defined
Buffered Mode	000b = Return status after data is on tape 001b = Return status when data is in the buffer
Speed Code	0h = 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 71. 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)							

Parameter	Value
Density Code	00h = Default density 4Ah = T10000A default density 4Bh = T10000B default density 4Ch = T10000C 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 2,097,152 bytes Note: 2,097,156 bytes is now the upper limit in fixed block mode when the DIV mode is enabled. See “Control Data Protection Mode Page” on page 111

Read/Write Error Recovery Page

Table 72. Mode Select Read/Write Error Page

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

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
TB: Transfer Block	0 = Unrecoverable data block not transferred
ERR: Enable Early Recovery	0 = Normal error recovery
PER: Post Error	0 = Normal mode
DTE: Disable Transfer on Error	0 = Normal mode
DCR: Disable Correction	0 = Always use error correction codes
Read Retry Count	Extent of error recovery during read operations Count ignored, always maximum recovery
WriteRetry Count	Extent of error recovery during the write operations 0h 5 minutes (same as default) 1h – 13h 10 seconds 14h – 3Bh 1 minute 3Ch – 63h 3 minutes 64h – 77h 5 minutes 78h – C7h 6 minutes C8h – FFh 10 minutes 64h Default value (5 minutes)

Disconnect–Reconnect Page

Table 73. Mode Select Disconnect–Reconnect Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	SPF (0)	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	DImm	DTDC		
13	Reserved							
14 thru 15	(MSB) First burst size (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
Buffer Full Ratio	0 = Not supported
Buffer Empty Ratio	0 = Not supported
Bus Inactivity Limit	0 = Not supported
Disconnect Time Limit	0 = Not supported
Connect Time Limit	0 = Not supported
Maximum Burst Size	0 = No limit
EMDP: Enable Modify Data Pointers	0 = Modify data pointers is disabled

Parameter	Value
FARd: Loop Fairness Algorithm Read	0 = Target chooses
FAWrt: Loop Fairness Algorithm Write	0 = Target chooses
FAStat: Loop Fairness Algorithm Status	0 = Target chooses
DImm: Disconnect Immediate	0 = Target chooses
DTDC: Data transfer disconnect control	0 = Target chooses
First Burst Size	0 = No limit

Control Data Protection Mode Page

This Mode Select page returns information about the current Data Integrity Validation (DIV) mode.

The Mode Select Block Descriptor Data, Block Length field now has 2,097,156 for the upper limit in fixed block mode when the DIV mode is enabled.

Table 74. Mode Select Control Data Protection Mode Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	SPF (1)	Page Code (0Ah)					
1	Subpage Code (F0h)							
2 thru 3	(MSB) Page Length (0004h) (LSB)							
4	Logical Block Protection Information Method							
5	Reserved		Logical Block Protection Information Length					
6	LBP_W	LBP_R	RBDP	Reserved				
7	Reserved							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	1 = SubPage mode format
Subpage code	F0h = Control Data Protection mode page
Logical Block Protection • Information Method • Information Length	See Table 75 on page 112

Parameter	Value
LBP_W Logical Blocks Protected during	0 = Protection Information is not included with the data transferred when writing. 1 = Protection Information is included with the data transferred when writing. Notes: • If the Logical Block Protection Method field is set to zero, the LBP_W bit is set to zero. • If Logical Block Protection Method field is set to a non-zero then one or more of LBP_W or LBP_R bits must be set to a non-zero.
Parameter	**Value**
RBDP: Recover Buffered Data Protected	0 = Protection Information is not included with the data transferred by the Recover Buffered Data command. 1 = Protection Information is included with the data transferred by the Recover Buffered Data command. (This bit is Ignored). Notes: • If the Logical Block Protection Method field is set to zero, the RBDP bit is set to zero. • If Logical Block Protection Method field is set to a non-zero then this bit is ignored.

Table 75. Protection Information Method

Method (Byte 4)	Description	Length (Byte 5)	Drives Supported
00h	Do not use logical block protection.	00h	T10000 All
01h	Reed-Solomon CRC, See ECMA-319[1], CRC appended on any byte boundary	04h	T10000C
02h - EFh	Reserved	–	–
F0h	Vendor Unique SB-2, CRC appended on modulo 4 byte boundary	04h	T10000A T10000B
F1h	Vendor Unique Intel CRC32C, CRC appended on any byte boundary	04h	T10000C
F2h - FFh	Reserved	–	–

1.European Computer Manufacturers Association “Data Interchange on 12.7 mm 384-Track magnetic Tape Cartridges,” ECMA-319 Standard, 2001.

Data Compression Page

Table 76. Mode Select Data Compression Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	PS	SPF (0)	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)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
DCE: Data Compression Enabled	0 = Data compression on writes is disabled 1 = Data compression on writes is enabled
DCC: Data Compression Capable	Controlled by operator configuration menu, not changeable 0 = Not supported 1 = Supported
DDE: Data Decompression Enable	1 = Data decompression on reads is enabled
RED: Report Exception on Decompression	0b = Not supported
Compression Algorithm	00h = No compression algorithm 01h = Default algorithm
Decompression Algorithm	00h = No decompression algorithm 01h = Default algorithm

Device Configuration Page

Table 77. Mode Select Device Configuration Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	SPF (0)	Page Code (10h)					
1	Page Length (0Eh)							
2	RSVD	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	SWP	Reserved	
11 thru 13	(MSB) Buffer Size at Early Warning (LSB)							
14	Select Data Compression Algorithm							
15	Reserved					ASOCWP	PERSWP	PRMWP

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
CAP: Change Active Partition	0 = Active partition not changeable
CAF: Change Active Format	0 = Active format not changeable
Active Format	0 = Default format not changeable
Active Partition	0 = Default partition not changeable
Write Buffer Full Ratio	0 = Controlled by device
Read Buffer Empty Ratio	0 = Controlled by device
Write Delay Time	64h = 10 seconds
DBR: Data Buffer Recovery	0 = Recover buffered data not supported

Parameter	Value
BIS: Block IDs Supported	1 = Tape format includes block ID
RSMK: Report Setmarks	0 = Setmarks not supported
AVC: Automatic Velocity Control	1 = Speed automatically selected
SOCF: Stop On Consecutive Filemarks	00b = Stop read ahead when buffer is full
RBO: Recover Buffer Order	0 = Not supported
REW: Report Early Warning	0 = Report early warning only on Write and Write Filemarks commands
Gap Size	0 = Gap size not selectable
EOD Defined: End Of Data	000b = Default EOD only
EEG: EOD Enabled Generation	1 = EOD generated per EOD field
SEW: Synchronize at Early Warning Logical End-of-Tape (LEOT)	0 = Buffered write data and filemarks not flushed to tape when LEOT detected 1 = Buffered write data and filemarks written to tape when LEOT detected
SWP: Soft Write Protect	0 = Not supported
Buffer Size at Early Warning	0 = Buffer size not selectable
Select Algorithm: Select Data Compression Algorithm	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.
ASOCWP: Associated Write Protect	0 = Not supported
PERSWP: Persistent Write Protect	0 = Not supported
PRMWP: Permanent Write Protect	0 = Not supported

Fibre Channel Logical Unit Control Page

Table 78. Fibre Channel Logical Unit Control Page (18h)

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

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
EPDC: Enable Precise Delivery Checking	0 = Not supported

Fibre Channel Port Control Page

Table 79. Fibre Channel Port Control Page (19h)

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

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
DTFD: Disable Target Fabric Discovery	0 = Not supported
PLPB: Prevent Loop Port Bypass	0 = Not supported
DDIS: Disable Discovery	0 = Not supported
DLM: Disable Loop Master	0 = Not supported
DSA: Disable Soft Address	0 = Not supported
ALWI: Allow Login Without Loop Initialization	0 = Not supported
DTIPE: Disable Target Initiated Port Enable	0 = Not supported
DTOLI: Disable Target Originated Loop Initialization	0 = Not supported
RR_TOV units	101b = 10 second units
RR_TOV value	1Eh = 300 seconds

TapeAlert Page

Table 80. Mode Select TapeAlert Page

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

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
Perf: Performance	0 = Informational exception operations that cause delays are acceptable
EWasc: Early Warning	0 = Disable reporting of warning, MRIE Field, ignored
DExcpt: Disable Exception	1 = Target disables all information exception operations ignoring the MRIE field. In this mode the software must poll the TapeAlert Log page.
Test: Test operations	0 = Do not generate any false/test informational exception conditions
LogErr: Log Errors	0 = Logging of informational exception conditions is vendor-specific
MRIE: Method used to Report Informational Exception conditions	0h = No reporting of informational exception conditions, ignored
Interval Timer	Must be 0
Report Count/Test Flag Number	Must be 0

Medium Configuration Page

Table 81. Mode Select Medium Configuration Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	SPF (0)	Page Code (1Dh)					
1	Page Length (1Eh)							
2	Reserved							WORMM
3	Reserved							
4	WORM Mode Label Restrictions							
5	WORM Mode Filemark Restrictions							
6 thru 31	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
WORMM: WORM mode	0 = Normal mode 1 = WORM (VolSafe) mode
WORM Mode Label Restrictions	1 = Some types of format labels may be overwritten
WORM Mode Filemark Restrictions	2 = All but one filemark at the EOD may be overwritten.

Read/Write Control Page

Vendor unique page used to control writing to maximum tape capacity.

Table 82. Read/Write Control Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	SPF (0)	Page Code (25h)					
1	Page Length (1Eh)							
2 thru 4	(MSB) Reserved							(LSB)
5	Reserved							AMC
6 thru 7	(MSB) Reserved							(LSB)
8	DFSA	Reserved						
9 thru 31	(MSB) Reserved							(LSB)

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
AMC: Allow Maximum Capacity	0 = Constant capacity 1 = Maximum capacity
DFSA: Disable File Sync Accelerator	0 = FSA Enabled (default setting) 1 = Disable FSA
Note: Reserved bytes 2 – 4, 6-7, and 9 – 31 are ignored.	

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 83. Mode Sense—6 Byte Command

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

Table 84. Mode Sense—10 Byte Command

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

Parameter	Value
LLBAA: Long LBA Accepted	0 = Normal
DBD: Disable Block Descriptor	0 = Return block descriptor after header 1 = Do not return the block descriptor
PC: Page Control	00b = Current values 01b = Changeable values 10b = Default values
Page Code: Mode page to return	00h = No page data 01h = Read/Write Error Recovery page 02h = Disconnect–Reconnect page 0Ah = Control Data Protection Mode Page 0Fh = Data Compression page 10h = Device Configuration page 18h = Fibre Channel Logical Unit Control page 19h = Fibre Channel Port Control page 1Ch = Tape Alert page 1Dh = Medium Configuration page 25h = Read/Write Control Page 3Fh = All pages
Subpage Code	Subpage to return
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 Byte Command returns a 4-byte header.

Table 85. 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							

Mode Sense—10 Byte Command returns an 8-byte header

Table 86. 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 thru 5	(MSB) Reserved (LSB)							
6 thru 7	(MSB) Block Descriptor Length (LSB)							

Parameter	Value
Medium Type	0 = Vendor-specific (reserved)
WP: Write Protect	0 = Not file-protected 1 = File-protected
Buffered Mode	000b = Return Status on write commands after the data is written on tape. 001b = Return status on write commands after data has been transferred to the drive's data buffer
Speed	0 = Default speed

Mode Sense Block Descriptor Data

Table 87. 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)							

Parameter	Value
Density Code	4Ah = T10000A default density 4Bh = T10000B default density 4Ch = T10000C default density
Block Count	Will always be 0
Block Length	Variable block mode length is 0 Fixed block mode length 1 to 2,097,152 bytes Note: 2,097,156 bytes is now the upper limit in fixed block mode when the DIV mode is enabled. See “Control Data Protection Mode Page” on page 128

Read/Write Error Recovery Page

Table 88. Mode Sense Read/Write Error Recovery Page

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

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
TB: Transfer Block	0 = Unrecoverable data block not transferred
ERR: Enable Early Recovery	0 = Normal error recovery
PER: Post Error	0 = Normal mode
DTE: Disable Transfer on Error	0 = Normal mode
DCR: Disable Correction	0 = Always use error correction codes
Read Retry Count	Extent of error recovery during read operations 64h = Default value, always maximum recovery
WriteRetry Count	Extent of error recovery during the write operations 0h 5 minutes (same as default) 1h – 13h 10 seconds 14h – 3Bh 1 minute 3Ch – 63h 3 minutes 64h – 77h 5 minutes 78h – C7h 6 minutes C8h – FFh 10 minutes 64h Default value (5 minutes)

Disconnect–Reconnect Page

Table 89. Mode Sense Disconnect–Reconnect Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	SPF (0)	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	DImm	DTDC		
13	Reserved							
14 thru 15	(MSB) First Burst Size (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
Buffer Full Ratio	0 = Not supported
Buffer Empty Ratio	0 = Not supported
Bus Inactivity Limit	0 = Not supported
Disconnect Time Limit	0 = Not supported
Connect Time Limit	0 = Not supported
Maximum Burst Size	0 = No limit
EMDP: Enable Modify Data Pointers	0 = Disabled
FARd: Loop Fairness Algorithm Read	0 = Target chooses
FAWrt: Loop Fairness Algorithm Write	0 = Target chooses
FAStat: Loop Fairness Algorithm Status	0 = Target chooses
DImm: Disconnect Immediate	0 = Target chooses
DTDC: Data transfer disconnect control	0 = Target chooses
First Burst Size	0 = No limit

Control Data Protection Mode Page

This Mode Sense page returns information about the current Data Integrity Validation (DIV) mode.

Mode Sense Block Descriptor Data, Block Length field now has 2,097,156 for the upper limit in fixed block mode when the DIV mode is enabled.

Table 90. Mode Sense Control Data Protection Mode Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	PS	SPF (1)	Page Code (0Ah)					
1	Subpage Code (F0h)							
2 thru 3	(MSB) Page Length (0004h) (LSB)							
4	Logical Block Protection Information Method							
5	Reserved		Logical Block Protection Information Length					
6	LBP_W	LBP_R	RBDP	Reserved				
7	LBP_W_R		Reserved					

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	1 = SubPage mode format
Subpage code	F0h = Control Data Protection mode page
Logical Block Protection • Information Method • Information Length	See Table 91 on page 129
LBP_W Logical Blocks Protected during	0 = Protection Information is not included with the data transferred when writing. 1 = Protection Information is included with the data transferred when writing. Note: If the Logical Block Protection Method field is set to zero, the LBP_W bit is set to zero.
LBP_R: Logical Blocks Protected during Read	0 = Protection Information is not included with the data transferred when reading. 1 = Protection Information is included with the data transferred when reading. Note: If the Logical Block Protection Method field is set to zero, the LBP_R bit is set to zero.

Parameter	Value	
LBP_W_R: Logical Blocks Protected during Write Reporting	Drive reports a: • DIV CRC error as a deferred error if in buffered mode • Current error if in non buffered mode Note: Bit values 00b and 01b are Ignored.	
	Value	Drive behavior when the validation of write data fails
	00b	Report a Check Condition using Sense Code of Current Sense, the sense key set to HARDWARE ERROR and the additional sense code set to LOGICAL BLOCK PROTECTION ERROR ON WRITE.
	01b	Establish a Check Condition for return on the next eligible command with the Sense Code set to Deferred Sense, the sense key set to HARDWARE ERROR and the additional sense code set to LOGICAL BLOCK PROTECTION ERROR ON WRITE.
	10b - 11b	Reserved

Table 91. Protection Information Method

Method (Byte 4)	Description	Length (Byte 5)	Drives Supported
00h	Do not use logical block protection.	00h	T10000 All
01h	Reed-Solomon CRC, See ECMA-319[1], CRC appended on any byte boundary	04h	T10000C
02h - EFh	Reserved	–	–
F0h	Vendor Unique SB-2, CRC appended on modulo 4 byte boundary	04h	T10000A T10000B
F1h	Vendor Unique Intel CRC32C, CRC appended on any byte boundary	04h	T10000C
F2h - FFh	Reserved	–	–

1.European Computer Manufacturers Association “Data Interchange on 12.7 mm 384-Track magnetic Tape Cartridges,” ECMA-319 Standard, 2001.

Data Compression Page

Table 92. Mode Sense Data Compression Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	PS	SPF (0)	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)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
DCE: Data Compression Enabled	0 = Data compression on writes is disabled 1 = Data compression on writes is enabled
DCC: Data Compression	Capable Controlled by operator configuration menu 0 = Not supported 1 = Supported
DDE: Data Decompression Enable	1 = Data decompression on reads is enabled
RED: Report Exception on Decompression	0 = Not supported
Compression Algorithm	01h = Default algorithm
Decompression Algorithm	01h = Default algorithm

Device Configuration Page

Table 93. Mode Sense Device Configuration Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (10h)					
1	Page Length (0Eh)							
2	RSVD	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	SWP	Reserved	
11 thru 13	(MSB) Buffer Size at Early Warning (LSB)							
14	Select Data Compression Algorithm							
15	Reserved					ASOCWP	PERSWP	PRMWP

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
CAP: Change Active Partition	0 = Active partition not changeable
CAF: Change Active Format	0 = Active format not changeable
Active Format	0 = Default format not changeable
Active Partition	0 = Default partition not changeable
Write Buffer Full Ratio	0 = Controlled by device
Read Buffer Empty Ratio	0 = Controlled by device
Write Delay Time	64h = 10 seconds
DBR: Data Buffer Recovery	0 = Recovered buffer data not supported
BIS: Block IDs Supported	1 = Tape format includes block ID

Parameter	Value
RSMK: Report Setmarks	0 = Setmarks not supported
AVC: Automatic Velocity Control	1 = Speed automatically selected
SOCF: Stop On Consecutive Filemarks	00b = Stop read ahead when buffer is full
RBO: Recover Buffer Order	0 = Not supported
REW: Report Early Warning	0 = Report early warning only on Write and Write Filemarks commands
Gap Size	0 = Gap size not selectable
EOD Defined: End Of Data	000b = Default EOD only
EEG: EOD Enabled Generation	1 = EOD generated per EOD field
SEW: Synchronize at Early Warning (LEOT)	0 = Buffered write data and filemarks not flushed to the tape when LEOT is detected 1 = Buffered write data and filemarks written to the tape when LEOT is detected
SWP: Soft Write Protect	0 = Not supported
Buffer Size at Early Warning	0 = Buffer size not selectable
Select Algorithm: Select Data Compression Algorithm	Default is operator configurable 00h = No data compression 01h = LZ1 compression of write records
ASOCWP: Associated Write Protect	0 = Not supported
PERSWP: Persistent Write Protect	0 = Not supported
PRMWP: Permanent Write Protect	0 = Not supported

Fibre Channel Logical Unit Control Page

Table 94. Fibre Channel Logical Unit Control Page (18h)

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

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
EPDC: Enable Precise Delivery Checking	0 = Not supported

Fibre Channel Port Control Page

Table 95. Fibre Channel Port Control Page (19h)

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

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
DTFD: Disable Target Fabric Discovery	0 = Public Loop behavior supported
PLPB: Prevent Loop Port Bypass	0 = Not supported
DDIS: Disable Discovery	0 = Not supported
DLM: Disable Loop Master	0 = Not supported
DSA: Disable Soft Address	0 = Not supported
ALWI: Allow Login Without Loop Initialization	0 = Not supported
DTIPE: Disable Target Initiated Port Enable	0 = Not supported
DTOLI: Disable Target Originated Loop Initialization	0 = Not supported
RR_TOV units	101b = 10 second units
RR_TOV value	1Eh = 300 seconds

TapeAlert Page

Table 96. Mode Sense Tape Alert page

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

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
Perf: Performance	0 = Informational exception operations that causes delays are acceptable
DExcpt: Disable Exception	1 = Target disables all information exception operations ignoring the MRIE field. In this mode the software must poll the TapeAlert Log page.
Test: Test operations	0 = Do not generate any false/test informational exception conditions
LogErr: Log Errors	0 = Logging of informational exception conditions is vendor–specific
MRIE	Method the drive uses to Report Informational Exception conditions. 0h = No reporting of informational exception conditions
Interval Timer	Will always be 0
Report Counter/Test Flag Number	Will always be 0

Medium Configuration Page

Table 97. Mode Sense Medium Configuration Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	SPF (0)	Page Code (1Dh)					
1	Page Length (1Eh)							
2	Reserved							WORMM
3	Reserved							
4	WORM Mode Label Restrictions							
5	WORM Mode Filemark Restrictions							
6 thru 31	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
WORMM: WORM mode	0 = Normal mode 1 = WORM (VolSafe) mode
WORM Mode Label Restrictions	1 = Some types of format labels may be overwritten
WORM Mode Filemark Restrictions	2 = All but one filemark at the EOD may be overwritten.

Read/Write Control Page

Vendor unique page used to control writing to maximum tape capacity.

Table 98. Read/Write Control Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	SPF (0)	Page Code (25h)					
1	Page Length (1Eh)							
2 thru 4	(MSB) Reserved							(LSB)
5	Reserved							AMC
6 thru 31	(MSB) Reserved							(LSB)

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
AMC: Allow Maximum Capacity	0 = Constant capacity 1 = Maximum capacity
Note: Reserved bytes 2 – 4 and 6 – 31 are ignored.	

Persistent Reserve In Command

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

Table 99. 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							

Parameter	Value
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. 02h = Report Capabilities: Returns information on persistent reservation features.
Allocation Length	Maximum length of parameter data to return

Read Keys Parameter Data

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 100. 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)

Parameter	Value
Generation	A 32-bit counter that is incriminated 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 Parameter Data

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

Table 101. 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)

Table 101. Read Reservations Parameter Data (Continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
8 thru n	(MSB) Reservation descriptor(s) (see Table 102) (LSB)							

Read Reservations Descriptors

Table 102. 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 thru 15	(MSB) Obsolete (LSB)							

Parameter	Value
Generation	A 32-bit counter that is incriminated 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 Keys	Reservation key for the active Persistent Reservation**.**
Scope Specific Address	0 = Not supported
Scope	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

Report Capabilities Parameter Data

A Persistent Reserve In command with a Service Action of 02h (Report Capabilities) will return information about persistent reservation features.

Table 103. Report Capabilities Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 1	(MSB) Length (0008h) (LSB)							
2	Reserved			CRH	SIP_C	ATP_C	RSVD	PTPL_C
3	TMV	Reserved						PTPL_A
4 thru 5	(MSB) Persistent Reservation Type Mask (see Table 104 on page 142) (LSB)							
6 thru 7	(MSB) Reserved (LSB)							

Parameter	Value
Length	Length in bytes of parameter data.
CRH: Compatible Reservation Handling	1= Supports exceptions to the SPC-2 Reserve and Release commands See Table 34 on page 60
SIP_C: Specify Initiator Ports Compatible	0 = Not supported
ATP_C: All Target Ports Capable	0 = Not supported
PTPL_C: Persist Through Power Loss Capable	0 = Not supported
TMV: Type Mask Valid	1 = Persistent reservation type mask valid
PTPL_A: Persist Through Power Loss Activated	0 = Not supported

Table 104. Persistent Reservation Type Mask Format

Byte	Bit							
	7	6	5	4	3	2	1	0
4	WR_EX_AR	EX_AC_RO	WR_EX_RO	Reserved	EX_AC	Reserved	WR_EX	Reserved
5	Reserved							EX_AC_AR

Parameter	Value
WR_EX_AR: Write Exclusive - All Registrants	0 = Not supported
EX_AC_RO: Exclusive Access - Registrants Only	1 = Supported
WR_EX_RO: Write Exclusive - Registrants Only	0 = Not supported
EX_AC: Excluisve Access	1 = Supported
WR_EX: Write Exclusive	0 = Not supported
EX_AC_AR: Exclusive Access- All Registrants	0 = Not supported

Persistent Reserve Out Command

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

Table 105. 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							

Parameter	Value
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 = Pre-empt. Take over a reservation previously made by another initiator 05h = Pre-empt and Abort. Take over a reservation and abort commands 06h = Register and Ignore existing key
Scope	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)

Persistent Reserve Out Parameter List

Table 106. 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) Obsolete (LSB)							
20	Reserved				SPEC_ I_PT	ALL_ TG_PT	Rsvd	APTPL
21	Reserved							
22 thru 23	(MSB) Obsolete (LSB)							

Parameter	Value
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, Pre-empt, or Pre-empt and Abort or Register and Ignore service action
SPEC_I_PT: Specify Initiator Ports	0 = Not supported
ALL_TG_PT: All Target Ports	0 = Not supported
APTPL: Active Persist Through Power Lost	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. 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.

A key may be registered without regard to whether one had been previously established by setting the Service Action field to Register and Ignore (06h).

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 field is 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 registered initiators.

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 field is 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 field is ignored and the APTPL bit is set to zero.

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

Pre-empting 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 Pre-empt, 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 Pre-empt and Abort instead of Pre-empt, all commands belonging to initiators who registered with the cleared key will be aborted.

When a reservation of type Exclusive Access, Registrants Only is Pre-empted, a unit attention condition is established for the Pre-empted 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 107. 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							

Parameter	Value
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 108. 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							

Parameter	Value
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:

- 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.
- 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.
- 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.
- 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.
- 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.
- 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.

Data Integrity Validation—Read Operations

During read operations when DIV mode is enabled, all Read commands should have a transfer length that includes both the user data and the appended 4 bytes of Protection Information.

Note: Use the Mode Select command Page 0Ah, Subpage F0h, to enable the DIV mode.

When in DIV mode the T10000 A and B tape drives generate the PI data as it is being transferred from the tape drive to the controller data buffer.

On T10000C tape Drives the PI data is read from the media and transferred to the controller data buffer.

If an error occurs during Read operations, and the drive detects a miscompare, it reports it as a:

Check condition, with
Key = 04h (Hardware Error), and
ASC/ASCQ = 10 01h — Logical Block Guard Check Failed

Examples of when this may occur include:

- During the transfer of data from the tape drive to the controller data buffer, PI data is generated or checked as required.
- During the transfer of data from the controller data buffer to the Fibre Channel Port protocol chip, if it supports the current PI method.
- If the transfer length is more than the actual user data plus the PI bytes the tape drive returns all available user data and the PI bytes, reporting an Illegal Length Indicator (ILI).
- If the transfer length is less than the actual user data plus the PI bytes the tape drive checks the entire record in the controller data buffer against the PI bytes. Then reports a PI miscompare if necessary.

  If there is no PI error then only the requested number of data bytes are returned to the Host, reporting of ILI and residuals as usual.

Read Attribute Command

The Read Attribute command transfers read attribute values to the host.

Table 109. Read Attribute Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (8Ch)							
1	Reserved			Service Action				
2 thru 4	(MSB) Restricted (00 00 00) (LSB)							
5	Volume Number							
6	Reserved							
7	Partition Number							
8 thru 9	(MSB) First Attribute Identifier (LSB)							
10 thru 13	(MSB) Allocation Length (LSB)							
14	Reserved							
15	Control Byte							

Parameter	Value / Description		
Service Action	00h	Attribute Values	Return attribute values.
	01h	Attribute List	Return a list of available attribute identifiers, identifiers that are not in the nonexistent state or unsupported state.
	02h	Volume List	Return a list of known volume numbers.
	03h	Partition List	Return a list of known partition numbers.
	04h	Restricted	
	05h – 1Fh	Reserved	
Volume Number	0		
Partition Number	0		
First Attribute Identifier	0000h – 0224h		
Allocation Length	Maximum length of data to transfer		

Attribute Values—Service Action

Returns parameter data containing the requested attributes in ascending numerical order by attribute value and in the following format.

Table 110. Read Attribute with Attribute Values—Service Action Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 3	(MSB)			Available Data (n-3)				(LSB)
Attributes								
4 thru n	Attribute 0 (see Table 112 on page 154) . . . Attribute x (see Table 112 on page 154)							

Parameter	Value
Available Data	Contains the number of bytes of attribute information in the parameter list

Medium Auxiliary Memory Attribute Format

Each medium auxiliary memory (MAM) attribute is communicated between the application client and device server in the following format.

Table 111. Medium Auxiliary Memory Attribute Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Attribute Identifier (0224h) (LSB)							
2	Read Only	Reserved					Format	
3 thru 4	(MSB) Attribute Length (n-4) (LSB)							
5 thru n	(MSB) Attribute Value (LSB)							

Parameter	Value/Description		
Attribute Identifier	Contains a code value that identifies the attribute. 0224h = Logical position of the first encrypted block		
Read Only	Indicates whether the attribute is in the read only state. 0 = The attribute is in the read/write state 1 = The attribute is in the read only state		
Format	Specifies the format of the data in the Attribute Value field		
	00b	Binary	Contains binary data.
	01b	ASCII	Contains left-aligned ASCII data.
	10b	Text	Contains textual data. The character set is described in the Text Localization Identifier attribute.
	11b		Reserved
Attribute Length	Specifies the length in bytes of the Attribute value field.		
Attribute Value	Contains the current value, for the Read Attribute command		

Attribute List—Service Action

Returns parameter data contains the attribute identifiers for the attributes that are not in the unsupported state and not in the nonexistent state in the specified partition and volume number.

Table 112. Read Attribute with Attribute List—Service Action Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 3	(MSB)			Available Data (n-3)				(LSB)
Attribute Identifiers								
4 thru 5	(MSB)			Attribute Identifier 0				(LSB)
	. . .							
n-1 thru n	(MSB)			Attribute Identifier x				(LSB)

Parameter	Value
Available Data	Contains the number of bytes of attribute identifiers in the parameter list
Attribute Identifier	Returns each attribute that is not in the unsupported state and not in the nonexistent state in the specified partition and volume number = 0x0224

Volume List—Service Action

Returns parameter data identifying the supported number of volumes.

The contents of Volume Number, Partition Number, and First Attribute Identifier fields in the CDB shall be ignored.

Table 113. Read Attribute with Volume List—Service Action Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Available Data (0002h) (LSB)							
2	First Volume Number							
3	Number of Volumes Available							

Parameter	Value
Available Data	Contains the number two
First Volume Number	Indicates the first volume available = 0
Number of Volumes Available	Indicates the number of volumes available = 1

Partition List—Service Action

Returns parameter data identifying the supported number of partitions supported in the specified volume.

The contents of Partition Number, and First Attribute Identifier fields in the CDB shall be ignored.

Table 114. Read Attribute with Partition List—Service Action Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 1	(MSB) Available Data (0002h) (LSB)							
2	First Partition Number							
3	Number of Partitions Available							

Parameter	Value
Available Data	Contains the number two
First Partition Number	Indicates the first partition number on the specified volume = 0
Number of Partitions Available	Indicates the number of partitions available on the specified volume = 1

Read Block Limits Command

The Read Block Limits command establishes the longest and shortest record size supported by the tape drive. This command returns six bytes of data.

- When the DIV feature is not enabled the Maximum Block Length reported by the Read Block Limits command is 2,097,152 bytes.
- When the DIV feature is enabled the Maximum Block Length reported by the Read Block Limits command is increased by 4 bytes to account for the extra bytes of PI data (2,097,156 bytes).

Table 115. 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 116. 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)							

Parameter	Value
Granularity	0
Maximum block length	2,097,152 bytes (standard) 2,097,156 bytes (with the DIV feature)
Minimum block length	1 byte

Read Buffer Command

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

Table 117. Read Buffer Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (3Ch)							
1	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

Parameter	Value
Mode	Read buffer mode 01h = Vendor-specific 03h = Descriptor 0Ah = Echo buffer 0Bh = Echo buffer descriptor
Buffer ID	FAh = MIR position data FCh = MIR performance data FDh = Permanent error trace 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:

- The tape drive must be unloaded when reading dump, permanent error trace, or event log data. The minimum allocation length is 4096 bytes.
- 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.
- The dump buffer may contain multiple dumps up to a maximum of 12 MB of data.
- The maximum amount of permanent error trace data or event log data is 524KB.
- 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.

Table 118. Read Buffer Descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Offset Boundary							
1 thru 2	(MSB) Buffer Capacity (LSB)							

Parameter	Value
Offset Boundary	FFh = 0 is the only supported offset boundary
Buffer Capacity	Size of selected buffer in bytes

Table 119. Echo Buffer Descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved							EBOS
1	(MSB) Reserved							
2	Reserved (LSB)			(MSB) Buffer Capacity				
3	Buffer Capacity (LSB)							

Parameter	Value
Buffer Capacity	Size of Echo Buffer in the bytes aligned to a four byte boundary. Maximum size is 4096 bytes
EBOS: Echo Buffer Overwritten Supported	1 = Supported. Illegal Request, echo buffer overwritten additional sense code is returned if data was not previously written by the same initiator.

Read Media Serial Number Command

The Read Media Serial Number Command returns the serial number of the currently mounted tape.

Table 120. Read Media Serial Number Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (ABh)							
1	Reserved			Service Action (01h)				
2 thru 5	(MSB) Reserved (LSB)							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control							

Parameter	Value
Allocation Length	Maximum length of data to transfer

Read Media Serial Number Parameter Data

Table 121. Read Media Serial Number Parameter Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 3	(MSB) Media Serial Number Length (4n-4) (LSB)							
4	(MSB) Media Serial Number							
4n-1	(LSB)							

Parameter	Value
Medial Serial Number Length	Number of bytes modulo four
Media Serial Number	Vendor specific

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 122. 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	PPI	Control Byte						

Parameter	Value
TCLP: Total Current Logical Position	0 = Return first and last block location
LONG: Long Format	0 = Return 20 bytes of data
	1 = Return 32 bytes of data
BT: Block address Type	0 = SCSI logical block address
	1 = Vendor specific (ignored)
PPI: Physical Position Indicator	0 = Return read position data
	1 = Return Physical Position Indicator data

Read Position Data

Table 123. Read Position Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0	BOP	EOP	BCU	BYCU	RSVD	BPU	PERR	RSVD
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)							

Parameter	Value
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 LEOT
BCU: Block Count Unknown	0 = Blocks in buffer field are valid
	1 = Blocks in buffer field are invalid
BYCU: 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

Parameter	Value
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 in buffer	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 in buffer	The number of uncompressed write bytes in the buffer.

Physical Position Indicator Data

Table 124. Physical Position Indicator Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Wrap							
1	Section							
2	Track Density				Length			
3	Section Layout							
4	Cartridge Type							
5	Last Tape Speed				Next Tape Speed			
6 thru 7	(MSB) Partition Size (LSB)							
8 thru 13	(MSB) Host Side ID (LSB)							
14 thru 19	(MSB) Device Side ID (LSB)							
20 thru 23	(MSB) Matrix Count (LSB)							
24 thru 27	(MSB) Space Remaining (LSB)							
28 thru 31	(MSB) Servo Position (LSB)							

Parameter	Value
Wrap	Wrap number
Section	Section number
Track Density	Number of tracks 1h = 768 tracks 2h = 1,152 tracks 3h = 3,584 tracks

Parameter	Value
Length	Tape length 2h = Standard cartridge 4h = Sport cartridge
Section Layout	Number of sections 01 = One section
Cartridge Type	10h = Data tape 20h = Code load tape 40h = Dump tape
Last Tape Speed	0h = Low speed 1h = High speed
Next Tape Speed	0h = Low speed 1h = High speed
Partition Size	Capacity in Gigabytes (GB)
Host Side ID	Next block to be written or read from the drive buffer
Device Side ID	Next block to be written or read from the tape
Matrix Count	Number of matrices down the tape
Space Remaining	Space remaining on the tape in 4K byte blocks
Servo Position	Longitudinal position

Receive Diagnostic Results

The receive diagnostic results command returns diagnostic information.

Table 125. 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							

Parameter	Value
PCV: Page Code Valid	0 = Return data defined by recent 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 126. 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 thru n	(MSB) Diagnostic Parameter (LSB)							

Parameter	Value
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.

Release Unit Command

The Release Unit command cancels reservations made by the Reserve Unit Command. 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.

Table 127. Release Unit—6 Byte Command

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

Table 128. 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	Obsolete
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							

Parameter	Value
3rd Party: Third party reservations	0 = Cancel reservations for current host (not supported)
Long ID: SCSI ID for third party release	0 = Not supported
Reservation Identification	0 = Not supported
Third Party Device ID	0 = Not supported
Parameter List Length	0 = Not supported

Report Density Support Command

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

Table 129. 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							

Parameter	Value
Media	0 = Report densities supported by this tape drive 1 = Report densities supported by currently mounted 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 130. Density Support Header

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Available Density Support Length (LSB)							
2 thru 3	(MSB) Reserved (LSB)							
4 thru n	(MSB) Density Support Block Descriptor (LSB)							

Parameter	Value
Available Density Support Length	Control data that follows. 36h = One density support block returned for T10000A 6Ah = Two density support blocks returned for T10000B 9Eh = Three density support blocks returned for T10000C
Density Support Block Descriptor	

Density Support Block Descriptor

Table 131. Density Support Data Block Descriptor

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Primary Density Code							
1	Secondary Density Code							
2	WRTOK	DUP	Deflt	Reserved				
3 thru 4	(MSB) Reserved (LSB)							
5 thru 7	(MSB) Bits per MM (LSB)							
8 thru 9	(MSB) Media Width (LSB)							
10 thru 11	(MSB) Tracks (LSB)							
12 thru 15	(MSB) Capacity (LSB)							
16 thru 23	(MSB) Assigning Organizations (LSB)							
24 thru 31	(MSB) Density Name (LSB)							
32 thru 51	(MSB) Description (LSB)							

Parameter	Value
Primary Density Code	4Ah = Density code for T10000A 4Bh = Density code for T10000B 4Ch = Density code for T10000C

Parameter	Value
Secondary Density Code	4Ah = Primary density code, no secondary density code for T100000A 4Bh = Primary density code, no secondary density code for T100000B 4Ch = Primary density code, no secondary density code for T10000C
WRTOK: Write Support	0 = Writes not permitted with this density code 1 = Drive is capable of writing at this density
DUP Duplicate Density Support Block	0 = Only 1 density support data block for this density code
Deflt: Default density code	1 = This is the default density code
Bits Per MM	Bit Density per Millimeter for This Recording Format 0 = Not applicable
Media Width	Width of Media in Tenths of a Millimeter 127(7Fh) = 1/2 inch
Tracks	Number of tracks with this recording format 768 (300h) tracks for T10000A tape drive 1,152 (480h) tracks for T10000B tape drive 3,584 tracks for T10000C tape drive
Capacity	Approximate capacity of the media in 1,000,000 byte measurement units 500,000 (7A120h) = T10000A cartridge tape capacity 120,000 (1D4C0) = T10000A Sport cartridge tape capacity 1,000,000 (F4240h) = T10000B cartridge tape capacity 240,000 (3A980h) = T10000B Sport cartridge tape capacity 5,000,000 (4C4b40h) = T10000C cartridge tape capacity 1,000,000 (F4240h) = T10000C Sport cartridge tape capacity
Assigning Organization	ASCII organization defining this recording format STK = Format defined by StorageTek, Sun Microsystems
Density Name	ASCII name for this recording format T1 – 500 = T10000A recording format TS – 120 = T10000A Sport tape T1 – 1000 = T10000B recording format TS – 240 = T10000B Sport tape T2 – 5000 = T10000C recording format TT – 1000 = T10000C Sport tape

Parameter	Value
Description	ASCII description for this recording format T1 – 500 GB = T10000A recording format TS – 120 GB = T10000A Sport tape T1 – 1000 GB = T10000B recording format TS – 240 GB = T10000B Sport tape T2 – 5000 GB = T10000C recording format TT – 1000 GB = T10000C Sport tape format

Report LUNs Command

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

Table 132. 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							

Parameter	Value
Allocation Length	Maximum allowed length in bytes of returned data.

Report LUNs Parameter Data

Table 133. 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 (LSB)							

Parameter	Value
LUN Address	Address of supported logical unit.

Report Supported Operation Codes Command

The Report Supported Operation Codes command returns information about the commands supported by the tape drive.

Table 134. Report Supported Operation Codes Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (A3h)							
1	Reserved			Service Action (0Ch)				
2	RCTD	Reserved				Reporting Options		
3	Requested Operation Code							
4 thru 5	Requested Service Action							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
RCTD: Return Command Timeouts Descriptor	0 = Do not return timeout descriptor. 1 = Return a timeout descriptor with each command descriptor.
Reporting options	000b = Return a list of all operation codes and service actions supported by the tape drive. 001b = Return command support data for the requested operation code. 010b = Return command support data for the requested operation code and service action.
Requested operation code	Operation code for reporting options 1 and 2.
Requested service action	Service action for reporting option 2.
Allocation length	Maximum length of data to return.

All_Commands Parameter Data Format

The Report Supported Operation Codes All_Commands Parameter Data Format begins with a four-byte header that contains the length in bytes of the parameter data followed by a list of supported commands.

The list of command descriptors contains all commands supported by the logical unit.

Table 135. All_Commands Parameter Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 3	(MSB) Command Data Length (n-3) (LSB)							
Command Descriptors								
4	(MSB) Command Descriptor 0 (see Table 136 on page 179)							
thru	. . .							
n	(MSB) Command Descriptor x (see Table 136 on page 179) (LSB)							

The Command Data Length field indicates the length in bytes of the command descriptor list.

Each command descriptor (Table 136) contains information about a single supported command CDB.

Table 136. Command Descriptor Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved							
2 thru 3	(MSB) Service Action (LSB)							
4	Reserved							
5	Reserved						CTDP	SERV ACTV
6 thru 7	(MSB) CDB Length (LSB)							
8 thru 19	(MSB) Command Timeouts Descriptor (see Table 138 on page 182) (LSB)							

Parameter	Value
Service Action	Contains a supported service action for the operation code. If the operation code does not have a service action, this field is set to 00h.
CTDP: Command Timeouts Descriptor Present	Command Timeouts Descriptor Present 0 = Indicates that the command timeouts descriptor is not included in this command descriptor 1 = Indicates that the command timeouts descriptor (see Table 138) is included in this command descriptor
SERVACTV: Service Action Valid	Service Action Valid 0 = Indicates the operation code does not have service actions and the Service Action field contents are reserved 1 = Indicates the operation code has service actions and the contents of the Service Action field are valid
CDB Length: Command Data Block Length	Command Data Block Length Contains the length of the command CDB in bytes for the operation code, and if the SERVACTV bit is set, for the Service Action.

One_Command Parameter Data Format

The Report Supported Operation Codes One_Command Parameter Data Format contains information and a usage map for bits in the CDB for the command and service action field.

Table 137. One_Command Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved							
1	CTDP	Reserved				Support		
2 thru 3	(MSB) CDB Size (n-3) (LSB)							
4 thru n	(MSB) CDB Usage Data (LSB)							
n+1 thru n+12	(MSB) Command Timeouts Descriptor (see Table 138 on page 182) (LSB)							

Parameter	Value
CTDP: Command Timeouts Descriptor Present	Command Timeouts Descriptor Present 0 = Indicates the command timeouts descriptor is not included in the parameter data 1 = Indicates the command timeouts descriptor is included in the parameter data (see Table 138)

Parameter	Value	
Support	000b	Data about the requested SCSI command is not currently available. All data after byte 1 is not valid. A subsequent request for command support data may be successful.
	001b	The device server does not support the requested command. All data after byte 1 is undefined.
	010b	Reserved
	011b	The device server supports the requested command in conformance with a SCSI standard. The parameter data format conforms to the definition in Table 137.
	100b	Reserved
	101b	The device server supports the requested command in a vendor specific manner. The parameter data format conforms to the definition in Table 137.
	110b to 111b Reserved	
CDB Size	Contains the size of the CDB Usage Data field in the parameter data, and the number of bytes in the CDB for command being queried. For example, the command specified by the Reporting Options, Requested Operation Code, and Requested Service Action fields in the Report Supported Operation Codes CDB.	
CDB Usage Data	Contains information about the CDB for the command being queried. The First byte of the field contains the operation code for the command. If the command being queried contains a service action, then that service action code is placed in the Usage Data field in the same location as the Service Action field of the command CDB. All other bytes of the Usage Data field contains a usage map for bits in the CDB for the command being queried. Usage Map: The bits in the usage map have a one-for-one correspondence to the CDB for the command being queried. • If the device server evaluates a bit in the CDB for the command being queried, the usage map shall contain a one in the corresponding bit position. • If any bit representing part of a field is returned as one, all bits for the field shall be returned as one. • If the device server ignores or treats as reserved a bit in the CDB for the command being queried, the usage map shall contain a zero in the corresponding bit position. The usage map bits for a given CDB field all shall have the same value.	

Command Timeouts Descriptor

The Command Timeouts Descriptor returns timeout information for commands supported by the logical unit based on the time from the start of processing for the command to its reported completion.

Values returned in the command timeouts descriptor do not include times that are outside the control of the device.

The Command Timeout Descriptor is included only if the RCTD bit in the Report Supported Operation Codes CDB = 1.

Table 138. Command Timeouts Descriptor Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Description Length (000Ah) (LSB)							
2	Reserved							
3	Command Specific							
4 thru 7	(MSB) Nominal Command Processing Timeout (LSB)							
8 thru 11	(MSB) Recommended Command Timeout (LSB)							

Parameter	Value
Description Length	Indicates the number of bytes that follow in the command timeouts descriptor.
Command Specific	Contains timeout information specific to one or more commands. If no command specific timeout information is defined this field is reserved.
Nominal Command Processing Timeout	0 = No timeout is indicated A non-zero value = Indicates the minimum amount of time in seconds the application client should wait prior to querying for the progress of the command Note: The value contained in this field may include time required for typical device error recovery procedures expected to occur on a regular basis.
Recommended Command Timeout	0 = No time is indicated A non-zero value = Specifies the recommended time in seconds the application client should wait before timing out the command

Report Supported Task Management Functions Command

The Report Supported Task Management Functions command returns information about the task management functions supported by the tape drive.

Table 139. Report Supported Task Management Functions Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (A3h)							
1	Reserved			Service Action (0Dh)				
2 thru 5	(MSB) Reserved (LSB)							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
Allocation length	Maximum length of data to return (4 or larger).

Supported Task Management Functions Data Format

Table 140. Report Supported Task Management Functions Data Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	ATS	ATSS	CACAS	CTSS	LURS	QTS	TRS	WAKEUP
1	Reserved					QAES	QTSS	ITNRS
2 thru 3	(MSB) Reserved (LSB)							

Parameter	Value
ATS	1 = About task supported
ATSS	1 = About task set supported
CACAS	0 = Clear ACA not supported
CTSS	1 = Clear task set supported
LURS	1 = Logical unit reset supported
QTS	0 = Query task not supported
TRS	1 = Target reset supported
WAKEUP	0 = Wakeup not supported
QAES	0 = Query asynchronous event not supported
QTSS	0 = Query task set not supported
ITNRS	0 = I_T Nexus reset not supported

Report Target Port Groups Command

The Report Target Port Groups command sends target port group information to the host.

Table 141. Report Target Port Groups Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (A3h)							
1	Reserved			Service Action (0Ah)				
2 thru 5	(MSB) Reserved (LSB)							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
Allocation length	Maximum length of data to return 4 or larger.

Report Target Port Group Parameter Data Format

The format for the parameter data returned by the Report Target Port Groups command is shown in the following table.

Table 142. Report Target Port Group Parameter Data Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 3	(MSB)			Return Data Length (n-3)				(LSB)
Target Port Group Descriptors								
4	(MSB)			Port Group Descriptor (First) (See Table 143 on page 187)				(LSB)
thru				. . .				
n	(MSB)			Port Group Descriptor (Last) (See Table 143 on page 187)				(LSB)

Parameter	Value
Return Data Length	Indicates the length in bytes of the list of target port groups.

Target Port Group Descriptor Format

There shall be one target port group descriptor for each target port group.

Table 143. Target Port Group Descriptor Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PREF	Reserved			Asymmetric Access State			
1	T_SUP	O_SUP	Reserved		U_SUP	S_SUP	AN_SUP	AO_SUP
2 thru 3	(MSB) Target Port Group (LSB)							
4	Reserved							
5	Status Code							
6	Vendor Specific							
7	Target Port Count							
Target Port Descriptors								
8 thru 11	(MSB) Target Port Descriptor (First) (See Table 144 on page 188) (LSB)							
	. . .							
n-3 thru n	(MSB) Target Port Descriptor (Last) (See Table 144 on page 188) (LSB)							

Parameter	Value
PREF	1 = Preferred target port
AAS	Asymmetric Access State 0 = Active / Optimized
T_SUP	0 = Not supported
O_SUP	0 = Not supported
U_SUP	0 = Not supported

Parameter	Value
AN_SUP	0 = Not supported
AO_SUP	1 = Active / Optimized is supported
Target Port Group	1 = Target port group identification
Status Code	0 = No status available
Vendor Specific	0 = Not supported
Target Port Count	2 = Number of target ports

Target Port Descriptor Format

Table 144. Target Port Descriptor Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 1	Obsolete							
2 thru 3	(MSB) Relative Target Port Identifier (LSB)							

Parameter	Value
Relative Target Port Identifier	Contains a relative port identifier of a target port in the target port group.

Request Sense Command

The Request Sense command transfers sense data to the initiator.

Table 145. 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:

- 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.
- 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.
- 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 146. Sense Data Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Valid	Response Code (70h or 71h)						
1	Reserved							
2	Filemark	EOM	ILI	RSVD	Sense Key			
3 thru 6	(MSB) Information (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	(MSB) **Sense Key Specific**						
16								
17		(LSB)						
18 thru 23	(MSB) Fault Symptom Codes 1–3 (LSB)							
24	Tape Type				DAvail	MIRBad	Volsafe	TapeEOL
25	Reserved						LibAtt	RSVD

Parameter	Value
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.
Filemark	0 = Normal 1 = A Read or Space command encountered a filemark

Parameter	Value
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.
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	0 = Not supported
ASC: Additional Sense Code	Provides more detail about the error or other condition. Used with the Sense Key and ASCQ fields. See Table 150.
ASCQ: Additional Sense Code Qualifier	Provides additional detail about the error when used with ASC and Sense Key. See Table 150.
Field Replaceable Unit Code	0 = Not supported

Table 147. Field Pointer Sense Key Illegal Request Specific Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	SKSV	C/D	Reserved		BPV	Bit Pointer		
1 thru 2	(MSB) Field Pointer (LSB)							

Parameter	Value
SKSV: Sense Key Specific Valid	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	Command or Data field. 0 = Illegal field in parameter data. 1 = Illegal field in Command Descriptor Block.
BPV: Bit Pointer Valid	0 = Not supported
Bit Pointer	0 = Not supported
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.

Table 148. Progress Indication Sense Key Not Ready or No Sense Specific Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0	SKSV	Reserved						
1 thru 2	(MSB) Progress Indication (LSB)							

Parameter	Value
SKSV: Sense Key Specific Fields Valid	0 = Progress indication not valid 1 = Progress indication valid. Only set when sense key is 0.
Progress Indication	Percent complete 0000h to FFFFh
FSC-1	Fault Symptom Code for the first error encountered while attempting the requested operation. The FSC codes are specific to the T10000 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 (EOL)
LibAtt	Drive is Attached to a library

Sense Keys

Table 149 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.

Table 149. 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.
E	**Miscompare** Indicates that the source data did not match the read data from the medium (Logical Block Protection Methods did not agree).

Additional Sense Codes and Qualifiers

Table 150 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.

Table 150. 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
	00	18	Erase operation in progress
	5B	02	Log counter at maximum
2	04	01	Logical unit is in the process of becoming ready (load immediate cmd.)
	04	03	Logical unit not ready, manual intervention required (drive is offline)
	30	03	Cleaning cartridge installed (cleaning)
	3A	00	Medium not present
	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 (can’t 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 decryption 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)

Table 150. Sense Key with ASC and ASCQ (Continued)

Key	Byte		
	12	13	Description
3	33	00	Tape length error (short tape error)
	3B	00	Sequential positioning error
	3B	01	Tape position error at beginning-of-tape
	3B	08	Reposition error (CU ERP failed and we are lost)
	51	00	Erase failure (long erase check)
4	03	00	Peripheral device write fault (used when a prior 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
	10	01	Logical block guard check failed
	15	01	Mechanical positioning error (tape lost tension)
	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
	44	C0	Internal DMA transmit failure
	44	C1	Internal DMA receive failure
	45	00	Select or reselect failure
	4B	80	Under run during data phase
	4B	81	Over run during data phase

Table 150. Sense Key with ASC and ASCQ (Continued)

Key	Byte		
	12	13	Description
4	4B	82	DMA error during data phase
	51	00	Erase fault
	52	00	Cartridge fault (a load/eject command failure reported by CSL)
	53	01	Unload tape failure (tape unload check)
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 a supported cmd)
	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	Write command has 1 through 4 as an invalid transfer count for the Data Protection mode selected
	24	81	Write command has non modulo 4 or less than 8 as an invalid transfer count for the Data Protection mode selected
	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
	26	11	Incomplete key-associated data set
	2C	00	Command sequence error
	30	02	Incompatible format
	39	00	Saving parameters not supported
	3B	0C	Partition past beginning of partition
	3F	0F	Echo buffer overwritten
	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

Table 150. Sense Key with ASC and ASCQ (Continued)

Key	Byte		
	12	13	Description
5	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 pre-empted by another host
	2A	04	Reservations released by another host
	2A	05	Reservation pre-empted by another host
	3F	01	Microcode has been changed
7	26	10	Data decryption key fail limit reached
	27	00	Write protected (and a write-type of command was attempted)
	27	80	Unable to overwrite data
	2A	13	Data encryption key instance counter has changed
	30	05	Cannot write medium - incompatible format
	74	01	Unable to decrypt data
	74	02	Unencrypted data encountered while decrypting
	74	03	Incorrect data encryption key
	74	04	Cryptographic Integrity Validation Failed
8	00	05	End-of-data detected
	14	00	Recorded entity not found (no EOD, but tape appears to be blank).

Table 150. 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	83	Command timeout
	4B	84	Re-selection 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
E	10	05	Logical Block Protection Method error

Reserve 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.

Table 151. Reserve—6 Byte Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (16h)							
1	Reserved			Obsolete				
2	Reservation Identification							
3 thru 4	(MSB) Parameter List Length (LSB)							
5	Control Byte							

Table 152. Reserve—10 Byte Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (56h)							
1	Reserved			3rd Pty	Reserved		LongID	Obsolete
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							

Parameter	Value
Parameter List Length	0 = Not supported
3rd Pty	0 = Not supported
LongID	0 = Not supported
Reservation ID	0 = Not supported
Third Party Device ID	0 = Not supported

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 153. 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							

Parameter	Value
Immed	Immediate bit: 0 = Return status when rewind completes 1 = Return 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.

Security Protocol In Command

The Security Protocol In (SPIN) command returns information about security and encryption

Table 154. Security Protocol In Command (SPIN)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (A2h)							
1	Security Protocol							
2 thru 3	(MSB) Security Protocol Specific (LSB)							
4	INC512 (0)	Reserved						
5	Reserved							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
Security Protocol	The Security Protocol field specifies which security protocol is being requested. • 00h = Security Protocol Information • 20h = Tape Data Encryption
Security Protocol Specific	The Security Protocol Specific specifies the type of page being requested. When Security Protocol is 00h; • 0000h = Supported Security Protocol List • 0001h = Certificate Data When Security Protocol is 20h; • 0000h = Tape Data Encryption In Support page • 0001h = Tape Data Encryption Out Support page • 0010h = Data Encryption Capabilities page • 0011h = Supported Key Formats page • 0012h = Data Encryption Management Capabilities page • 0020h = Data Encryption Status page • 0021h = Next Block Encryption Status page
INC512	Allocation length increment 0 = Normal allocation length

Security Protocol Information Pages

Supported Security Protocol List

A request of Security Protocol of 00h and a Security Protocol Specific 0000h will return a list of supported security protocols.

Table 155. Security Protocol List

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 5	(MSB) Reserved (LSB)							
6 thru 7	(MSB) Length of remaining data in bytes (0002h) (LSB)							
8	Security Protocol Information (00h)							
9	Tape Data Encryption (20h)							

Certificate Data

A request of Security Protocol of 00h and a Security Protocol Specific 0001h will return the certificate data.

Table 156. Certificate Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Reserved (LSB)							
2 thru 3	(MSB) Length of Certificate Data (0000h) (LSB)							

Note: A length of 0 (zero) indicates no certificate available.

Tape Data Encryption Pages

Tape Data Encryption In Supported Page

A request of Security Protocol of 20h and a Security Protocol Specific 0000h will return a list of supported values for the Security Protocol Specific field supported by the SPIN command.

Table 157. Tape Data Encryption In Supported Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0000h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (000Eh) (LSB)							
4 thru 5	(MSB) Tape Data Encryption In Support (0000h) (LSB)							
6 thru 7	(MSB) Tape Data Encryption Out Support (0001h) (LSB)							
8 thru 9	(MSB) Data Encryption Capabilities (0010h) (LSB)							
10 thru 11	(MSB) Supported Key Formats (0011h) (LSB)							
12 thru 13	(MSB) Data Encryption Management Capabilities (0012h) (LSB)							
14 thru 15	(MSB) Data Encryption Status (0020h) (LSB)							
16 thru 17	(MSB) Next Block Encryption Status (0021h) (LSB)							

Tape Data Encryption Out Supported Page

A request of Security Protocol of 20h and a Security Protocol Specific 0001h will return a list of supported values for the Security Protocol Specific field supported by the Security Protocol Out (SPOUT) command.

Table 158. Tape Data Encryption Out Supported Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0001h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (0002h) (LSB)							
4 thru 5	(MSB) Set Data Encryption (0010h) (LSB)							

Data Encryption Capabilities Page

A request of Security Protocol of 20h and a Security Protocol Specific 0010h will return information regarding data encryption algorithms supported.

Table 159. Tape Data Encryption Capabilities Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0010h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (0028h) (LSB)							
4	Reserved				EXTDECC (00b)		CFG_P (01b)	
5 thru 19	(MSB) Reserved (LSB)							
20 thru 43	(MSB) Data Encryption Algorithm Descriptor (LSB)							

Parameter	Value
EXTDECC: External data encryption control capable	External data encryption control capable 00b = The external data encryption control capability is not supported
CFG_P: Configuration prevented	Configuration prevented 01b = Drive is configured to allow changes of data encryption parameters

Data Encryption Algorithm Descriptor

Table 160. Data Encryption Algorithm Descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Algorithm Index (01h)							
1	Reserved							
2 thru 3	(MSB) Descriptor Length (0014h) (LSB)							
4	AVFMV	SDK_C (0)	MAC_C (0)	DELB_C (1)	Decrypt_C (10b)		Encrypt_C (10b)	
5	AVFCLP (00b)		NONCE_C (01b)		Rsvd	VCELB_C (0)	UKADF (0)	AKADF (0)
6 thru 7	(MSB) Maximum Unauthenticated Key-Associated Data Bytes (001Eh) (LSB)							
8 thru 9	(MSB) Maximum Authenticated Key-Associated Data Bytes (0000h) (LSB)							
10 thru 11	(MSB) Key Size (0020h) (LSB)							
12	DKAD_C (01b)		EEMC_C (00b)		RDMC_C (001b)			EAREM (1)
13	Reserved							
14 thru 15	(MSB) MSDK_Count (LSB)							
16 thru 19	(MSB) Reserved (LSB)							

Table 160. Data Encryption Algorithm Descriptor (Continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
20 thru 23	(MSB) Security Algorithm Code (80010010h) (LSB)							

Parameter	Value
AVFMV	Algorithm valid for mounted volume 0 = Not valid or no volume mounted 1 = Valid
SDK_C	Supplemental decryption key capable 0 = Not supported
MAC_C	Message authentication code capable 0 = Not supported
DELB_C	Distinguish encrypted logical block capable 1 = Drive can distinguish encrypted data from unencrypted data when reading from the media
Decrypt_C	Decryption capable 10b = Drive can decrypt using this algorithm in hardware
Encrypt_C	Encryption capable 10b = Drive can encrypt using this algorithm in hardware
AVFCLP	Algorithm valid for current logical position 00b = Algorithm valid regardless of logical position or no volume is loaded
NONCE_C	Nonce capable. 01b = Drive generates nonce values
VCELB_C	Volume contains encrypted logical blocks capable 0 = Drive can determine that volume contains encrypted data when the volume is mounted
UKADF	U-KAD fixed (Unauthenticated Key-Associated Data) 0 = Not fixed length
AKADF	A-KAD fixed (Authenticated Key-Associated Data) 0 = Not fixed length
Maximum Unauthenticated Key-Associated data bytes	001Eh
Maximum Authenticated Key-Associated data bytes	0000h = Not supported
Key size	0020h = Device uses 256 bit keys

Parameter	Value
DKAD_C	Decryption KAD capable when Decryption Mode is Decrypt or Mixed • 00b = Not specified (Not supported) • 01b = Drive requires a U-KAD provided by the Host for decrypting operations. If not provided with SPOUT command Set Data Encryption page then terminate the command with Check Condition with sense key set to Illegal Request and the ASC set to Incomplete Key-Associated Date Set. • 10b = Not required (Not supported) • 11b = Optional (Not supported)
EEMC_C	External encryption mode capabilities 00b = Not supported
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
MSDK_Count	Maximum supplemental decryption key count supported 00000000h = Currently not supported
Security Algorithm Code	80010010h = 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

A request of Security Protocol of 20h and a Security Protocol Specific 0011h will return a list of all supported key formats.

Table 161. Supported Keys Formats Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 1	(MSB) Page Code (0011h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (0001h) (LSB)							
4	Supported Key Formats (00h)							

Parameter	Value
Supported Key Formats	00h = Plain text Keys

Data Encryption Management Capabilities Page

A request of Security Protocol of 20h and a Security Protocol Specific 0012h will return information about encryption management features supported.

Table 162. Data Encryption Capabilities Management Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0012h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (000Ch) (LSB)							
4	Reserved							LOCK_C (1)
5	Reserved					CKOD_C (1)	CKORP_C (1)	CKORL_C (1)
6	Reserved							
7	Reserved					AITN_C (1)	LOCAL_C (1)	PUBLIC_C (1)
8 thru 15	(MSB) Reserved (LSB)							

Parameter	Value
LOCK_C	LOCK bit supported in the Set Data Encryption page 1 = Supported
CKOD_C	Clear key on demount bit supported in the Set Data Encryption page 1 = Supported
CKORP_C	Clear key on reservation preempt bit supported in the Set Data Encryption page 1 = Supported
CKORL_C	Clear key on reservation loss bit supported in the Set Data Encryption page 1 = Supported
AITN_C	All I_T Nexus bit supported in the Set Data Encryption page 1 = Supported
LOCAL_C	LOCAL bit supported in the Set Data Encryption page 1 = Supported

Parameter	Value
PUBLIC_C	PUBLIC bit supported in the Set Data Encryption page 1 = Supported

Data Encryption Status Page

A request of Security Protocol of 20h and a Security Protocol Specific 0020h will return the current data encryption status.

Table 163. Data Encryption Status Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 1	(MSB) Page Code (0020h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (n -3) (LSB)							
4	I_T Nexus Scope			Reserved		Logical Block Encryption Scope		
5	Encryption Mode							
6	Decryption Mode							
7	Algorithm Index							
8 thru 11	(MSB) Key Instance Counter (LSB)							
12	Rsvd	Parameters Control (010b)			VCELB (0)	CEEMS (01b)		RDMD (0)
13	Reserved							
14 thru 15	(MSB) ASDK_Count (LSB)							
16 thru 23	(MSB) Reserved (LSB)							
24 thru n	(MSB) Key Association Descriptor List (LSB)							

Parameter	Value
I_T Nexus Scope	I_T nexus of the saved data encryption parameters 000b = Public 001b = Local 010b = All I_T Nexus
Logical Block Encryption Scope	Logical block encryption scope of the saved data encryption parameters 000b = Public 001b = Local 010b = All I_T Nexus
Encryption Mode	Encryption mode of the saved data encryption parameters 00h = Data encryption is disabled 02h = Write data will be encrypted
Decryption Mode	Decryption mode of the saved data encryption parameters 00h = Data decryption is disabled 02h = Decrypt mode, encrypted data will be decrypted 03h = Mixed mode, encrypted data will be decrypted and non encrypted data read
Algorithm Index	Algorithm index of the saved data encryption parameters 00h = Not valid, such as encryption & decryption not enabled 01h = Algorithm to be used for encryption and decryption
Key Instance Counter	Key instance counter assigned to the key indicated in the key scope field
Parameters Control	Information on how the data encryption parameters are controlled 010b = Parameters are exclusively controlled by the device
VCELB	Volume contains encrypted logical blocks 0 = Capability is not supported
CEEMS	Check external encryption mode status 00b = Vendor Specific (Ignored) 01b = Encryption mode is not checked
RDMD	Raw decryption mode disabled 0 = Default mode
ASDK_Count	Available supplemental decryption key count 00000000h = Currently Not Supported
Key-Associated Data Descriptors List	The following key association descriptors are returned in the Key Descriptor Type order, Table 164 on page 213

Key-Associated Data Descriptors List

The following key association descriptors are returned in the Key Descriptor Type order.

Table 164. Key Association Descriptor Type

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Key Descriptor Type							
1	Reserved					Authenticated		
2 thru 3	(MSB) Key Descriptor Length in bytes (n-3) (LSB)							
4 thru n	(MSB) Key Descriptor (LSB)							

Parameter	Value
Key Descriptor Type	00h = Unauthenticated key-associated data: U-KAD 01h = Authenticated key-associated data: A-KAD (not supported) 02h = Nonce value (not supported) 03h = Metadata key-associated data (not supported)
Authenticated	000b = Reserved
Key Descriptor Length	For U-KAD = Up to 001Eh bytes

Next Block Encryption Status Page

A request of Security Protocol of 20h and a Security Protocol Specific 0021h will return the next block encryption status.

Table 165. Next Block Encryption Status

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0021h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (n-3) (LSB)							
4 thru 11	(MSB) Logical Object Number (LSB)							
12	Compression Status (0h)				Encryption Status			
13	Algorithm Index							
14	Reserved						EMES (0)	RDMDS (0)
15	Reserved							
16 thru n	(MSB) Key-Associated Data Descriptors List (LSB)							

Parameter	Value
Logical Object Number	Logical block address
Compression Status	0h = The drive is incapable of determining if the logical object referenced has been compressed
Encryption Status	• 1h = Drive is capable of determining if the logical block referenced has been encrypted, but is not able to at this time, for example: not read into the buffer, error, end of data • 2h = Drive has determined the logical block is not a logical block • 3h = Drive has determined the logical block is not encrypted • 5h = Drive has determined the logical block is encrypted • 6h = Drive has determined that the logical block is encrypted, but the drive is either not enabled to decrypt or does not have the correct key to decrypt the encrypted block
Algorithm Index	00h = Not valid, for example: encryption and decryption not enabled 01h = Default algorithm index

Parameter	Value
EMES	Encryption mode external status 0 = Not supported
RDMDS	Raw decryption mode disabled status 0 = Not supported
Key-Associated Data Descriptors List	The key-associated data descriptors are only returned on Encryption Status 6h. The following key association descriptors are returned in the Key Descriptor Type order:

Key-Associated Data Descriptors List

The key-associated data descriptors are only returned on Encryption Status 6h and in the following Key Descriptor Type order.

Table 166. Key-Associated Data Descriptors

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Key Descriptor Type							
1	Reserved					Authenticated		
2 thru 3	(MSB) Key Descriptor Length in bytes (n-3) (LSB)							
4 thru n	(MSB) Key Descriptor (LSB)							

Parameter	Value
Key Descriptor Type	00h = Unauthenticated key-associated data: U-KAD 01h = Authenticated key-associated data: A-KAD (not supported) 02h = Nonce value (not supported) 03h = Metadata key-associated data (not supported)
Authenticated	000b = Reserved 001b = The value in the key descriptor field is not covered by authentication, for example: U-KAD
Key Descriptor Length	For U-KAD = Up to 001Eh bytes

SPIN Implementation Notes

The following table lists the possible key-associated data (KAD) parameters reported in the Next Block Encryption Status page.

Table 167. Key-Associated Data Reported Parameters (SPIN)

Record Information	Decryption Mode	Read Data	Encryption Status	Key-Associated Descriptors				Notes
				U-KAD 00h	A-KAD 01h	Nonce 02h	Metadata 03h	
Unknown	Any	?	1h	n/a	n/a	n/a	n/a	
Filemark	Any	n/a	2h	n/a	n/a	n/a	n/a	
EOD	Any	n/a	2h	n/a	n/a	n/a	n/a	
Error	Any	n/a	1h	n/a	n/a	n/a	n/a	
Unencrypted	Disable	Cleartext	3h	n/a	n/a	n/a	n/a	
Unencrypted	Raw							Not Supported
Unencrypted	Decrypt	Error	3h	n/a	n/a	n/a	n/a	Unreadable
Unencrypted	Mixed	Cleartext	3h	n/a	n/a	n/a	n/a	
Encrypted	Disable	Error	5 or 6	Y	N	N	N	Unreadable
Encrypted	Raw							Not Supported
Encrypted	Decrypt	Decrypted	5 or 6	Y	N	N	N	
Encrypted	Mixed	Decrypted	5 or 6	Y	N	N	N	

- If the SECURITY PROTOCOL or the SECURITY PROTOCOL SPECIFIC field is set to a reserved or unsupported value, the device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN CDB.
- If the SPIN command is sent to an older drive firmware that does not support the SPIN/SPOUT commands, the drive shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID COMMAND OPERATION CODE.
- If the SPIN command is sent to a drive that has not been configured for DPKM support, the drive shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN CDB such as the Security Protocol field).
- If the Spin command requesting Next Block Encryption Status is sent to a drive that does not have a volume mounted, the drive shall terminate the command with CHECK CONDITION status, with the sense key set to NOT READY, and the additional sense code set to MEDIUM NOT PRESENT.

Security Protocol Out Command

The Security Protocol Out (SPOUT) command specifies the Tape Data Encryption security protocol to be used when encrypting and decrypting.

Table 168. Security Protocol Out Command (SPOUT)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (B5h)							
1	Security Protocol (20h)							
2 thru 3	(MSB) Security Protocol Specific (0010h) (LSB)							
4	INC_512 (0)	Reserved						
5	Reserved							
6 thru 9	(MSB) Transfer Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
Security Protocol	The Security Protocol field specifies which security protocol is being requested. 20h = Tape Data Encryption
Security Protocol Specific	The Security Protocol Specific specifies the type of page that is being requested. 0010h = Set Data Encryption page
INC512	Allocation length increment 0 = Normal allocation length

Set Data Encryption Page

A request of Security Protocol of 20h and a Security Protocol Specific 0010h will select the data encryption capabilities of the drive.

Table 169. Set Data Encryption Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0010h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (m-3) (LSB)							
4	Scope			Reserved				Lock
5	CEEM (01b)		RDMC (00b)		SDK (0)	CKOD	CKORP	CKORL
6	Encryption Mode							
7	Decryption Mode							
8	Algorithm Index (01h)							
9	Logical Block Encryption Key Format (00h)							
10 thru 17	(MSB) Reserved (LSB)							
18 thru 19	(MSB) Logical Block Encryption Key Length (0020h) (LSB)							
20 thru 51	(MSB) Logical Block Encryption Key (LSB)							
52 thru m	(MSB) Key-Associated Data Descriptors List (LSB)							

Parameter	Value
Scope	Scope of the data encryption parameters 000b = Public 001b = Local 010b = All I_T Nexus
Lock	0 = Not locked 1 = Locked
CEEM	Check external encryption mode 00b = Vendor Specific (Ignored) 01b = Encryption mode is not checked
RDMC	Raw decryption mode disabled 00b = Default mode
SDK	Supplemental decryption key 0 = Not supported
CKOD	Clear key on volume demount 0 = No 1 = Yes
CKORP	Clear key on reservation preempt 0 = No 1 = Yes
CKORL	Clear key on reservation loss 0 = No 1 = Yes
Encryption Mode	Encryption mode 00h = Data encryption is disabled 02h = Write data will be encrypted
Decryption Mode	Decryption mode 00h = Data decryption is disabled 02h = Decrypt mode, encrypted data will be decrypted 03h = Mixed mode, encrypted data will be decrypted and non encrypted data will be read
Algorithm Index	Algorithm index of the saved data encryption parameters 01h = Algorithm to be used for encryption and decryption
Logical Block Encryption Key Format	Key format of the value in the key field 00h = Plain-text key
Logical Block Encryption Key Length	0020h = Length in bytes of the key field, drive uses 256 bit keys
Logical Block Encryption Key	Host supplied plain-text key

Key-Associated Data Descriptors List

The following key association descriptors must be provided in Key Descriptor Type order.

Notes:

- If the U-KAD descriptor is not present when Encryption Mode is enabled a 30 byte Key Descriptor of all zeroes is used.
- In the future if this drive supports Supplemental Decryption Keys then the Host will be required to supply the U-KAD when Encryption Mode is enabled.

Table 170. Key Association Descriptor Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Key Descriptor Type							
1	Reserved					Authenticated		
2 thru 3	(MSB) Key Descriptor Length in bytes (n-3) (LSB)							
4 thru n	(MSB) Key Descriptor (LSB)							

Parameter	Value
Key Descriptor Type	00h = Unauthenticated key-associated data: U-KAD 01h = Authenticated key-associated data: A-KAD (not supported) 02h = Nonce value (not supported) 03h = Metadata key-associated data (not supported)
Authenticated	000b = Reserved
Key Descriptor Length	For U-KAD = Up to 001Eh bytes

SPOUT Implementation Notes

The following table lists the possible Key-Associated Data (KAD) parameters supported in the Set Data Encryption page.

Table 171. Key-Associated Data Reported Parameters (SPOUT)

Record Information	Decryption Mode	Read Data	Encryption Status	Key-Associated Descriptors				Notes
				U-KAD 00h	A-KAD 01h	Nonce 02h	Metadata 03h	
0h Disable	0h Disable	C/C	P	P	P	P	P	
0h Disable	1h Raw							Not Supported
0h Disable	2h Decrypt	D/C	M	M[1]	P	P	P	
0h Disable	3h Mixed	D/C	M	M[1]	P	P	P	
1h External	0h Disable							Not Supported
1h External	1h Raw							Not Supported
1h External	2h Decrypt							Not Supported
1h External	3h Mixed							Not Supported
2h Encrypt	0h Disable	C/E	M	O[2]	P	P	P	
2h Encrypt	1h Raw							Not Supported
2h Encrypt	2h Decrypt	D/E	M	M[1]	P	P	P	
2h Encrypt	3h Mixed	D/E	M	M[1]	P	P	P	

Legend:

C = Cleartext read & write data
D = Decrypted read data
E = Encrypted write data
P = Prohibited
M= Mandatory
O = Optional
n/a = Not Applicable

Notes:

1. Pending ANSI approval.
2. Optional when SDK is not supported, SDK supported will become Mandatory.

Note: The references in the following paragraphs refer to SSC-3.

- If the SECURITY PROTOCOL or the SECURITY PROTOCOL SPECIFIC field is set to a reserved or unsupported value.

  The device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN CDB.

- If the SPOUT command is sent to an older drive firmware that does not support the SPIN/SPOUT commands.

  The drive shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID COMMAND OPERATION CODE.

- If the SPOUT command is sent to a drive that has not been configured for DPKM support.

  The drive shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN CDB (such as the Security Protocol field).

The PAGE LENGTH field specifies the number of bytes of parameter data to follow. If the page length value results in the truncation of any field the device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

The device server shall terminate the SECURITY PROTOCOL OUT command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER DATA if the CEEM field is set to either 10b or 11b, and:

a. The DECRYPTION MODE field is set to DISABLE.

The device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST and the additional sense key set to INVALID FIELD IN PARAMETER DATA if:

a. The ENCRYPTION MODE field is set to ENCRYPT;

b. The RDMC field is set to 10b or 11b; and

c. The RDMC_C field in the algorithm descriptor for the encryption algorithm selected by the value in the ALGORITHM INDEX field is set to 1h, 6h, or 7h.

- If the clear key on demount (CKOD) bit is set to *one* the physical device shall set the data encryption parameters to default values upon completion of a volume demount.

  If the CKOD bit is set to *zero*, the demounting of a volume CKOD shall not affect the data encryption parameters.

If the bit is set to *one* and there is *no volume mounted* the device server shall terminate the command with CHECK CONDITION status and set the sense key to ILLEGAL REQUEST and the additional sense code to INVALID FIELD IN PARAMETER DATA.

- If the clear key on reservation preempt (CKORP) bit is set to *one*.

  The physical device shall set the data encryption parameters to default values when a persistent reservation is preempted (for example, a PERSISTENT RESERVE OUT command specifying a service action of PREEMPT or PREEMPT AND ABORT is processed).

  If the bit is set to *zero*, a preemption of a persistent reservation shall not affect the data encryption parameters.

  If the bit is set to *one* and there is no persistent reservation in effect for the I_T nexus associated with the SECURITY PROTOCOL OUT command, the device server shall terminate the command with CHECK CONDITION status and set the sense key to ILLEGAL REQUEST and the additional sense code to INVALID FIELD IN PARAMETER DATA.

- If the clear key on reservation loss (CKORL) bit is set to *one* the physical device shall set the data encryption parameters to default values on a reservation loss.

  If the bit is set to *zero*, a reservation loss shall not affect the data encryption parameters.

  If the CKORL bit is set to *one* and there is *no reservation in effect* for the I_T nexus associated with the SECURITY PROTOCOL OUT command, the device server shall terminate the command with CHECK CONDITION status and set the sense key to ILLEGAL REQUEST and the additional sense code to INVALID FIELD IN PARAMETER DATA.

- If the ENCRYPTION MODE field is set to ENCRYPT and the KEY LENGTH field is set to zero.

  The device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER DATA.

- If the DECRYPTION MODE field is set to DECRYPT or MIXED and the KEY LENGTH field is set to zero,

  The device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER DATA.

- If the device server reports that it requires key-associated data (DKAD_C) from the application client and a Set Data Encryption page is processed that does not include a key-associated data descriptor.

The device server shall terminate the command with CHECK CONDITION, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INCOMPLETE KEY-ASSOCIATED DATA SET.

- If a nonce value descriptor is included and the algorithm and the device server supports application client generated nonce values

  The value in the KEY DESCRIPTOR field shall be used as the nonce value for the encryption process.

- If a nonce value descriptor is included and the encryption algorithm or the device server does not support application client generated nonce values,

  The device server shall terminate the command with CHECK CONDITION, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

The device server shall terminate the command with CHECK CONDITION, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER LIST if an A-KAD or M-KAD is included and:

a. The encryption algorithm specified by the ALGORITHM INDEX field does not support A-KAD or M-KAD.

If a device server processes a Set Data Encryption page with the ENCRYPTION MODE field set to DISABLE and DECRYPTION MODE field set to DISABLE or RAW, the physical device shall:

a. Release any resources that it had allocated to store data encryption parameters for the I_T nexus associated with the SECURITY PROTOCOL OUT command and shall change the contents of all memory containing a key value associated with the data encryption parameters that are released; and

b. Establish a unit attention condition, if the key actually changes, with the additional sense of DATA ENCRYPTION PARAMETERS CHANGED BY ANOTHER I_T NEXUS for all other I_T nexus that has its registered for encryption unit attentions state set to one (see 4.2.22.13) and is affected by the loss of the key, (i.e., any I_T nexus that is using a data encryption scope of PUBLIC and sharing the keys).

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 172. Send Diagnostic Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Dh)							
1	Reserved			PF	RSVD	SelfTest	DevOfl	UnitOfl
2	Reserved							
3 thru 4	(MSB) Parameter List Length (LSB)							
5	Force Dump		Control Byte					

Parameter	Value
PF: Page Formatted	0 = Parameter data sent is not page formatted 1 = Parameter data sent is page formatted
SelfTest: Self Test	1 = Perform default self test
DevOfl: Device Offline	0 = Diagnostics will not affect all logical units
UnitOfl: Unit Offline	0 = Diagnostics will not affect media loaded on logical unit
Parameter List Length:	Length in bytes of parameter data transferred to the drive.
Force Dump: Force dump	11b = Force a dump

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 173. 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							

Parameter	Value
Code	Type of space operation: 000b = Space blocks 001b = Space filemarks 011b = End-of-data (EOD)
Count	Number of blocks or 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.

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 174. 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:

- Good status is returned if the tape drive is loaded and ready.
- Check Condition status with a sense key of Not Ready is returned if the tape drive is not loaded.
- Busy status is returned if a Rewind, Erase, Load/Unload, or Locate command with the immediate bit set was previously issued and the tape drive has not completed the command.

Verify Command

The Verify command reads one or more blocks of data from the tape without transferring the data to the host.

Table 175. Verify Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (13h)							
1	Reserved		VTE	VLBPM	VBF	Immed	BYTCMP	Fixed
2 thru 4	(MSB) Verification Length (LSB)							
5	SILI	Control Byte						

Parameter	Value
VTE	Verify To End-of-data 0 = Do not verify to end-of-data 1 = Verify to end-of-data If the verification fails the Information field in Status is zero The BYTCMP and VBF must be zero The Verification Length field is ignored
VLBPM	Verify Logical Block Protection Method 0 = Do not verify logical block protection mode 1 = Verify logical block protection mode Verify that each logical block uses the logical block protection method specified in the Control Data Protection mode page
VBF	Verify By Filemarks 0 = Do not verify by filemarks 1 = Verify by filemarks The Verification Length field contains the number of files to verify If the verification fails the Information field in Status is the number of files successfully verified, Read Position should be used to determine the record that failed The BYTCMP must be zero

Parameter	Value
Immed: Immediate	Immediate 0 = Return status when verify is completed
BYTCMP: Byte compare	Byte compare 0 = Medium verification
Fixed	Block mode 0 = Variable block 1 = Fixed block
Verification Length	Number of bytes or blocks to verify
SILI: Suppress Illegal Length Indication	Suppress Illegal Length Indication 0 = Check condition status is returned if the record length does not match Verification Length. 1 = Return Check Condition status only when the actual record length is larger than Verification Length, and the Mode Sense block length field in not zero. **Note:** This option is not allowed if the fixed bit is 1.

Write Command

The Write command transfers one or more blocks of data from the host to tape.

Table 176. 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							

Parameter	Value
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, Check Condition status is returned and the end-of-medium (EOM) bit is set in sense data. The SEW bit in the mode sense device configuration page controls when data is written to the tape at LEOT.

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 un-correctable 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.

Data Integrity Validation—Write Operations

During write operations when DIV mode is enabled, all Write commands must have a transfer length that includes both the user data and the appended 4 bytes of Protection Information.

Note: Use the Mode Select command Page 0Ah, Subpage F0h, to enable the DIV mode.

When in DIV mode the T10000 A and B tape drives strip away the PI data during transfer from the controller data buffer to the tape drive.

On T10000C tape drives, the PI data is written to the media.

If an error occurs during Write operations, and the drive detects a miscompare, it reports it as a:

Check condition, with
Key = 04h (Hardware Error), and
ASC/ASCQ = 10 01h — Logical Block Guard Check Failed

This record is not written on the media.

Examples of when this may occur include:

- When transferring data for Write operations. As data passes from the Fibre Channel FC protocol chip (if it supports the current PI method) to the controller data buffer.
- If the drive is operating in Buffered mode, later when transferring the data to tape, the PI data is checked and a deferred error occurs.
- If the drive is operating in Non Buffered mode, when transferring the data from the controller data buffer to the tape, the PI data is checked.

Write Buffer Command

The Write Buffer command updates the functional microcode for the drive. 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 177. 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							

Parameter	Value
Mode	Indicates the type of download: 06h = 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. 07h = 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. 0Ah = Write echo buffer
Buffer ID	Indicates the region of memory to be modified (must be 00h).
Buffer Offset	Offset from start of the buffer area (this field is ignored).
Parameter List Length	Number of bytes to transfer.

Notes:

- 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.
- The tape drive must be unloaded to perform this command.
- Blocks of firmware data must be transferred in sequential order. Each block except the last block transferred must be 262,144 bytes long. A parameter list length of 0 is allowed for mode 111b only.
- 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.
- 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 178. 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							

Parameter	Value
WSmk: Write Setmark bit	Write Setmark bit 0 = Write filemarks
Immed: Immediate mode	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 logical end of tape (LEOT).

Data Integrity Validation

A

This appendix contains information about the Data Integrity Validation (DIV) feature for the T10000 tape drive. This feature is based on the ANSI T10 Technical Committee's implementation of the Data Integrity Field (DIF).

The terms DIV or DIF are also referred to as Protection Information (PI).

Data Integrity Validation

Oracle's StorageTek T10000-Series tape drive supports the Data Integrity Validation (DIV) feature. This feature provides end-to-end protection of user data during a transfer.

Initiators generate the Protection Information (PI) during a write operation. Any object associated with the I_T_L nexus[1] (such as the Host: application or host bus adapter; Target: controller or device) may check for this information.

Once the device receives the protection information (for example, written to tape), it keeps this information until overwritten. Any loss of power, hard reset, or a logical unit reset has no effect on the retention of this protection information.

Protection information is appended to the end of the record using the following format for the PI data.

Logical Block	Protection Information (4-byte CRC)

- The Logical Block field contains the original user data.
- The Protection Information field contains the CRC.

Notes:

1. The capability of the drive to support DIV is advertised in Inquiry data and Mode Sense data.
2. To enable or disable DIV protection mode—use the Mode Select command.
3. Once enabling DIV mode; only the following commands are affected:
   - Read (08h)
   - Verify (13h)
   - Write (0Ah)

1. I_T_L nexus: A nexus is a connection that exists between an initiator, a target, and a logical unit. This is where one Initiator Port talks to one Target Port, addressing one LUN and together they execute one Task.

4. The transfer lengths (CDB bytes 2-4) for these commands must include the additional 4 bytes of Protection Information.
5. During Reading or Writing with DIV mode enabled the Target returns a Check condition if a PI miscompare is detected.

Reed-Solomon CRC

The following is a sample ‘C program’ to generate the Reed Solomon CRC[1] on an i386 class processor:

Figure 1. Reed Solomon CRC Program Example (Sheet 1 of 4)

```
#include <unistd.h>
#include <stdio.h>

/*---------------------------------------------------------------------------------------------
** INPUTS: crc - initial crc (0 for fresh) (i.e., seed)
** cnt - the number of data bytes to compute CRC for
** start - the starting address of the data bytes (e.g., data buffer)
** OUTPUTS: UINT32 - crc in big endian (MSB is first byte)
*/ ---------------------------------------------------------------------------------------------

uint32_t GenerateRSCRC(uint32_t crc, uint32_t cnt, const void *start)
{

static const uint32_t crcTable[256]=
{

0x00000000,0x38CF3801,0x70837002,0x484C4803,0xE01BE004,0xD8D4D805,

0x90989006,0xA857A807,0xDD36DD08,0xE5F9E509,0xADB5AD0A,0x957A950B,

0x3D2D3D0C,0x05E2050D,0x4DAE4D0E,0x7561750F,0xA76CA710,0x9FA39F11,

0xD7EFD712,0xEF20EF13,0x47774714,0x7FB87F15,0x37F43716,0x0F3B0F17,

0x7A5A7A18,0x42954219,0x0AD90A1A,0x3216321B,0x9A419A1C,0xA28EA21D,

0xEAC2EA1E,0xD20DD21F,0x53D85320,0x6B176B21,0x235B2322,0x1B941B23,

0xB3C3B324,0x8B0C8B25,0xC340C326,0xFB8FFB27,0x8EEE8E28,0xB621B629,

0xFE6DFE2A,0xC6A2C62B,0x6EF56E2C,0x563A562D,0x1E761E2E,0x26B9262F,

0xF4B4F430,0xCC7BCC31,0x84378432,0xBCF8BC33,0x14AF1434,0x2C602C35,

0x642C6436,0x5CE35C37,0x29822938,0x114D1139,0x5901593A,0x61CE613B,

0xC999C93C,0xF156F13D,0xB91AB93E,0x81D5813F,0xA6ADA640,0x9E629E41,

0xD62ED642,0xEEE1EE43,0x46B64644,0x7E797E45,0x36353646,0x0EFA0E47,

0x7B9B7B48,0x43544349,0x0B180B4A,0x33D7334B,0x9B809B4C,0xA34FA34D,
```

1. Reed–Solomon is an error-correcting code (ECC) that works by oversampling a polynomial constructed from the data. The polynomial is evaluated at several points, and these values are either sent or recorded. Reed–Solomon codes are used in a wide variety of applications for data transmission technologies.

Figure 1. Reed Solomon CRC Program Example (Sheet 2 of 4)

```
0xEB03EB4E,0xD3CCD34F,0x01C10150,0x390E3951,0x71427152,0x498D4953,
0xE1DAE154,0xD915D955,0x91599156,0xA996A957,0xDCF7DC58,0xE438E459,
0xAC74AC5A,0x94BB945B,0x3CEC3C5C,0x0423045D,0x4C6F4C5E,0x74A0745F,
0xF575F560,0xCDBACD61,0x85F68562,0xBD39BD63,0x156E1564,0x2DA12D65,
0x65ED6566,0x5D225D67,0x28432868,0x108C1069,0x58C0586A,0x600F606B,
0xC858C86C,0xF097F06D,0xB8DBB86E,0x8014806F,0x52195270,0x6AD66A71,
0x229A2272,0x1A551A73,0xB202B274,0x8ACD8A75,0xC281C276,0xFA4EFA77,
0x8F2F8F78,0xB7E0B779,0xFFACFF7A,0xC763C77B,0x6F346F7C,0x57FB577D,
0x1FB71F7E,0x2778277F,0x51475180,0x69886981,0x21C42182,0x190B1983,
0xB15CB184,0x89938985,0xC1DFC186,0xF910F987,0x8C718C88,0xB4BEB489,
0xFCF2FC8A,0xC43DC48B,0x6C6A6C8C,0x54A5548D,0x1CE91C8E,0x2426248F,
0xF62BF690,0xCEE4CE91,0x86A88692,0xBE67BE93,0x16301694,0x2EFF2E95,
0x66B36696,0x5E7C5E97,0x2B1D2B98,0x13D21399,0x5B9E5B9A,0x6351639B,
0xCB06CB9C,0xF3C9F39D,0xBB85BB9E,0x834A839F,0x029F02A0,0x3A503AA1,
0x721C72A2,0x4AD34AA3,0xE284E2A4,0xDA4BDAA5,0x920792A6,0xAAC8AAA7,
0xDFA9DFA8,0xE766E7A9,0xAF2AAFAA,0x97E597AB,0x3FB23FAC,0x077D07AD,
0x4F314FAE,0x77FE77AF,0xA5F3A5B0,0x9D3C9DB1,0xD570D5B2,0xEDBFEDB3,
0x45E845B4,0x7D277DB5,0x356B35B6,0x0DA40DB7,0x78C578B8,0x400A40B9,
0x084608BA,0x308930BB,0x98DE98BC,0xA011A0BD,0xE85DE8BE,0xD092D0BF,
0xF7EAF7C0,0xCF25CFC1,0x876987C2,0xBFA6BFC3,0x17F117C4,0x2F3E2FC5,
0x677267C6,0x5FBD5FC7,0x2ADC2AC8,0x121312C9,0x5A5F5ACA,0x629062CB,
0xCAC7CACC,0xF208F2CD,0xBA44BACE,0x828B82CF,0x508650D0,0x684968D1,
0x200520D2,0x18CA18D3,0xB09DB0D4,0x885288D5,0xC01EC0D6,0xF8D1F8D7,
0x8DB08DD8,0xB57FB5D9,0xFD33FDDA,0xC5FCC5DB,0x6DAB6DDC,0x556455DD,
0x1D281DDE,0x25E725DF,0xA432A4E0,0x9CFD9CE1,0xD4B1D4E2,0xEC7EECE3,
0x442944E4,0x7CE67CE5,0x34AA34E6,0x0C650CE7,0x790479E8,0x41CB41E9,
0x098709EA,0x314831EB,0x991F99EC,0xA1D0A1ED,0xE99CE9EE,0xD153D1EF,
0x035E03F0,0x3B913BF1,0x73DD73F2,0x4B124BF3,0xE345E3F4,0xDB8ADBF5,
0x93C693F6,0xAB09ABF7,0xDE68DEF8,0xE6A7E6F9,0xAEEBAEFA,0x962496FB,
0x3E733EFC,0x06BC06FD,0x4EF04EFE,0x763F76FF
};
```

Figure 1. Reed Solomon CRC Program Example (Sheet 3 of 4)

```
uint32_t i;
const uint8_t* d = start;
for ( i = 0; i < cnt; i++ )
{
crc = (crc << 8) ^ crcTable[*d ^ (crc >> 24)];
d++;
}
return crc;
}

#define FICON
#define INIT 0x00000000
int main(void)
{

uint32_t   crc;
uint32_t   cnt;
uint32_t   blk_len;
uint8_t   *blk_adr;
uint8_t  test_data[]=
{

#ifdef FICON

/* Test data, expected CRC is 0x61A56001 */
0xC8, 0xC4, 0xD9, 0xF1,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0

#else
```

Figure 1. Reed Solomon CRC Program Example (Sheet 4 of 4)

```
/* ASCII "12345678" Expected CRC is 0x03124E3E */

0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38

/* Other odd byte size data crc's */
/* ASCII "123456789" Expected CRC is 0x4B4F673A */
/* ASCII "123456789A" Expected CRC is 0x25B15071 */
/* ASCII "123456789AB" Expected CRC is 0x5B929B1E */

#endif

};

printf("\nReed Solomon version 1.0, Demonstration Program.\n\n");

blk_len = sizeof(test_data);
printf("Sizeof test_data = %d \n", blk_len);
printf("Input String:\n");
for( cnt = 0; cnt < blk_len; cnt++ )
printf("%02X ", test_data[cnt]);

/* Compute Reed Solomon CRC */
blk_len = sizeof(test_data);
blk_adr = &test_data[0];
crc = INIT;
crc = GenerateRSCRC(crc, blk_len, blk_adr);

printf("\n\nReed Solomon Actual CRC = 0x%08X\n", crc);


#ifdef FICON

printf("\nExpected CRC = 0x61A56001\n\n");

#else

if(blk_len == 8)

printf("\nExpected CRC = 0x03124E3E\n\n");

#endif

return(0);

}
```

Vendor Unique SB-2 CRC

The following is a sample ‘C program’ to generate the SB-2 CRC on an i386 class processor.

Figure 2. SB-2 CRC Program Example (Sheet 1 of 6)

```
/*********************************************************************
* File: sbbyte.c
* Description:  32bit implementation of the CRC32 LFSR.
* Copyright 2009 Sun Microsystems, Inc. All rights reserved.
*
* CRC algorithm was excerpted from "18. Roll Your Own Table-Driven
* Implementation" in the following document:
* "Everything you wanted to know about CRC algorithms, but were afraid to
* ask for fear that errors in your understanding might be detected."
*
*  Author : Ross N. Williams
*  E-Mail : ross@guest.adelaide.edu.au
*  Date : 19 August 1993
*  Version : 3.00
*
*  FTP: ftp.adelaide.edu.au/pub/rocksoft/crc_v3.txt
*  WWW: http://www.on.net/clients/rocksoft/ro ksoft/
*
*  Company : Rocksoft(tm) Pty Ltd
*  Snail : 16 Lerwick Avenue, Hazelwood Park 5066, Australia
*  Fax : +61 8 373-4911 (c/- Internode Systems Pty Ltd)
*  Phone : +61 8 379-9217 (10am to 10pm Adelaide Australia time)
*  Note : "Rocksoft" is a trademark of Rocksoft Pty Ltd, Australia
*
*  Status: Copyright (C) Ross Williams, 1993,1994,1995,1996. However,
*  permission is granted to make and distribute verbatim copies of this
*  document provided that this information block and copyright notice is
*  included. Also, the C code modules included in this document are fully
*  PUBLIC DOMAIN (PD).
*
*  Thanks: Thanks to Jean-loup Gailly (jloup@chorus.fr) and Mark Adler
*  (me@quest.jpl.nasa.gov) who both proof read this document and picked
*  out lots of nits as well as some big fat bugs.
*
*********************************************************************/
```

Figure 2. SB-2 CRC Program Example (Sheet 2 of 6)

```
#include <unistd.h>
#include <stdio.h>

/*****************************************************************************/
/*                                                                           */
/* CRC LOOKUP TABLE                                                          */
/* ================================================                          */
/* The following CRC lookup table was generated automagically                */
/* by the Rocksoft^tm Model CRC Algorithm Table Generation                   */
/* Program V1.0 using the following model parameters:                        */
/*                                                                           */
/*    Width   : 4 bytes.                                                     */
/*    Poly    : 0x04C11DB7L                                                  */
/*    Reverse : FALSE.                                                       */
/*                                                                           */
/* For more information on the Rocksoft^tm Model CRC Algorithm,              */
/* see the document titled "A Painless Guide to CRC Error                    */
/* Detection Algorithms" by Ross Williams                                    */
/* (ross@guest.adelaide.edu.au.). This document is likely to be              */
/* in the FTP archive "ftp.adelaide.edu.au/pub/rocksoft".                    */
/*                                                                           */
/*****************************************************************************/

unsigned long  crctable[256] =
{
0x00000000L, 0x04C11DB7L, 0x09823B6EL, 0x0D4326D9L,
0x130476DCL, 0x17C56B6BL, 0x1A864DB2L, 0x1E475005L,
0x2608EDB8L, 0x22C9F00FL, 0x2F8AD6D6L, 0x2B4BCB61L,
0x350C9B64L, 0x31CD86D3L, 0x3C8EA00AL, 0x384FBDBDL,
0x4C11DB70L, 0x48D0C6C7L, 0x4593E01EL, 0x4152FDA9L,
0x5F15ADACL, 0x5BD4B01BL, 0x569796C2L, 0x52568B75L,
0x6A1936C8L, 0x6ED82B7FL, 0x639B0DA6L, 0x675A1011L,
0x791D4014L, 0x7DDC5DA3L, 0x709F7B7AL, 0x745E66CDL,
0x9823B6E0L, 0x9CE2AB57L, 0x91A18D8EL, 0x95609039L,
0x8B27C03CL, 0x8FE6DD8BL, 0x82A5FB52L, 0x8664E6E5L,
0xBE2B5B58L, 0xBAEA46EFL, 0xB7A96036L, 0xB3687D81L,
0xAD2F2D84L, 0xA9EE3033L, 0xA4AD16EAL, 0xA06C0B5DL,
```

Figure 2. SB-2 CRC Program Example (Sheet 3 of 6)

```
0xD4326D90L, 0xD0F37027L, 0xDDB056FEL, 0xD9714B49L,
0xC7361B4CL, 0xC3F706FBL, 0xCEB42022L, 0xCA753D95L,
0xF23A8028L, 0xF6FB9D9FL, 0xFBB8BB46L, 0xFF79A6F1L,
0xE13EF6F4L, 0xE5FFEB43L, 0xE8BCCD9AL, 0xEC7DD02DL,
0x34867077L, 0x30476DC0L, 0x3D044B19L, 0x39C556AEL,
0x278206ABL, 0x23431B1CL, 0x2E003DC5L, 0x2AC12072L,
0x128E9DCFL, 0x164F8078L, 0x1B0CA6A1L, 0x1FCDBB16L,
0x018AEB13L, 0x054BF6A4L, 0x0808D07DL, 0x0CC9CDCAL,
0x7897AB07L, 0x7C56B6B0L, 0x71159069L, 0x75D48DDEL,
0x6B93DDDBL, 0x6F52C06CL, 0x6211E6B5L, 0x66D0FB02L,
0x5E9F46BFL, 0x5A5E5B08L, 0x571D7DD1L, 0x53DC6066L,
0x4D9B3063L, 0x495A2DD4L, 0x44190B0DL, 0x40D816BAL,
0xACA5C697L, 0xA864DB20L, 0xA527FDF9L, 0xA1E6E04EL,
0xBFA1B04BL, 0xBB60ADFCL, 0xB6238B25L, 0xB2E29692L,
0x8AAD2B2FL, 0x8E6C3698L, 0x832F1041L, 0x87EE0DF6L,
0x99A95DF3L, 0x9D684044L, 0x902B669DL, 0x94EA7B2AL,
0xE0B41DE7L, 0xE4750050L, 0xE9362689L, 0xEDF73B3EL,
0xF3B06B3BL, 0xF771768CL, 0xFA325055L, 0xFEF34DE2L,
0xC6BCF05FL, 0xC27DEDE8L, 0xCF3ECB31L, 0xCBFFD686L,
0xD5B88683L, 0xD1799B34L, 0xDC3ABDEDL, 0xD8FBA05AL,
0x690CE0EEL, 0x6DCDFD59L, 0x608EDB80L, 0x644FC637L,
0x7A089632L, 0x7EC98B85L, 0x738AAD5CL, 0x774BB0EBL,
0x4F040D56L, 0x4BC510E1L, 0x46863638L, 0x42472B8FL,
0x5C007B8AL, 0x58C1663DL, 0x558240E4L, 0x51435D53L,
0x251D3B9EL, 0x21DC2629L, 0x2C9F00F0L, 0x285E1D47L,
0x36194D42L, 0x32D850F5L, 0x3F9B762CL, 0x3B5A6B9BL,
0x0315D626L, 0x07D4CB91L, 0x0A97ED48L, 0x0E56F0FFL,
0x1011A0FAL, 0x14D0BD4DL, 0x19939B94L, 0x1D528623L,
```

Figure 2. SB-2 CRC Program Example (Sheet 4 of 6)

```
0xF12F560EL, 0xF5EE4BB9L, 0xF8AD6D60L, 0xFC6C70D7L
0xE22B20D2L, 0xE6EA3D65L, 0xEBA91BBCL, 0xEF68060BL,
0xD727BBB6L, 0xD3E6A601L, 0xDEA580D8L, 0xDA649D6FL,
0xC423CD6AL, 0xC0E2D0DDL, 0xCDA1F604L, 0xC960EBB3L,
0xBD3E8D7EL, 0xB9FF90C9L, 0xB4BCB610L, 0xB07DABA7L,
0xAE3AFBA2L, 0xAAFBE615L, 0xA7B8C0CCL, 0xA379DD7BL,
0x9B3660C6L, 0x9FF77D71L, 0x92B45BA8L, 0x9675461FL,
0x8832161AL, 0x8CF30BADL, 0x81B02D74L, 0x857130C3L,
0x5D8A9099L, 0x594B8D2EL, 0x5408ABF7L, 0x50C9B640L,
0x4E8EE645L, 0x4A4FFBF2L, 0x470CDD2BL, 0x43CDC09CL,
0x7B827D21L, 0x7F436096L, 0x7200464FL, 0x76C15BF8L,
0x68860BFDL, 0x6C47164AL, 0x61043093L, 0x65C52D24L,
0x119B4BE9L, 0x155A565EL, 0x18197087L, 0x1CD86D30L,
0x029F3D35L, 0x065E2082L, 0x0B1D065BL, 0x0FDC1BECL,
0x3793A651L, 0x3352BBE6L, 0x3E119D3FL, 0x3AD08088L,
0x2497D08DL, 0x2056CD3AL, 0x2D15EBE3L, 0x29D4F654L,
0xC5A92679L, 0xC1683BCEL, 0xCC2B1D17L, 0xC8EA00A0L,
0xD6AD50A5L, 0xD26C4D12L, 0xDF2F6BCBL, 0xDBEE767CL,
0xE3A1CBC1L, 0xE760D676L, 0xEA23F0AFL, 0xEEE2ED18L,
0xF0A5BD1DL, 0xF464A0AAL, 0xF9278673L, 0xFDE69BC4L,
0x89B8FD09L, 0x8D79E0BEL, 0x803AC667L, 0x84FBDBD0L,
0x9ABC8BD5L, 0x9E7D9662L, 0x933EB0BBL, 0x97FFAD0CL,
0xAFB010B1L, 0xAB710D06L, 0xA6322BDFL, 0xA2F33668L,
0xBCB4666DL, 0xB8757BDAL, 0xB5365D03L, 0xB1F740B4L
};
/*****************************************************************/
/*              End of CRC Lookup Table                          */
/*****************************************************************/
```

Figure 2. SB-2 CRC Program Example (Sheet 5 of 6)

```
#define NAME                "CRC-32"
#define WIDTH               32
#define POLY                0x04C11DB7
#define INIT                0xFFFFFFFF
#define INIT_REFLECTED      0xFFFFFFFF
#define REFIN               FALSE
#define REFOUT              FALSE
#define XOROUT              0XFFFFFFFF
#define CHECK               0xFC891918

/* NOTE: The CHECK is for the standard 9 byte test data of
*  ASCII string "123456789"
*/

#define FICON

/*************************************************************************
*
* Function:   Main
* Purpose:    Calculate the FICON (Single Byte) CRC32
* Args:       none
* Return Value:  none
* Remarks:
* CRC32 Generator Polinomial:
* 0x104C11DB7
*
* x^0+x^1+x^2+x^4+x^5+x^7+x^8+x^10+x^11+x^12+x^16+x^22+x^23+x^26+x^32
*
* The CRC 32 polinomial is a linear feedback shift register that will
* generate a Maximal Length Sequence, implemented here using a lookup
* table, to reduce the number of shift and XOR operations.
*
*************************************************************************/

int main(void)

{

uint32_t   crc;
uint32_t   cnt;
uint32_t   blk_len;
uint8_t    *blk_adr;
uint8_t  test_data[]=

{
```

Figure 2. SB-2 CRC Program Example (Sheet 6 of 6)

```
#ifdef FICON

/* Test data, expected CRC is 0x1DC41771 */
0x00, 0x00, 0x00, 0xC7,
0x00, 0x00, 0x00, 0xC8
#else

/* ASCII "123456789" Expected CRC is 0xFC891918 */
0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38, 0x39
#endif
};

printf("\nCrc32 ver. 1.0, 32bit CRC32 Demonstration Program.\n\n");

blk_len = sizeof(test_data);
printf("Sizeof test_data = %d \n", blk_len);
printf("Input String:\n");
for(cnt = 0; cnt < blk_len; cnt++)
printf("%02X ", test_data[cnt]);

/* Do Non Reflected CRC */
blk_len = sizeof(test_data);
blk_adr = &test_data[0];
crc = INIT;
while (blk_len--)
crc = crctable[((crc>>24) ^ *blk_adr++) & 0xFF] ^ (crc << 8);
crc = crc ^ XOROUT;

printf("\n\nNon Reflected Actual CRC32 = 0x%08X\n", crc);

#ifdef FICON
printf("\nExpected CRC32 = 0x1DC41771\n");
#else

printf("\nExpected CRC32 = 0xFC891918\n");

#endif

return(0);

}

/*********************************************************************/
```

Vendor Unique Intel CRC32C

The following is a sample ‘C program’ to software generate the Intel CRC32C on an i386 class processor. This example also includes the assembly language code to utilize the Nehalem class server with SSE4_2 support to generate this CRC with the hardware CRC32 instructions.

Figure 3. CRC32C Program Example (Sheet 1 of 8)

```
/*************************************************************************
*
* File: intelcrc.c
* Description:  32bit implementation of the CRC32C.
* Copyright 2009 Sun Microsystems, Inc. All rights reserved.
*
* CRC algorithm was excerpted from "18. Roll Your Own Table-Driven
* Implementation" in the following document:
*
*  "Everything you wanted to know about CRC algorithms, but were afraid to
*   ask for fear that errors in your understanding might be detected."
*
*  Author : Ross N. Williams
*  E-Mail : ross@guest.adelaide.edu.au
*  Date : 19 August 1993
*  Version : 3.00

*  FTP: ftp.adelaide.edu.au/pub/rocksoft/crc_v3.txt
*  WWW: http://www.on.net/clients/rocksoft/rocksoft/

*  Company : Rocksoft(tm) Pty Ltd
*  Snail : 16 Lerwick Avenue, Hazelwood Park 5066, Australia
*  Fax : +61 8 373-4911 (c/- Internode Systems Pty Ltd)
*  Phone : +61 8 379-9217 (10am to 10pm Adelaide Australia time)
*  Note : "Rocksoft" is a trademark of Rocksoft Pty Ltd, Australia
*
*  Status: Copyright (C) Ross Williams, 1993,1994,1995,1996. However,
*  permission is granted to make and distribute verbatim copies of this
*  document provided that this information block and copyright notice is
*  included. Also, the C code modules included in this document are fully
*  PUBLIC DOMAIN (PD).
*
*  Thanks: Thanks to Jean-loup Gailly (jloup@chorus.fr) and Mark Adler
*  (me@quest.jpl.nasa.gov) who both proof read this document and picked
*  out lots of nits as well as some big fat bugs.
*
*************************************************************************/
```

Figure 3. CRC32C Program Example (Sheet 2 of 8)

```
#include <unistd.h>
#include <stdio.h>

/*****************************************************************************/
/*                                                                           */
/* CRC LOOKUP TABLE                                                          */
/* ================================================                          */
/* The following CRC lookup table was generated automagically                */
/* by the Rocksoft^tm Model CRC Algorithm Table Generation                   */
/* Program V1.0 using the following model parameters:                        */
/*                                                                           */
/*    Width   : 4 bytes.                                                     */
/*    Poly    : 0x1EDC6F41L                                                  */
/*    Reverse : True.                                                        */
/*                                                                           */
/* For more information on the Rocksoft^tm Model CRC Algorithm,              */
/* see the document titled "A Painless Guide to CRC Error                    */
/* Detection Algorithms" by Ross Williams                                    */
/* (ross@guest.adelaide.edu.au.). This document is likely to be              */
/* in the FTP archive "ftp.adelaide.edu.au/pub/rocksoft".                    */
/*                                                                           */
/*****************************************************************************/


uint32_t crctable[256] =

{

0x00000000L, 0xF26B8303L, 0xE13B70F7L, 0x1350F3F4L,

0xC79A971FL, 0x35F1141CL, 0x26A1E7E8L, 0xD4CA64EBL,

0x8AD958CFL, 0x78B2DBCCL, 0x6BE22838L, 0x9989AB3BL,

0x4D43CFD0L, 0xBF284CD3L, 0xAC78BF27L, 0x5E133C24L,

0x105EC76FL, 0xE235446CL, 0xF165B798L, 0x030E349BL,

0xD7C45070L, 0x25AFD373L, 0x36FF2087L, 0xC494A384L,

0x9A879FA0L, 0x68EC1CA3L, 0x7BBCEF57L, 0x89D76C54L,

0x5D1D08BFL, 0xAF768BBCL, 0xBC267848L, 0x4E4DFB4BL,

0x20BD8EDEL, 0xD2D60DDDL, 0xC186FE29L, 0x33ED7D2AL,

0xE72719C1L, 0x154C9AC2L, 0x061C6936L, 0xF477EA35L,

0xAA64D611L, 0x580F5512L, 0x4B5FA6E6L, 0xB93425E5L,

0x6DFE410EL, 0x9F95C20DL, 0x8CC531F9L, 0x7EAEB2FAL,
```

Figure 3. CRC32C Program Example (Sheet 3 of 8)

```
0x30E349B1L, 0xC288CAB2L, 0xD1D83946L, 0x23B3BA45L,
 0xF779DEAEL, 0x05125DADL, 0x1642AE59L, 0xE4292D5AL,
 0xBA3A117EL, 0x4851927DL, 0x5B016189L, 0xA96AE28AL,
 0x7DA08661L, 0x8FCB0562L, 0x9C9BF696L, 0x6EF07595L,
 0x417B1DBCL, 0xB3109EBFL, 0xA0406D4BL, 0x522BEE48L,
 0x86E18AA3L, 0x748A09A0L, 0x67DAFA54L, 0x95B17957L,
 0xCBA24573L, 0x39C9C670L, 0x2A993584L, 0xD8F2B687L,
 0x0C38D26CL, 0xFE53516FL, 0xED03A29BL, 0x1F682198L,
 0x5125DAD3L, 0xA34E59D0L, 0xB01EAA24L, 0x42752927L,
 0x96BF4DCCL, 0x64D4CECFL, 0x77843D3BL, 0x85EFBE38L,
 0xDBFC821CL, 0x2997011FL, 0x3AC7F2EBL, 0xC8AC71E8L,
 0x1C661503L, 0xEE0D9600L, 0xFD5D65F4L, 0x0F36E6F7L,
 0x61C69362L, 0x93AD1061L, 0x80FDE395L, 0x72966096L,
0xA65C047DL, 0x5437877EL, 0x4767748AL, 0xB50CF789L,
 0xEB1FCBADL, 0x197448AEL, 0x0A24BB5AL, 0xF84F3859L,
 0x2C855CB2L, 0xDEEEDFB1L, 0xCDBE2C45L, 0x3FD5AF46L,
 0x7198540DL, 0x83F3D70EL, 0x90A324FAL, 0x62C8A7F9L,
 0xB602C312L, 0x44694011L, 0x5739B3E5L, 0xA55230E6L,
 0xFB410CC2L, 0x092A8FC1L, 0x1A7A7C35L, 0xE811FF36L,
 0x3CDB9BDDL, 0xCEB018DEL, 0xDDE0EB2AL, 0x2F8B6829L,
 0x82F63B78L, 0x709DB87BL, 0x63CD4B8FL, 0x91A6C88CL,
 0x456CAC67L, 0xB7072F64L, 0xA457DC90L, 0x563C5F93L,
0x082F63B7L, 0xFA44E0B4L, 0xE9141340L, 0x1B7F9043L,
 0xCFB5F4A8L, 0x3DDE77ABL, 0x2E8E845FL, 0xDCE5075CL,
 0x92A8FC17L, 0x60C37F14L, 0x73938CE0L, 0x81F80FE3L,
 0x55326B08L, 0xA759E80BL, 0xB4091BFFL, 0x466298FCL,
 0x1871A4D8L, 0xEA1A27DBL, 0xF94AD42FL, 0x0B21572CL,
 0xDFEB33C7L, 0x2D80B0C4L, 0x3ED04330L, 0xCCBBC033L,
```

Figure 3. CRC32C Program Example (Sheet 4 of 8)

```
 0xA24BB5A6L, 0x502036A5L, 0x4370C551L, 0xB11B4652L,
 0x65D122B9L, 0x97BAA1BAL, 0x84EA524EL, 0x7681D14DL,
  0x2892ED69L, 0xDAF96E6AL, 0xC9A99D9EL, 0x3BC21E9DL,
  0xEF087A76L, 0x1D63F975L, 0x0E330A81L, 0xFC588982L,
  0xB21572C9L, 0x407EF1CAL, 0x532E023EL, 0xA145813DL,
  0x758FE5D6L, 0x87E466D5L, 0x94B49521L, 0x66DF1622L,
  0x38CC2A06L, 0xCAA7A905L, 0xD9F75AF1L, 0x2B9CD9F2L,
  0xFF56BD19L, 0x0D3D3E1AL, 0x1E6DCDEEL, 0xEC064EEDL,
  0xC38D26C4L, 0x31E6A5C7L, 0x22B65633L, 0xD0DDD530L,
  0x0417B1DBL, 0xF67C32D8L, 0xE52CC12CL, 0x1747422FL,
  0x49547E0BL, 0xBB3FFD08L, 0xA86F0EFCL, 0x5A048DFFL,
  0x8ECEE914L, 0x7CA56A17L, 0x6FF599E3L, 0x9D9E1AE0L,
  0xD3D3E1ABL, 0x21B862A8L, 0x32E8915CL, 0xC083125FL,
  0x144976B4L, 0xE622F5B7L, 0xF5720643L, 0x07198540L,
  0x590AB964L, 0xAB613A67L, 0xB831C993L, 0x4A5A4A90L,
  0x9E902E7BL, 0x6CFBAD78L, 0x7FAB5E8CL, 0x8DC0DD8FL,
  0xE330A81AL, 0x115B2B19L, 0x020BD8EDL, 0xF0605BEEL,
  0x24AA3F05L, 0xD6C1BC06L, 0xC5914FF2L, 0x37FACCF1L,
  0x69E9F0D5L, 0x9B8273D6L, 0x88D28022L, 0x7AB90321L,
  0xAE7367CAL, 0x5C18E4C9L, 0x4F48173DL, 0xBD23943EL,
  0xF36E6F75L, 0x0105EC76L, 0x12551F82L, 0xE03E9C81L,
  0x34F4F86AL, 0xC69F7B69L, 0xD5CF889DL, 0x27A40B9EL,
  0x79B737BAL, 0x8BDCB4B9L, 0x988C474DL, 0x6AE7C44EL,
  0xBE2DA0A5L, 0x4C4623A6L, 0x5F16D052L, 0xAD7D5351L
 };
 /*****************************************************************/
 /*              End of CRC Lookup Table                          */
 /*****************************************************************/
```

Figure 3. CRC32C Program Example (Sheet 5 of 8)

```
#define NAME                    "CRC-32C"
#define WIDTH                   32
#define POLY                    0x1EDC6F41
#define INIT                    0xFFFFFFFF
#define INIT_REFLECTED          0xFFFFFFFF
#define REFIN                   TRUE
#define REFOUT                  TRUE
#define XOROUT                  0XFFFFFFFF
#define CHECK                   0xE3069283

/* NOTE: The CHECK is for the standard 9 byte test data of
*  ASCII string "123456789"
*/

//#ifdef CONFIG_X86_64
#if 1
#define REX_PRE "0x48, "
#define SCALE_F 8
#else
#define REX_PRE
#define SCALE_F 4
#endif

/*****************************************************************************
*
* Function:   crc32c_intel_le_hw_8b
*
*****************************************************************************/

static uint32_t crc32c_intel_le_hw_8b(uint32_t crc,
uint8_t const *data,
uint32_t length)
{

while (length--) {
__asm__ __volatile__(
".byte 0xF2, 0x0F, 0x38, 0xF0, 0xF1"
:"=S"(crc)
:"0"(crc), "c"(*data)
);
data++;
}

return crc;
}
```

Figure 3. CRC32C Program Example (Sheet 6 of 8)

```
/*****************************************************************************
*
* Function:   crc32c_intel_le_hw_64b
*
*****************************************************************************/

static uint32_t crc32c_intel_le_hw_64b(uint32_t crc,
uint64_t const *data,
uint32_t length)

{

while (length--) {
__asm__ __volatile__(
".byte 0xF2, " REX_PRE "0x0F, 0x38, 0xF1, 0xF1"
:"=S"(crc)
:"0"(crc), "c"(*data)
);
data++;

}
return crc;
}

/*****************************************************************************
*
* Function:   Main
* Purpose:    Calculate the CRC32C
* Args:       none
* Return Value:  none
* Remarks:
* CRC32 Generator Polinomial:
* 0x11EDC6F41
* x^32+x^28+x^27+x^26+x^25+x^23+x^22+x^20+x^19+x^18+x^14+x^13+x^11+
* x^10+x^9+x^8+x^6+x^0
*
*****************************************************************************/

int main(void)
{

uint32_t   crc;
uint32_t   cnt;
uint32_t   blk_len;
uint8_t    *blk_adr;
uint32_t   iquotient;
uint32_t   iremainder;
```

Figure 3. CRC32C Program Example (Sheet 7 of 8)

```
/* Test Data */
uint8_t  test_data[]=
{
/* ASCII "123456789" Expected CRC is 0xCBF43926 */
0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38, 0x39, 0x3A, 0x3B
};

printf("\nCrc32 ver. 1.0, 32bit CRC32C Demonstration.\n\n");

/* Display Test Data */
blk_len = sizeof(test_data);
printf("Sizeof test_data = %d \n", blk_len);
printf("Input String:\n");
for(cnt = 0; cnt < blk_len; cnt++)

printf("%02X ", test_data[cnt]);

/* Do Reflected CRC */
blk_len = sizeof(test_data);
blk_adr = &test_data[0];
crc = INIT_REFLECTED;
while (blk_len--)
crc = crctable[(crc ^ *blk_adr++) & 0xFF] ^ (crc >> 8);
crc = crc ^ XOROUT;

printf("\nSW Reflected CRC32C = \t0x%08X\n", crc);

/* Do CPU 8 instruction */
blk_len = sizeof(test_data);
blk_adr = &test_data[0];
crc = INIT;
crc = crc32c_intel_le_hw_8b(crc, blk_adr, blk_len);
crc = crc ^ XOROUT;

printf("\nCPU 8b CRC32C = \t0x%08X\n", crc);
```

Figure 3. CRC32C Program Example (Sheet 8 of 8)

```
 /* Do CPU 64 instruction */
blk_len = sizeof(test_data);
blk_adr = &test_data[0];
iquotient = blk_len / 8;
iremainder = blk_len % 8;
crc = INIT;
while (iquotient--)
{

crc = crc32c_intel_le_hw_64b(crc, (uint64_t *)blk_adr, 1);
blk_adr += 8;
}

if (iremainder)
crc = crc32c_intel_le_hw_8b(crc, blk_adr, iremainder);
crc = crc ^ XOROUT;

printf("\nCPU 64b & 8b CRC32C = \t0x%08X\n", crc);

printf("\nEnd of Demonstration\n\n");

return(0);

}


/*********************************************************************/
```

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.

arbitration Any process by which a user of a shared resource negotiates with other users for the right to use the resource. A port connected to a shared bus must win arbitration before it transmits data on the bus

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 mega-baud 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.

HBA See host bus adapter.

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 instead of 10.

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.

host bus adapter (HBA) A circuit installed in a multi-platform host or device that interfaces between the device and the bus.

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.

LC connector A standard connector for 2 Gbps Fibre Channel data transfer. This type of connector is used on fiber-optic cables.

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.

multi mode A graded-index or step-index optical fiber that allows more than one bound mode to propagate. Contrast with single mode.

multimode fiber An optical fiber designed to carry multiple signals, distinguished by frequency or phase, at the same time.

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

SC connector A standard connector for 1 Gbps Fibre Channel data transfer. This type of connector is used on fiber-optic cable.

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.

SFP *See* small form-factor pluggable.

single mode fiber Optical fiber in which only the lowest-order bound mode can propagate at the wavelength of interest.

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.

small form-factor pluggable Technology with 2-gigabit transfer speed over small connectors, cables, and transceivers for larger bandwidth capability.

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.

switch In Fibre Channel technology, a device that connects Fibre Channel devices together in a Fabric.

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.

V

VolSafe A Sun StorageTek feature that provides write once, read many (WORM) technology to VolSafe-designated tape cartridges. VolSafe only permits new data to be appended to data currently on the tape. Once written, the data cannot be overwritten.

W

World Wide Name (WWN) A 64-bit integer that identifies a Fibre Channel port.

World Wide Node Name (WWNN) A 64-bit network address that identifies the company (in IEEE format) with a vendor specific identifier.

World Wide Port Name (WWPN) A 64-bit network address that identifies the port name.

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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